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GRAZING ON THE EDGE: CATTLE MOBILITY, ECOLOGY,
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**GRAZING ON THE EDGE: CATTLE MOBILITY, ECOLOGY AND MAASAI
HERDING IN SOUTHERN KENYA.**

VOLUME I

By

Bilal Butt

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ABSTRACT

GRAZING ON THE EDGE: CATTLE MOBILITY, ECOLOGY AND MAASAI HERDING IN SOUTHERN KENYA.

By

Bilal Butt

This study is concerned with the social, ecological, political and cultural dimensions of pastoral herding around the Maasai Mara National Reserve (MMNR) in south-western Kenya. The research was aimed at uncovering the complexities inherent in the herding strategies of Maasai pastoralists and better understanding the relationships between the patterns of cattle mobility and both the social and ecological processes influencing mobility. In particular, the study focuses on four areas of research: the effects of herd size on household relocation during drought periods; vegetation dynamics and the spatio-temporal variability of pastoral cattle activities on vegetation; the effects of wealth on herding strategies of pastoralists; and the etiology of grazing conflicts between herders and protected area managers. The research used a wide variety of primary and secondary data sources to understand these four dimensions.

The results of the study suggest that pastoral household relocation reduces the stress faced by pastoralists during the drought by lowering the average total daily distance and time, directing cattle towards the interior of the MMNR and concentrating the direction towards distinct grazing zones inside the Reserve. In addition, the study also found that as grazing intensity increases, mean grassland vegetation indices decrease during the wet season, remain stable in the dry season, and increase in the drought season. The spatial location of high intensity areas differ by season and demonstrate that cattle intensively use different parts of the landscape at different time periods. These

findings demonstrate remarkable resiliency within the pastoral livelihood system in adapting to changing environmental conditions. However, the results also suggest that wet season impacts are likely to be greater than dry or drought periods. While conventional wisdom suggests that impacts are likely to be greater during periods of high stress, this research suggests otherwise. Results of the analysis on wealth and herding found that herding strategies were similar between all three wealth categories during the wet and dry seasons, but vastly different during the drought. Finally, I demonstrate that the rise and importance of tourism in and around the MMNR is largely responsible for the presence and continued exacerbation of conflicts between herders and protected area managers. The presence of cattle inside the MMNR results in tourist dissatisfaction and thus protected area managers enforce an ideal of nature conservation that is devoid of cattle because of complaints by tourists and not because of the presumed environmental degradation caused by cattle.

This research makes important methodological contributions to the study of pastoralists, livestock and the environment by demonstrating the efficacy of using low-cost GPS collars to track cattle mobility at fine scales of space and time, and in using mixed method research to better understand nature-society relationships. The theoretical contributions to the literature lie in determining what type of ecology can be best inserted into the political ecology of pastoralism. In addition this research has demonstrated the resiliency and flexibility of pastoral livelihood systems at the finest scales of space and time. The policy implications of this study address the issue of extractive resource use inside protected areas as well as nature of coercive conservation tactics against pastoralists who reside at the periphery of a protected area.

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Dedicated To:

**Oppressed, persecuted and occupied peoples all over the world, and
to those who ensure that their voices are heard.**

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PREFACE

In November 2006, I began to pen the first words to this lengthy dissertation. A continent and an ocean away, over 6,000 of the world's politicians, policy makers, scientists and activists converged at the United Nations Environment Programme (UNEP) global headquarters in my home town of Nairobi, Kenya. Their goal was to discuss and chart the way forward on the most critical environmental issue facing human kind today. Global Climate Change. The United Nations Under-Secretary General for the Environment and UNEP Executive Director stated that climate change over the next 100-years would significantly affect sites of cultural and natural heritage and that the poor, particularly in East Africa were likely to be worst affected. Between the live webcasts of the conference, a rather inept and repeated defense on the part of the US to not sign the Kyoto protocol, as well as immense political maneuvering amongst the delegates on emissions cutbacks, carbon trading resolutions and the adoption of environmentally sound technologies, a small group of indigenous peoples from around the world demanded to be heard! They had traveled from Panama and India, New Zealand and Guyana to receive accreditation to attend the conference pleading that the rights of indigenous peoples be considered as part of the conference. Instead they stood at the gates, and watched one limousine after another shuttle delegates back and forth between their luxury hotels and the lush grounds of the UN complex. They were not heard.

Climate change is going to be the next great problem that the poor and marginalized are going to face. From as early as the rinderpest epidemic in the late 1800's to the conquest of colonialism, and the loss of their traditional grazing lands to create a wilderness for outsiders, pastoralists have continued to be marginalized in many different ways. The readers of this dissertation will hopefully acknowledge the main

theme running throughout this empirical work on the impacts that the drought, experienced between January and February 2006, had on herding strategies and the pastoral livelihood system. However, the data accrued from the year of the fieldwork only demonstrates a snap shot in time of increased environmental variability in the savannas of East Africa. Less than eleven months after the worst drought in 25 years, the study site experienced the worst flood in 75 years.

The world has still not appreciated the vast amount of indigenous knowledge that has been accrued by centuries of ‘dwelling,’ and the immense potential that lies in working with indigenous peoples in order to ameliorate rural suffering and devastation that is being caused by climate change. Positive change can only come about by working with indigenous peoples, *as equals*, and not just as ‘stakeholders’. It is after all, their land, and their traditions and livelihood systems that we are impacting beyond repair. Let us hope that we do not repeat history.

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LIST OF ACRONYMS

CBNRM	Community Based Natural Resource Management
CBS	Central Bureau of Statistics
DRSRS	Department of Remote Sensing and Resource Surveys
EOS	Earth Observation System
EVI	Enhanced Vegetation Index
FOC	Friends of Conservation
GIS	Geographic Information Systems
GOK	Government of Kenya
GPS	Global Positioning System
ICDP	Integrated Conservation and Development Program
ILRI	International Livestock Research Institute
KGR	Koyake Group Ranch
KREMU	Kenyan Rangeland Ecological Monitoring Unit
KWS	Kenya Wildlife Service
MMNR	Maasai Mara National Reserve
MODIS	Moderate Resolution Imaging Spectroradiometer
NASA	National Aeronautics and Space Administration
NCC	Narok County Council
NDVI	Normalized Differential Vegetation Index
NEMA	National Environmental Management Authority
NGO	Non-Governmental Organization
PRA	Participatory Rapid Appraisal
RS	Remote Sensing
SME	Serengeti-Mara Ecosystem
SNP	Serengeti National Park
SRF	Systematic Reconnaissance Flights
ETM	Enhanced Thematic Mapper
UNEP	United Nations Environment Programme
WWF	World Wildlife Fund

LIST OF SWAHILI AND MAA WORDS

Word	Language	Meaning
<i>Boma</i>	Swahili	Agglomeration of households
<i>Chai</i>	Swahili	Tea
<i>Chappa</i>	Swahili	Hit or beat aggressively
<i>Emarti</i>	Maasai	Hills
<i>Engiro</i>	Maasai	Dirty water
<i>Enkaji</i>	Maasai	Dwelling unit (synonymous with boma)
<i>Enkaji</i>	Maasai	Sub-household
<i>Enkang</i>	Maasai	Agglomeration of households
<i>Enkutoto</i>	Maasai	Neighborhood/locality
<i>Erashe</i>	Maasai	Grass/Forage
<i>Fimbo</i>	Swahili	Thin branches used as whips or canes
<i>Ilmutende</i>	Maasai	Cattle raiders
<i>Kiangazi</i>	Swahili	Drought
<i>Laibon</i>	Maasai	Advisor
<i>Luggas</i>	Swahili	Seasonal streams
<i>Mchungaji</i>	Swahili	Herder
<i>Muindi</i>	Swahili	Asian
<i>Mzungu</i>	Swahili	Caucasian
<i>Ntalengos</i>	Maasai	Ceremonies (weddings and circumcisions)
<i>Ngare</i>	Maasai	Water
<i>Olale</i>	Maasai	A place with no grass or water
<i>Olgilata</i>	Maa	Clan
<i>Olgilata</i>	Maa	Maasai clan affiliation
<i>Olmarei</i>	Maa	Household
<i>Olomonera</i>	Maa	Stagnant water
<i>Oloshon</i>	Maa	Maasai section
<i>Posse</i>	Maa	Grass Plains
<i>Sukuma-wiki</i>	Swahili	Spinach
<i>Ugali</i>	Swahili	Maize meal

CHAPTER 1

Introduction and theoretical foundations

1.0 Introduction

On January 22, 2005 long running tensions between Maasai¹ pastoralists and Kikuyu farmers reached a violent climax after an extended dry period on the rangelands at floor of the Rift Valley in Kenya. 'Fifteen killed in fights over water, land' read the national headlines the next day (Standard 2005). The same phenomena reached parallel proportions in three different parts of the country during that dry period, as well as many other smaller conflicts (UNPO 2005). The ethnicities and livelihood systems were different, but the source of conflict remained the same: the struggle by indigenous peoples to secure access to, utilization and control over natural resources critical to sustaining their livelihood systems. The newspaper headline demonstrated the outcome of resource scarcity, but it did not examine the historical processes leading to conflict; the changing social relations of production and exchange developed over centuries, and which has been constrained by the modern day state.

Around many protected areas in sub-Saharan Africa, natural resource related conflicts are partly constituted by historical and contemporary state and local policies of control and exclusion. The state, through protected area institutions, has restricted access to environmental resources inside protected areas by park adjacent dwellers. This is partly because of wrongly deduced perceptions that resource use will adversely impact the integrity of protected areas, without an understanding of the complex social and ecological dynamics of the livelihood system (Homewood and Rodgers 1991).

¹ Maasai is commonly spelt as either Maasai or Masai. There is a great deal of confusion regarding the correct spelling. In this dissertation, I rely on Maasai following Mol (1996) which is considered the most authoritative and comprehensive compilation of Maasai language and culture.

There are two purposes of this dissertation research: (1) *to understand the social and ecological dynamics of pastoral resource use around protected areas and;* (2) *to understand incidences of grazing conflict as they relate to grazing access, environmental resources and control over protected areas.* This research employs a political ecology conceptual framework (Robbins 2004; Forsyth 2003; Zimmerer and Bassett 2003) to develop a historical and contemporary case study on Maasai pastoralism, conservation abuses, herd mobility and environmental change in southwestern Kenya (Fig. 1.1). I adopt the same approach that Peluso and Watts take in their seminal edited volume on *Violent Environments*, which:

“...accounts for the ways that resource environments (*rangelands*) and environmental processes (*grazing*) are constituted by, and in part constitute, the political economy of access to and control over resources” (Peluso and Watts 2001: 5)

1.1 Research Framework

The political ecology research framework is marked by theoretical pluralism² and helps to: orient the field research, selectively integrate key concepts that underlie the social, economic, political and ecological processes underlying resource use and control, and offers a loose structure within which to integrate and analyze both social and ecological data. The political ecology framework is commonly accepted as the dominant framework within nature-society studies today (Zimmerer and Bassett 2003; Robbins 2004). While there are many concurrent approaches to research that utilize the broad

² Agrarian, peasant, feminist development, post-colonial studies, Marxism, dependency theory, world systems theory, and property theory have all made theoretical contributions towards shaping the sub-field of political ecology.

political ecology framework (McCarthy 2002), this research is motivated by the political ecology of pastoralism approach articulated by Little (2003: 165) which: (1) queries access to resources; (2) examines the allocation and management of resources, and; (3) documents the physical ecological changes and feedbacks that occur as a result of (1) and (2) (Fig. 1.2).

Political ecology was originally defined as combining the, “concerns of ecology with a broadly defined political economy” (Blaikie and Brookfield 1987: 17), in order to explain nature-society relationships in an analysis of environmental resource access and utilization. The political ecology framework has been incorporated in the structured analyses of pastoral herding through case studies in Mali and Niger by Matt Turner (Turner and Hiernaux 2002; Turner 1999c; Turner 1999a); Côte d’Ivoire by Tom Bassett (Bassett 1988, 1994; Bassett and Zueli 2000), Tanzania by Little (Little 2003) and Kenya by McCabe (McCabe 2004).

Key themes of the broader political ecology framework that are incorporated in this research are: a critical focus on the multiple interactions, among and between, *social* and *ecological processes* (Zimmerer 1994); using *ecological concepts* to understand the environmental impacts that human populations have on the natural environment (Blaikie and Brookfield 1987; Zimmerer 2000); emphasizing the *political-economic* processes that affect patterns of local resource utilization (Paulson, Gezon, and Watts 2003); recognizing the role of *power relations* in these processes (Bryant 1992; Robbins 2003b; Rocheleau, Thomas-Slayter, and Wangari 1996); an attention to detail within each of these processes and interactions across *multiple spatial* and *temporal scales* (Blaikie 1994; Bryant 1998); the centrality of *the state* in environmental management and control

(Neumann 2004b; Peluso 1992; Robbins 2000, 2003b); and a critical emphasis on *local knowledge* as it relates to resource access, utilization and control (Bassett and Crummey 2003; Fairhead and Leach 1996; Goldman 2003; McCarthy 2002). McCarthy (2002) suggests that, “it is the presence of most or all of these themes as components of case studies that defines political ecology more than any consistent theoretical or methodological approach to them” (McCarthy 2002: 1283).

In this study I define the ‘political’ as the political economy of herding practices of Maasai pastoralists, situated within both formal and informal institutions that describe and dictate the social relations of production and exchange related to the maintenance of the household and livelihood system. Similarly, I define the ‘ecological’ as a combination of: (1) qualitative indigenous environmental knowledge of dynamic rangeland environments; (2) a systematic quantitative assessment of changing ecological conditions characterized by remotely sensed normalized differential vegetation indices (NDVI).

These two different, but cohesive terms allow for an explanation of natural resource management, utilization and control by pastoralists who reside at the periphery of a large protected area. The framework allows for, and depends upon, an understanding of the different components that help understand the adaptive dynamic nature of ecosystems and livelihood systems that are largely governed by seasonal constraints and spatio-temporal dynamism.

1.2 Research Contexts

This research is situated within the context of changing relationships between the state, pastoral livelihood systems, and the environment, as a way in which ecological and social processes related to natural resource conflicts can be characterized and understood.

Relationships between the state and environment can be understood by examining the conservation, development and management strategies in areas of high biological diversity (Anderson and Grove 1987) and efforts to preserve a wilderness identity devoid of people (with the exception of fee paying tourists) (Neumann 2001, 1998).

Relationships between pastoralists and the environment may be recognized through the many adaptation strategies pastoralists rely on to cope with environmental uncertainty and variability in rangelands (Behnke, Scoones, and Kerven 1993; Scoones 1994b).

Relationships between pastoralists and the state may be envisioned through the institutional management of pastoralists at different state levels (local, national and international) as it relates to both protected areas management and the socio-economic and political development of pastoralists in rangelands (Norton-Griffiths 1995; Salzman 2004; Sandford 1983; Sandford and Scoones 2006; Vedeld 1994).

As relationships between and among the state, pastoralists, and the environment change, there are growing uncertainties in how pastoralists secure access to, utilize and control environmental resources critical to their livelihood systems (McCabe 2004, 1987; Homewood 2004; Homewood and Lewis 1987b). Whenever these uncertainties could not be sustained by the dynamics of flexibility and diversification of the livelihood system, conflicts between various parties has occurred and in some cases, through the use of violent force (McCabe 2004; Fleisher 1999)

Protected areas in rangeland environments of sub-Saharan Africa were often established by forcefully displacing indigenous pastoralists from their ancestral lands during the colonial era (Jacobs 1975; Lindsay 1987; Neumann 1998; Peluso 1993; Talbot and Olindo 1990). Consequently, pastoralists were confined to 'native reserves,' resulting in the loss of access to traditional grazing areas (Lindsay 1987) and severely disrupting traditional modes of livestock production (Rutten 1992). In the early post-Independence era national governments imposed communal land management structures as a means to increase livestock productivity and incorporate pastoralists more formally into the national economy and reduce environmental degradation (Ayuko 1981; Kimani and Pickard 1998). In Kenya, this took the form of group ranches, an American inspired communal land management program that sought to achieve collective management of resources and infrastructure (described in detail in chapter 2 and Galaty 1992; Seno and Shaw 2002; Sadara 1986).

Over the last three decades, range managers and scientists have consistently argued that communal herding areas are especially vulnerable to 'overgrazing' and 'degradation' due to high stocking rates (livestock density) and poor management techniques by pastoralists (Lamprey and Reid 2004; Lamprey 1983; Niamir-Fuller and Turner 1999; Turner 1993). These assertions, made using western range science paradigms, were based on coupling stocking rates with ecological or economic carrying capacity (Turner 1993; de Leeuw and Tothill 1993). These assessments are inaccurate for three main reasons. First, they ignore the complex social relations of production and exchange of pastoralist herding strategies (Homewood and Rodgers 1991). Second, they do not account for the spatial and temporal heterogeneity associated with grazing

resources in non-equilibrium environments (Turner 1998a). Lastly, in areas where protected areas border communal areas, they overlook the varied social and ecological impacts of protected areas on pastoral livelihood systems (Anderson and Grove 1987; McCabe, Perkin, and Schofield 1992).

State involvement of protected areas in Kenya started as early as the 1940's by the colonial government. The initial conservation framework was imported from the U.S. and based on the Yellowstone model (Collett 1987) which adopted the 'fences and fines' approach to conservation and advocated the complete restriction of natural resources utilization from inside conservation territories (Western, Wright, and Strum 1994). Many protected areas were given a conservation status, the most common being '*National Parks*' which were nationally managed through the Royal National Parks of Kenya during the colonial period. In the early post-Independence period, these protected areas were managed by the Wildlife Conservation and Game Department (part of the Ministry of Tourism and Wildlife) (Talbot and Olindo 1990). Other protected areas were assigned as '*National Reserves*' managed by local government authorities. The current literature reflects differing perspectives on the extent of resource utilization in National Reserves with some researchers suggesting that some utilization is possible by park adjacent dwellers, while others assert that there is no utilization permissible (Western 1997; Lovatt Smith 1997).

Situating Pastoral Livestock Mobility: Given these various research contexts, I propose to follow the *livestock mobility* approach by articulated by Niamir-Fuller (1999b) and Adriansen (2003) to capture and understand these changing relationships as they relate to grazing conflict.

Livestock mobility is among the most important modes of flexibility that pastoralists rely on to counter environmental uncertainty and variability in rangelands. In recent years, researchers have argued for the adoption of a ‘mobility paradigm’ to provide new insights into the social, political and ecological dynamics of pastoralism in rangelands as one way to link the scientific inquiry of pastoral mobility to sustainable development practices (Niamir-Fuller 1999b). A number of salient aspects exist that provide a framework for understanding livestock mobility (Figure 1.3). These are: the resource base, the resource users, their adaptive strategies and their common property regimes (Niamir-Fuller and Turner 1999: 32-40). The *resource base* is aligned to the concepts of high ecological variability, uncertainty, non-equilibrium theory and high ecological resilience. *Resource users* are described through the key words of social capital, indigenous technical knowledge systems, interdependence and political alliance. The *adaptive strategies* combine the concerns of the type of mobility with the decision-making and management strategies of pastoralists. Finally, *common property regimes* incorporate keywords of common-pool resources, nested property, fluid boundaries, inclusive rights and popular enforcement, among others.

1.3 Research Objectives

Given these brief research, geographic and historical contexts, the objectives of this research are twofold:

Objective 1: To document, characterize and delineate the patterns and processes of pastoral resource use at the periphery of a protected area.

Objective 2: To understand and contextualize incidences of grazing conflict between herders and protected area managers.

The case study site chosen for this research is the Talek area north of the Maasai Mara National Reserve (MMNR), a locally managed protected area in southern Kenya (Lamprey and Reid 2004) (Fig. 1.1).

This research makes methodological, theoretical and analytical contributions to the changing relationships between the state, pastoralists and the environment. Specifically, I focus on the context specific causes of grazing conflict, as well as provide policy implications for conflict resolution and conservation and development strategies in Kenya.

1.4 Research Questions

This research will focus on three critical questions: The first two questions will be used to accomplish the first objective, while the latter two questions will help to undertake the second objective:

- (1) What are the *patterns* of pastoral livestock movement near the MMNR?
- (2) What are the:
 - a. ecological and,
 - b. socio-economic and political-economic *processes* that influence livestock movement patterns?
- (3) When, where and why do grazing *conflicts* occur between herders and the state?

1.5 Theories, Concepts and Frameworks

This study is grounded in the nature-society tradition of geography and located at the intersection of three broad bodies of inter-disciplinary literature.

- (1) Non-equilibrium based theories of environmental change in African pastoral systems.
- (2) Dynamics of diversity, flexibility and resilience of pastoral herding systems.
- (3) Encounters between people, protected areas and conservation ideals and the conditions under which resource conflicts occur.

Collectively these literatures contribute to a greater understanding on how Maasai pastoralists secure access to and gain control of natural resources around protected areas and how these change over space and time.

1.5.1 Non-Equilibrium Theories of Environmental Change and Carrying Capacity

This first body of literature focuses on recent research that dismisses equilibrium based theories of environmental change in African pastoral areas and asserts a move towards non-equilibrium rangeland theories (Behnke, Scoones, and Kerven 1993; Ellis and Swift 1988). Equilibrium based theories are based on plant succession models and defined by relatively high levels of climatic *stability*, resulting in predictably constant levels of primary production (Botkin 1990; Coppock 1993; Ellis, Coughenour, and Swift 1993; Illius and O'Connor 1999). Equilibrium hypothesis suggest that:

“...livestock populations are tightly coupled to the availability of forage and can thereby impact adversely on vegetation when concentration of herbivores exceed productivity” (Sullivan and Rohde 2002: 1597)

As a result, it is assumed that changes in the stocking rates create predictable changes in plant composition where ‘grazing-desirable’ plant species decrease with grazing pressure, the potential carrying capacity of the ecosystem can be predicted and stocking rates regulated according to the carrying capacity (Hary et al. 1996; Illius and O'Connor 1999; Oba, Stenseth, and Lusigi 2000; Oba et al. 2003b)

In contrast, non-equilibrium theories emphasize feedback mechanisms and gradual succession models, such that climatic *variability* results in varying degrees of primary productivity (forage resources), creating fluctuations in animal numbers (Oba, Stenseth, and Lusigi 2000; Oba et al. 2003a). Climatic variability in rangelands is high, both spatially and temporally, and vegetation systems are often the product of mediating processes between wildlife and livestock herbivory and rainfall (Ellis, Coughenour, and Swift 1993). More recently, there is increasing evidence to suggest that the timing and intensity of grazing is determined not only by the shifting spatial and temporal patterns of rangeland resources (Turner 1998a) but also by social, economic, political and institutional dynamics such as the quality of herd management (Bassett 1994), which includes gender (Hodgson 1999b; Hodgson 2001) and labor availability (Turner 2000, 1999a) and human and herd mobility (Baker and Hoffman 2006; de Bruijn and van Dijk 2003)

However, this shift to non-equilibrium paradigms did not prevent wrongly deduced analysis of environmental change perpetuating and popularizing misconceptions

over pastoralism-livestock-environment narratives³ (Scoones 1994b; Lamprey 1983; Leach and Mearns 1996). Range scientists' preoccupation with stocking rates as an indicator for degradation and overgrazing has been critiqued by Turner (2003a). He argues that defining and debating overgrazing by comparing stocking rates in a given area to an estimated carrying capacity is problematic because stocking rates exclude complex social, political and economic processes of pastoral herding, and livestock densities fluctuate through livestock demography (birth and death rates). These fluctuations are:

“...driven not only by an area's rangeland ecology (affecting livestock fodder and disease vectors) but also by its economy. A more spatially explicit environmental assessment of livestock grazing requires an understanding of what may affect not only the size of an area's livestock population, but its *spatial distribution* within the area, which are driven by land use and the '*herding decisions of the people*'” (Turner 2003a: 160)

There have been significant contributions to understanding the 'herding decisions' of various pastoral groups around the world (Fratkin 1997; Salzman 2004; Galaty 2003; Galaty 1981a; Fratkin 1991b), although these contributions have been limited when examining herding decisions in areas where pastoralists reside in close proximity to large protected areas in East Africa. Terry McCabe's work on the Maasai in northern Tanzania around the Ngorongoro Conservation Area (NCA) (McCabe 2003; McCabe, Perkin, and Schofield 1992), stands in exception.

³ These misconceptions may be termed as 'apolitical ecologies' following Robbins (2004: 5-7) attempt to describe dominant (largely global) discourses that do not take into account local level perspectives, or the embedded power relations that allow the dominant narrative to be privileged over local or cross-scalar perspectives.

1.5.2 Pastoral Herding Systems

Pastoralists inhabiting rangelands of sub-Saharan Africa number between 20-25 million and keep an estimated 377 million cattle, sheep and goats (Scoones 1994a). Cumulatively, the value of livestock products which pastoralists contribute to in Africa's rangelands are estimated to be approximately 25% of the total agricultural GDP, thereby contributing significantly to national economies (Bourn and Blench 1999). However, the development of rangelands in Kenya, where pastoralism is the main livelihood system, has been significantly affected by state policies that are biased towards sedentary agriculture (Bennett 1984; Hansen, Woie, and Child 1986). Where the development of rangelands has taken place, pastoralists have been subjected to various policies that were intended to 'modernize' their economies and integrate livestock production into the national economy (Anderson 1993, 2002). The implementation and success of these modernization policies have varied significantly over the past 50 years, but have resulted in undermining the *traditional* management and coping strategies of pastoralists (Evangelou 1984). This has occurred by denying pastoralists access to critical environmental and social resources through a number of land restriction mechanisms, such as the creation of protected areas and the establishment of communally owned group ranches with no traditional basis (Kimani and Pickard 1998; Seno and Shaw 2002). These land reductions have affected pastoral mobility patterns, contributing to growing uncertainties in securing property rights and critical environmental resources such as water and grazing resources (Bourn and Blench 1999; Juul and Lund 2002; Prins 2000)

As the relative sizes and rates of growth of pastoral populations change there is also growing uncertainty in the political relationships with non-pastoralists and national

governments which institute and operationalize development policies within pastoral areas, with the help of foreign development partners (Fratkin 1997; Mbaaria 2004).

In order to cope with uncertainties in political relationships and property rights, pastoralists have adopted *diverse* and *flexible* strategies, through a number of social, economic, environmental and political *mechanisms* and *processes* (Niamir-Fuller 1998; Behnke, Scoones, and Kerven 1993) These include, but are not limited to, drought adaptation strategies (through cropping activities, employment, and the sale of livestock), livestock diversity, common property regimes, monitoring of resources and key site management, all of which have an effect on *livestock mobility* (Swift 1994). Drawing on research by Niamir-Fuller (1998), Sørbo (2003) suggests that:

“...the challenge to resource management is not to maintain stability, but to maintain *diversity* and *flexibility*...wherever diversity has been reduced, environmental degradation has followed. Wherever the flexibility offered by each of these mechanisms has been curtailed, the production system has suffered and the community has lost its (pastoral) viability” (Sørbo 2003: 113)

This research examines both the socio-political and ecological processes that alter both the flexibility and diversification of pastoralists, determine the extent to which these processes physically impact the environment and describe the conditions under which conflict over environmental resources occurs.

1.5.3 People, Protected Areas and Conservation

A large part of this body of literature has historically focused on the impacts of people on protected areas (Anderson and Grove 1987; Western 2000, 1998; Zimmerer 2000). However, more recently, there have been numerous studies that examine the

impacts of protected areas on people. Within this body of literature, a number of common themes emerge as noted by Robbins (2004). These include a critical examination on the constructed character of natural wilderness and its impact on conservation and development strategies (Neumann 1998), increasing coercion and governmentality of state rule over conservation units (Peluso 1993, 1992), and a growing understanding of traditional resource management strategies where rules govern extraction without state intervention (Bryant 2002). Collectively this body of research reveals how ‘conservation encounters’ can shape landscapes and livelihoods in contradictory ways (Zimmerer and Bassett 2003: 5-7).

The encounters between people and protected areas are varied and complex, partly because protected areas act as both *political institutions of the state* and *reservoirs of biological diversity* (Butt 2002). This plurality of competing roles defines how park-adjacent dwellers form the means to secure access to grazing resources to meet their production goals. Several case studies around the world have examined this issue. Within Latin America, Sundberg illustrates the relationships between NGOs and local people and finds that groups who conform to essentialist views of living with nature are in a better position to gain from conservation projects in the Maya Biosphere Reserve in Guatemala (Sundberg 1998). Nygren presents the conflicting views of different stakeholders over the access to and control of resources in the Indio-Maiz Reserve in Nicaragua (Nygren 2004). Protected area managers and members of some NGOs on the one hand see peasants as ignorant and in need of environmental education, while peasant farmers view the creation of fields and pasture out of the Reserve as a necessary path out of poverty and destitution, even though it conflicts with conservation efforts. Emily Young also illustrates how

access to the oceanic commons has shifted under changing political-economic conditions, such as the centralized management of coastal resources, the dominance of foreign companies involved in ecotourism and a greater participation of local communities, which has been aided by transnational corporations and NGO's on the Pacific coast of Baja, Mexico (Young 1999)

Conservation conflicts are common across parts of East Africa and may fall under two broad categories: social and ecological. Ecological conflicts take place between pastoralists' livestock and wildlife within and around protected areas over the use of grazing and water resources (Bourn and Blench 1999). These conflicts are exacerbated during dry and drought periods. Conflict is also exhibited through the spread of epizootic diseases from livestock to wildlife and vice-versa (Grootenhuis 2000b; Prins 2000). These include, Malignant Catarrhal Fever, African Trypanosomoses, Canine Distemper, East Coast Fever and Rinderpest. Over the past 80 years these diseases have had varying effects on both livestock and wildlife populations in the Serengeti-Mara Ecosystem, because of different approaches to disease monitoring and control in Kenya and Tanzania (Bourn and Blench 1999).

Social conflicts also occur between pastoralists and protected area institutions, because protected area managers have often viewed pastoralists as a direct threat to the conservation of biodiversity (Homewood and Rodgers 1987; Homewood and Rodgers 1984). This is because of perceptions that pastoralist densities will grow, sedentarization increase, livestock production intensifies and overgrazing will take place. As a result pastoralists have had difficulty securing access to natural resources that fall within protected areas because of state policies that are biased towards sedentary agriculture and

exclude the extraction and utilization of resources from these areas. However, many park-adjacent dwellers feel morally justified to encroach onto these lands because of ancestral occupation and customary rights to resources.

From his experiences in the Serengeti National Park in Tanzania, Rod Neumann suggests that, “violence against people is inherent and perpetually latent in the practice of state-directed wildlife conservation” in East Africa, because of four main reasons: (1) people involved in hunting or defending crops against wildlife predation are armed with weapons; (2) the processes of modern state formation involved the government securing control over natural resources, such as wildlife, and were particularly conducive to violence because the stakes were high; (3) wildlife conservation efforts were closely associated with military activities (such as the fight against poachers), and; (4) the geographical isolation of protected areas from major towns and cities allows for the possibility of committing illegal acts of violence and escaping prosecution (Neumann 2001: 305-306).

1.6 Structure of the Dissertation

This dissertation is divided into three parts. The first part titled ‘*theory and method in a study of pastoralists, livestock and the environment*’ consists of three chapters. This introduction, a description of the study area and methodology are intended to provide the reader with the theoretical underpinnings of the study, that is, what motivates the study from a theoretically plural perspective and provides a contextual framework from which to situate the study. This part also describes the unique qualities of the study site, providing detailed information on the socio-cultural and physical attributes of the study site, as well as a rationale for selecting the study site. The last

chapter of this part provides a description of the data and methods used to collect and support the various different narratives of the dissertation.

The second part of the dissertation titled '*the evidence: pattern to process to conflict*,' is designed to illustrate through empirical inquiry, the multi-dimensional perspectives on the herding strategies of Maasai pastoralists around a large protected area. This section is divided into four chapters. The first of these (chapter 4) presents the spatially and temporally explicit *patterns* of cattle mobility and broad trends in mobility are described by season. Specifically, I examine two aspects of the drought coping strategies of pastoralists and herd management. These are: (1) movement into protected areas, and; (2) the relocation of pastoralists and their cattle from permanent settlements to temporary camps. By hypothesizing mobility and considering spatially and temporally explicit parameters of cattle mobility, I demonstrate how these two strategies were profoundly different during the drought than in either the wet or dry season. The fifth chapter examines, through the use of satellite derived remote sensing data, the relationships between patterns of cattle mobility and *ecological processes*. Specifically I test hypotheses of: (1) vegetation indices of different land cover types; (2) vegetation indices of cover types inside and outside the protected area; (3) grassland greenness as a function of distance away from pastoral settlements, and; (4) grassland greenness as a function of cattle intensity. The sixth chapter considers the *social processes* driving herding strategies. In this chapter, I rely on key informant interviews with herders before they left their enclosures and again once they returned, to demonstrate how wealth differentially influences herding strategies during each of the seasons. The final chapter in this part seeks to document and understand the etiology of *grazing conflicts* between

herders and protected area managers. By reporting on key informant interviews conducted with herders, elders, tourists, rangers, and game wardens, I demonstrate how grazing conflicts in the case of the study site do not conform to dominant theoretical perspectives. Instead I provide an alternative explanation that considers the spatio-temporal roles of different actors in exacerbating conflict.

The third part of the dissertation is titled '*Conclusions, implications and recommendations for further research*' and consists of just one chapter. As the title suggests, the aim of this final chapter is to: (1) summarize the main findings of the study from each of the four data chapters; (2) examine the implications of the study as it regards the political-ecology framework, and; (3) suggest new avenues for future research.

Figure 1.1: Study area, the Talek Area of the Maasai Mara National Reserve, Rift Valley Province, Narok District, Kenya. Data Source: Reid et al. (2003)

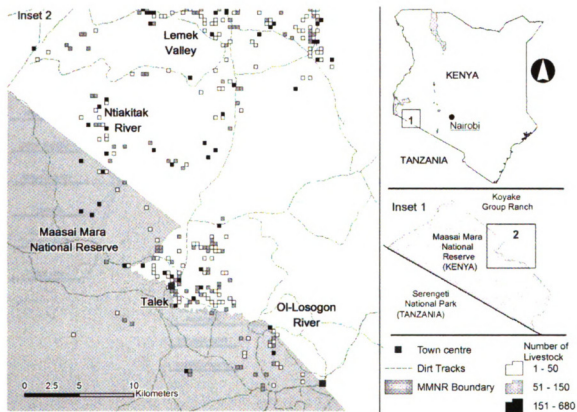


Figure 1.2: Components of the Mobility Paradigm – Source: Niamir-Fuller (1999)

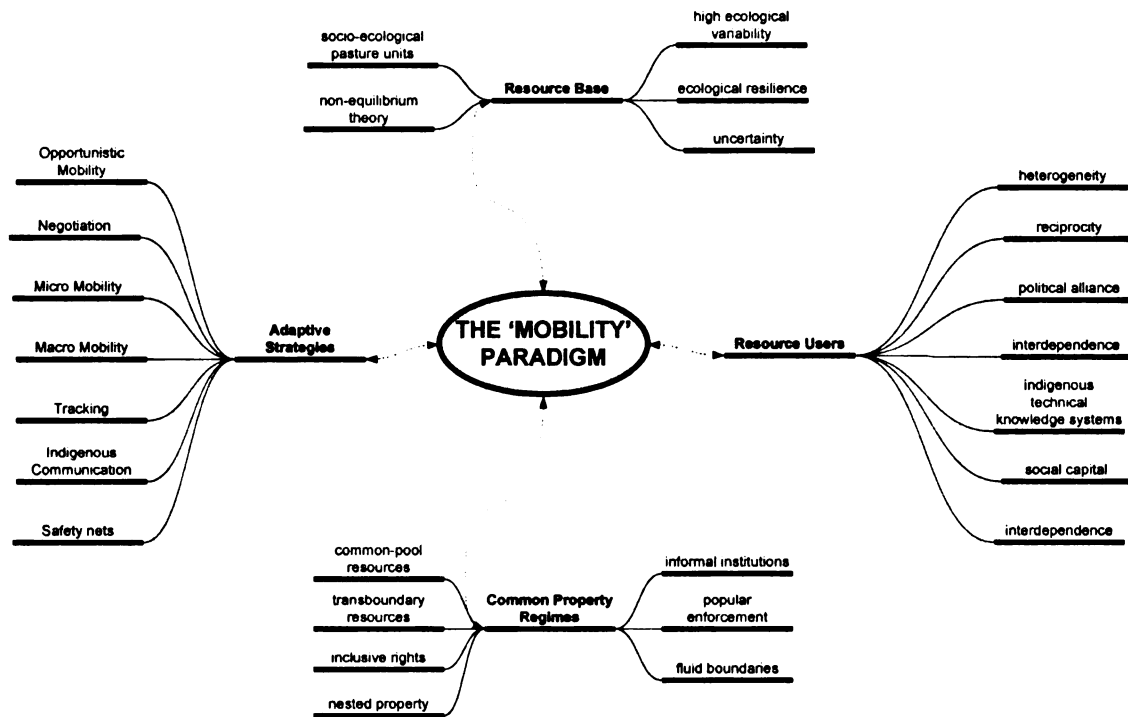
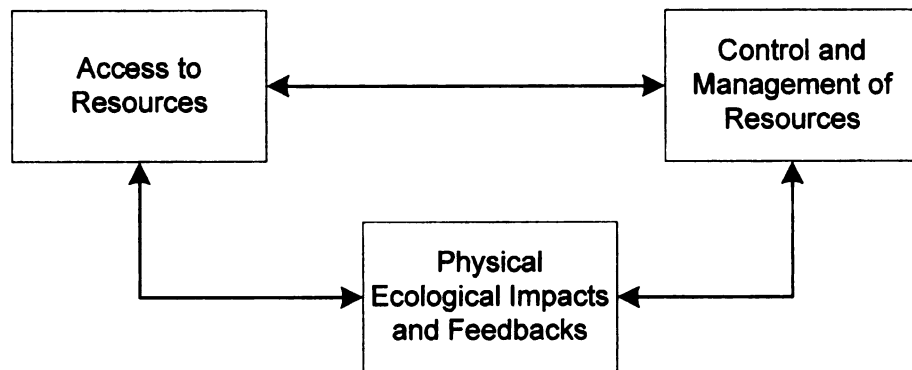


Figure 1.3: The Political Ecology of Pastoralism as articulated by Little (2003).



CHAPTER 2

History, Geography and Anthropology of the study site

2.0 Introduction

The case study site selected for this research is the Talek area adjacent to the Maasai Mara National Reserve (MMNR) in Southwestern Kenya encompassing an area of approximately 700 km²), where Maasai pastoralists live along the northern borders of the Reserve. The MMNR is located within the bounds of the larger Serengeti-Mara Ecosystem (SME), a 25,000 square kilometer land area considered to be East Africa's most biologically diverse area, straddling the Kenya and Tanzania border (Sinclair and Arcese 1995; Sinclair 1979, 1995). This study will concentrate on the park-adjacent Talek community, around the Talek park gate of the MMNR (Fig. 1.1).

In this chapter I discuss the physical geography of the landscape of the Mara, and outline landscape characteristics such as climate and weather patterns, vegetation and land cover, landforms, soils, livestock and wildlife distributions and densities. I also provide a discussion on the cultural geography of the Maasai pastoralists, noting the configuration of Maasai households, clans, age sets, groups and ceremonial practices, the subsistence economy of livestock and the contemporary political dimensions of Maasai livelihoods within the study area. The next section outlines an environmental history of the Maasai Mara and describes landscape history which had led to the current landscape. This context includes prehistoric settlements and landscape histories that are a product of fire, wildlife and livestock population dynamics and their associated grazing effects. The final two sections address the presence of formal institutions within the study area and a narrative is presented on the individual families that served as the focus units for the

cattle tracking and to help understand the political economy of grazing and herding practices. This chapter concludes by generalizing the social, cultural, political, economic and environmental attributes of the study area to larger landscapes where pastoralists' border protected areas in rangeland environments of Eastern Africa.

2.1 Physical Geography of the Mara

Climate and weather patterns: Precipitation is bi-modal, corresponding to a single long dry season between May and August/September and 'short' rains between October/November and January/February and 'long' rains between March and May (Lamprey and Reid 2004). Precipitation varies across the Mara region from an estimated 1,000 mm along the Isuria escarpment in the western part of the MMNR, to 600 mm in the eastern part (Lamprey and Reid 2004) and also varies between the north where rainfall is higher and southern parts of the MMNR (Brotten and Said 1995). Rainfall is highly discontinuous in the Mara and is loosely associated with the movement of the Inter-Tropical Convergence Zone (ITCZ) as it alternates north and south of the equator; the convergence of the easterly monsoons; and the Lake Victoria Convergence Zone (LVGZ) (Brotten and Said 1995; Norton-Griffiths, Herlocker, and Pennycuick 1975; Pennycuick and Norton-Griffiths 1976; Sinclair 1979). Rainfall is also driven by local variations in relief (orographic precipitation) and is particularly high along the Isuria Escarpment. Heavy rainfall events are short in duration and spatially isolated (Sinclair 1979). Aore (1988) notes that these events have only limited infiltration into the soil, especially after hot and dry periods where desiccation cracks occur, although these cracks help with infiltration.

Temperatures range from a minimum nighttime temperature of 10 degrees Celsius in July to a maximum of 20 degrees Celsius in January, while maximum daytime temperatures range from 20 degrees Celsius in July to 35 degrees Celsius in February. Rainfall is bi-modal with a short wet season between December and February, long wet season between March and May, and a dry season between June and September (Fig.2.1). The study site experienced a major drought during the study period which reached its extreme between mid January and mid-February 2006. This event is discussed in greater detail in Chapter 4 and 5.

The study area and the south of Kenya as a region have also recorded many other major droughts⁴. Over the last century, there have been at least 16 major droughts that have been formally recorded (IPCC 2001; FEWS 2006; DMCN 2006; Ojany and Ogendo 1981; Lamprey and Reid 2004). Over the last decade, the periodicity of drought has increased and climate change scenarios predict that this trend will continue over the next 50 years⁵ (IPCC 2001).

Vegetation and land cover: Vegetation around the MMNR is dominated by red oats grasses (*Themeda triandra*), thatch grass (*Hyparrhenia* spp.), sweet pitted grasses (*Bothriochloa insculpta*) and *Pennisetum* spp. interspersed with *Croton* (*Croton*

⁴ Over the last 100 years, droughts have occurred in the following years: 2006, 1999-2001, 1995, 1991-1992, 1988, 1981-1984, 1972-1974, 1965-1966, 1960-1961, 1952-1955, 1942-1944, 1939, 1933-1934, and 1928, 1914, and 1906. It is difficult to estimate the severity and impact of these droughts due to the poor records kept by district officials and these impacts may differ within Southern Kenya.

⁵ According to the IPCC Third Assessment Report (TAR), "... The direct impacts of changes (in Eastern Africa) in the frequency, quantity, and intensity of precipitation and water availability on domestic animals are uncertain. However, increased droughts could seriously impact the availability of food and water." (IPCC 2001)

dichogamus) thickets, Acacia⁶ woodland and riverine forests (Heady 1960; Pratt, Gwynne, and Blackie 1977; Lamprey and Reid 2004). The upland areas of the Ngama and the Emarti Hills are covered by Croton and Acacia thickets and predominantly have a *Themeda triandra* or *Aristida kelleri* understory. Vegetation dynamics are a complex product of rainfall, fire, livestock and wild herbivore grazing dynamics, bushland clearing schemes to eradicate tsetse flies. These interacting processes and their dynamics have been described in detail by Dublin (1995), Dublin, Sinclair and McGlade (1990), Waller (1990; 2004b), and Walpole, Nabaala and Matankory (2004). This discussion is described in greater detail of this chapter as part of the environmental history of the MMNR.

The highly seasonal trends in rainfall and temperature affect the concentration of nitrogen, phosphorous, potassium and calcium in the herb layers of vegetation within the MMNR and are discussed in greater detail in Boutton et al. (1988a; 1988b). The changing mineral compositions may reduce the availability of nutritionally adequate food during the dry seasons, which may in-turn affect the numbers and distributions of herbivore populations.

Land cover analysis conducted by the Kenya Rangeland Ecological Monitoring Unit (KREMU) undertook the first systematic land cover assessment of the Maasai Mara National Reserve and surrounding areas in 1976. The largest land cover classification category is 2,210 square kilometers of shrubland, followed by 1,802 square kilometers of dwarf shrubland (Tab. 2.1).

In 2002, the AFRICOVER project unveiled their land use and land cover assessment of Kenya. Their categories are in marked contrast to the categories used by

⁶ Common Acacia species found in the Mara include the wait-a-bit thorn (*Acacia brevispica*), whistling thorn (*A. drepanolobium*, *A. gerrardii*, *A. hockii*), yellow bark fever tree (*A. xanthophloea*) and *Acacia Commiphora* shrubs.

KREMU. Using the same spatial bounding area as the 1976 KREMU assessment, trees and shrub savanna compromise 2,747 square kilometers, followed by open low shrubs that account for 2,262 square kilometers (Tab. 2.2).

Landforms: The study area is relatively flat with undulating hills and piedmont slopes. Altitudes range from between 1,501 to 1,985 meters above sea level. There are two upland areas within the study site; the Emarti Hills to the north and the Ngama Hills to the Southeast. To the west of the study area is the Isuria Escarpment and the north lie the Bardamat Hills, where the village center of Aitong is located. The Emarti Hills are covered with dense acacia and croton bush land and heavily infested with tsetse flies (*Glossina spp.*). The Isuria Escarpment lies approximately 40 kilometers to the West of the Talek center and is a steep escarpment with approximately 800 meters of relief running north to south (approximately 80 kilometers long) between the Tanzania border and Emarti village. The Isuria escarpment also forms the western border of the MMNR. The area is dissected by numerous small streams, known locally as *luggas*, which stay dry through most of the year, or have small pools of water that are naturally dammed up. Between luggas are relatively large open plains areas. Within the study area, there are four main plains areas to the south of the Talek center and within the MMNR: the Olorukoti, Burungat, Mosee and Angata Posee plains. Large populations of resident ungulates are frequently found within these plains as well as several carnivore species along with migratory wildebeest and elephants.

There are two main perennial rivers, the Mara River and the Talek River; the latter flows east to west through the center of the study area. The Talek River is also a tributary of the larger Mara River where crocodiles and hippos are frequently found as

well as many wildlife species which are drawn to the river for water. During drought periods river levels fall along the Mara River but the river seldom dries up completely. The Talek River stops flowing but is naturally dammed at several locations in the study area. During these periods, water stagnates, concentrating human effluent from tourist lodges and camps (Fig. 2.2) and animal waste in the Talek River. Water quality becomes poor and increases the transmission of water borne diseases, the most common of which is typhoid. Tourism establishments draw fresh water⁷ from boreholes while the Maasai draw their water from luggas that have filled up with water from the rains, the Talek River or a borehole along the Talek River a few hundred meters from the Talek center.

Soils: Towards the east of Talek center and north of the MMNR, soils are of volcanic origin developed on biotite gneiss with a volcanic ash mixture and generally are of low fertility (Brotten and Said 1995). These soils are a dark brown to dark gray color and sandy-clay to clay composition that are seasonally waterlogged (commonly known as 'black cotton soils'). They are classified as Verto-eutric Planosols and Pellic Vertisols (Sombroek, Braun, and van der Pouw 1982). These soils are also rich in minerals such as calcium and magnesium (Brotten and Said 1995). Sheep and goats can be frequently seen eating these soils along the exposed banks of the Talek River (Fig. 2.3). There is a natural salt lick within the study site near the Ntiakitiak River and herders will direct their cattle to these areas on a regular basis.

⁷ Although the water from boreholes is clean relative to water flowing in the rivers, it very salty and must be boiled or treated before it is used for human consumption. Local health officials have commented that in spite of drawing water from boreholes; there are still many diseases that may be contracted from borehole water as the boreholes are located close to the edge of the river where the water table is low.

2.2 Animal Geography

Livestock: Livestock around the Maasai Mara National Reserve are comprised on cattle, sheep goats and to a much lesser extent, donkeys. The most dominant cattle species is the East Africa Zebu (*Bos taurus indicus*). Characteristics of the East African Zebu are, “a small and narrow head, a large dewlap, variable coat color, the horn and shape of horns also varies and the heterogeneous phenotypes reflect the continual traditional cattle raids and counter raids among adjacent pastoral groups”(DAGRIS 2006). Present day Maasai breeds are very heterogeneous because of the long history of cattle raiding among and between the Maasai and other ethnic groups that have similar herds such as the Kuria and Ndorobo (Maule 1990; Hodgson 2001; Rege and Tawah 1999). The average wither height⁸ of Zebu cattle is between 110 and 140 centimeters (cm). The average weight for Zebu cattle ranges from 275 to 445 kilograms (kg) (DAGRIS 2006). Cattle diet is broad but coarse grasses such as *Themeda spp.* and *Pennisetum spp.* are more palatable.

The most common sheep breed is the red Maasai fat tailed hair sheep and weighs approximately 40 kg and is 70 cm in height, while the most common breed of goats is the Maasai short eared and short horned goat, approximately 64 cm in height and weights around 40 kg (DAGRIS 2006). Sheep and goats (collectively called shoats by researchers) are *both grazers and browsers*, grazing on *Cynodon spp.* and *Digitaria spp.* grasses and browse on *Croton dichogamus* and *Grewia similes*.

Data from aerial surveys between 1980 and 2000 over the MMNR and the Koyake Group Ranch (north of the MMNR) reveals that cattle numbers within the study

⁸ Wither height is a measure of bone growth and frame size. Wither height is measured as the highest point on the cattle shoulder, immediately above the front legs to the ground.

area have fluctuated between 6,000 and 55,000 (Lamprey and Reid 2004). Researchers have assumed that fluctuations are a result of drought periods and large scale livestock movements (Brotten and Said 1995; Lamprey and Reid 2004; Ottichilo, Said et al. 2000). Lamprey and Reid (2004) estimate that 75% of the variation in wet-season cattle numbers can be explained by rainfall in the previous two years, though none of the variation can be explained in the dry season as there are on/off ranch movements mainly to neighboring Trans-Mara district where orographic precipitation is more reliable. Accounts of some of the historical livestock movements around the MMNR in the 1970's have been described in Lamprey's PhD thesis (1984).

A separate ground count of the MMNR and the KGR in 2002 suggests that there are approximately 31,683 cattle within the entire ecosystem (12,910 of which were found inside the MMNR) (Reid et al. 2003). Some of the earliest censuses of wildlife and livestock in and around the MMNR have always noted the presence of cattle inside the MMNR (Tab 2.3).

Data from an aerial count of the ecosystem between 1977 and 1997 suggest that there was a statistically significant decline in livestock numbers (defined here as cattle, sheep, goats and donkeys) between 1977 and 1988. This decline was attributed largely to the drought of 1983-1984. Between 1989 and 1997 livestock numbers remained stable (Ottichilo, De Leeuw et al. 2000).

Brotten and Said (1995: 178-179), using part of the same dataset⁹, document the actual numbers of cattle, sheep and goats from the aerial counts between November 1977

⁹ The data used from (Brotten and Said 1995; Ottichilo 1999; Ottichilo, De Leeuw, and Prins 2001; Ottichilo, Said et al. 2000) all originate from the Department of Remote Sensing and Resource Surveys (formerly known as the Kenya Rangeland Ecological Monitoring Unit (KREMU). Currently this institution is part of the National Environmental Management Authority (NEMA) of the Government of Kenya.

and April 1991 (Tab. 2.3). The authors of that study, which presents the most complete and reliable dataset on livestock numbers within the study area, suggests that variations in cattle numbers can be explained by "... fluctuations (that) match the variability of rainfall during primary productivity rather than indicating any long term decline" (Ottichilo, De Leeuw et al. 2000: 213). This statement appears to contradict studies which suggest that wildlife species are declining as a result of sedentarization and intensification of livestock production practices (Waithaka 2004; Boydston et al. 2003). These data coupled with studies by Reid et al. (2003) demonstrates that livestock have grazed inside the bounds of the Maasai Mara National Reserve, more or less continuously and with varying numbers, prior to the 1970's and continues today.

Wildlife: The Maasai Mara National Reserve forms the northern most extension of the greater Mara-Serengeti ecosystem and is considered, "one of the richest assemblages of wildlife in the world, and supports about 237 herbivores per square kilometer, making it one of the most productive natural terrestrial ecosystems." (Waithaka 2004; pg. 79). Wildebeest (*Connochaetes taurinus*) and lesser numbers of Thompsons gazelle (*Gazella thompsonii*) and zebra (*Equus burchelli*) migrate yearly (Fig.2.4) between the Serengeti National Park (SNP) in Tanzania to the MMNR and surrounding area every year between August and November, driven by rainfall and the availability of green biomass in the dry season (Sinclair and Arcese 1995). The migration pattern begins from the wetter grasslands in Tanzania's Serengeti National Park between January and June, moving to the western corridor inside the MMNR in Kenya where rainfall begins between June and August and then traverses the tall dry grasses back to the Serengeti National Park between August and November (Onyeanusi 1989). The main driving force

of the migration is rainfall and its associated effects on food supply through the dry season (Serneels and Lambin 2001a; Sinclair and Arcese 1995).

Between July and October each year, the Maasai Mara National Reserve is used heavily by migratory wildebeest following the rains (Steflox et al. 1986). In addition, there is a secondary wildebeest population that is resident around the northern boundary of the MMNR (known as the Loita plains), which numbers approximately 30,000. The Loita plains are used by the resident Mara wildebeest as the calving area. Wildebeest calving usually takes place between January and May each year for both the resident Mara population and the Serengeti migratory populations.

Wet season estimates of migratory wildebeest have increased from 220,000 in 1961 to over 1.3 million in 2001 (Serneels and Lambin 2001a; Talbot and Steward 1964). This increase is attributed to the disappearance of the rinderpest virus in ungulate populations of the Serengeti-Mara Ecosystem (Dobson 1995) and the yearly migration is considered one of the greatest wildlife spectacles on Earth, drawing hundreds of thousands of tourists to the Mara during this period (Waithaka 2004).

Wildlife¹⁰ populations within the MMNR have undergone significant changes over the last 20 years. Based on aerial systematic reconnaissance flights (SRF's) over the MMNR between 1977 and 1997 Ottichilo et al. (2000) report that there has been a 58% decline in the total number of non-migratory wildlife, a 70% decline in buffalo, giraffe,

¹⁰ The most common wild animals found in the Maasai Mara ecosystem include elephant (*Loxodonta africana*), black rhinoceros (*Diceros bicornis*), buffalo (*Syncerus cafer*), Burchell's zebra (*Equus burchelli*), giraffe (*Girafa camelopardalis*), wildebeest (*Connochaetes taurinus*), eland (*Taurotragus oryx*), topi (*Damaliscus korigum*), kongoni (*Alcelaphus buselaphus cokii*), waterbuck (*Kobus allipsiprymnus*), warthog (*Phacochoerus aethiopicus*), Thomson's gazelle (*Gazelle thomsonii*), Grant's gazelle (*Gazelle granti*), lion (*Panthera leo*), spotted hyena (*Crocuta crocuta*), the Nile crocodile (*Crocodylus niloticus*) and the hippopotamus (*Hippopotamus amphibious*).

eland and waterbuck, a 72% decline in topi and kongoni populations, and an 88% decline in warthogs. The authors of the study state,

“...in the case of wildlife, land use and vegetation changes, drought effects and poaching are considered to be among the potential factors that may have been responsible for the decline...but... *(the) data provide no evidence to support the hypothesis that the long term decline of wildlife was caused by droughts.*” (emphasis added) (Ottichilo, De Leeuw et al. 2000: 202)

Additionally,

“...while land use and vegetation changes (Dublin, Sinclair, and Mcglade 1990; Serneels and Lambin 2001a), land degradation and utilization have been studied and quantified, the link between these factors and wildlife population decline have not been studied. Hence, *there is no direct evidence that these changes caused the reported decline in animal populations.*” (emphasis added) (Ottichilo, De Leeuw et al. 2000: 211)

In spite of dramatic increases in migratory wildebeest¹¹ numbers, estimates of non-migratory wildebeest populations (resident Loita plains population) have decreased by 81% over the same twenty year period (Ottichilo, De Leeuw, and Prins 2001). The spatial extent of this decline is limited to areas north of the MMNR near the towns of Lemek (60 kms from Talek) and is attributed to the expansion of mechanized agriculture, particularly wheat cultivation (Homewood et al. 2001).

¹¹ “...The wildebeest is a flagship or keystone species in the Maasai Mara ecosystem because of its occurrence in large numbers and its annual migrations within and outside the ecosystem (Sinclair 1995; Talbot and Talbot 1963). Their migration generates, through their grazing activities, optimal conditions for other large mammals, a process generally referred to as facilitation (Bell 1970, 1971; Prins and Olff 1998). This facilitation can only be sustained through regular migrations between protected and dispersal areas” (Ottichilo, De Leeuw, and Prins 2001: 209). Given the importance of the role of wildebeest to ecosystem functioning and the importance the wildebeest migration plays in the attracting tourists, this species is crucial to the conservation and development of the entire system (both ecological and socio-political)

2.3 Cultural Geography of the Maasai

A study that examines the livestock herding strategies of pastoralists is centered on the pastoral livelihood systems, the people that comprise that livelihood system and the environments in which they live. This section highlights some of the important demographic, cultural, social, political and economic perspectives on the Maasai livelihood system as it relates to the political economy of herding and the indigenous knowledge of the environment. I discuss the configurations of Maasai socio-spatial spaces, clan, age set, groups and ceremonial practices of the Maasai in a historical and contemporary context.

Demographic change: Kenya has experienced high rates of demographic growth in the years following Independence. Between 1948 and 1962 Kenya's population grew from 5.4 million to 8.6 million. Following Independence in 1963 the population has grown rapidly from 10.9 million in 1969 to an estimated 29.4 million in 1999 (CBS 1964, 1970, 1981, 1994, 2001). Within Narok district this trend has also been noticeable. The population for the district was approximately 210,306 in 1979 and grew to approximately 555,417 in 2001, demonstrating a population growth rate of 6.26% (CBS 1994, 2001). The high rates of population growth are attributed to high fertility rates and the relative improvement of health care facilities within the district (Sindiga 1987a). Census data reveals that the youthful population (between the ages of 0-14) accounts for 57.3% of the district's total population in 1979 and 52.3% in 1989, and 52.4% in 2001 (Campbell and Migot-Adholla 1979; CBS 2001, 1994, 1981).

The Osupuko administrative division of the Narok district (which borders the MMNR) had an estimated 22,487 individuals in 1979. This number increased to 42,260 in 1989, 70,309 in 1997, 79,589 in 1999 and 90,178 in 2001. The population density has increased from 8 persons per sq. kilometer in 1989 to 17 persons per square kilometer in 2001 (CBS 2001, 1994). Although the Narok district is inhabited predominantly by the Maasai tribe, there are increasing numbers of non-Maasai immigrants into the district where cultivating communities have occupied the wetter parts of the district, such as the area around Mau-Narok (Thompson and Homewood 2002).

HIV/AIDS infection rates are high in pastoral districts where the Maasai reside (Valadez et al. 1999) and although there are no studies that have documented this within the study area, informal communication with medical health officials suggests that prevalence rates of HIV positive cases are between 20 to 30%.

The Maasai: The Maasai are livestock keeping pastoralists of Nilotic origin found between the borders of present day southern Kenya and northern Tanzania and historical extent spanned from the shores of Lake Victoria in the west, to the slopes of Mt. Kilimanjaro in the east (Fig. 2.5). Prior to colonialism, their geographic extent ranged more widely, especially to the north along the slopes of Mt. Kenya (Spear and Waller 1993). Today, there are approximately 360,000 Maasai pastoralists out of an estimated 1.6 million pastoralists in Kenya (Bekure et al. 1991). Maasai society is polygamous (Jacobs 1975) and recent research built on historical ethnographic analyses reveals that Maasai society, thought largely to be patriarchic, has distinct, valuable and powerful roles for women (Hodgson 2000; Hodgson 1999b, 1999c). Their diet was historically popularized as a mix between meat, milk and blood, and other livestock derived products

(Galvin 1992; Homewood 1992). Today, the Maasai diet is more diversified incorporating more carbohydrates (especially potatoes), rice, beans, ground maize meal (Swahili: Ugali) and spinach (Swahili: Sukuma wiki), which are the staple foods of Kenya (Arhem 1989; Brown 1993), while still maintaining high meat protein intake. Their economy is substantially based on livestock (cattle, sheep, goats, chickens and donkeys).

The Maasai have long been admired within and outside Kenya and as such have been used to represent the country at the international level. As described by Fratkin (1991):

“Few other African societies have been as romanticized and popularized by Europeans and Americans, while simultaneously neglected and underdeveloped, as the Maasai. Despite their image as ‘free and noble warriors,’ the Maasai have seen their grazing lands continuously reduced by colonial appropriation, the creation of national game parks, the steady incursions of agriculturalists, and most recently by the creation of private titles to individual ranches which are dividing the remaining land” (Fratkin 1991b: 112).

Historically, the Maasai were active in reciprocal cattle raiding practices. The motivations for cattle raiding are summarized by Fleisher (1999) as prestige, retaliation and revenge, looting, acquire or reacquire, and expand stock. Scholars have argued over the theoretical basis for raiding and assert that these discussions have;

“...generally focused on livestock raiding’s presumed human-ecological functions of redistribution and herd management (Sweet 1965a, 1965b; Vayda 1968: 86; Mair 1974; Lancaster 1981: 121-123, 139-145), the basic argument being that the “institutionalized” raiding of livestock serves to distribute livestock over a wide area, sustaining a general balance of pastoral economies through an extended region; circulating animals to where they are most needed in times of

famine or drought; functioning as “a continuously operating system of . . . exchange” (Sweet 1965b: 1146); and supporting “the whole network of social and ideological relations”(Sweet 1965b: 1149)” (Fleisher 1999: 746).

Maasai Socio-Spatial Scales of Organization: Maasai societal organization is divided into four broad socio-spatial scales (Fig. 2.6) that have been described in greatest detail by Bekure et al. (1991: 120-150) and expanded in Homewood and Rodgers (1991: 35-55), Spear and Waller (1993: 1-19) and Spencer (Spencer 1988: 18-55). These scales are (in ascending order): the household (Maa: *olmarei*) and sub-household (Maa: *enkaji*); boma¹² or agglomeration of households (Maa: *enkang*), neighborhood/locality (Maa: *enkutoto*), and section (Maa: *oloshon*).

The household is comprised of a married man and his wives (which range between one and twelve wives) and their associated unmarried and married children, and dependents. The household, as defined above, may encompass multiple individual dwelling units within the *enkang*. Characteristics of the household are: the the locus of cattle ownership; an autonomous decision making unit; the people attached to the household are highly mobile and flexible, occasionally splitting and moving elsewhere or joining other households (either to seeing better grazing and water access, or to buffer effects of droughts or maintaining food security within the household (Bekure et al. 1991). Additionally each household may be divided into sub-households (Thompson and Homewood 2002) called houses or huts (Maa: *enkaji*). The houses are traditionally constructed by women and girls from Olorkiridingai (*Croton dichogamus*) and Leleshwa (*Tarchonanthus camphoratus*) branches and leaves that are intertwined to form a mesh

¹² The term boma is the most widespread term for a dwelling unit and is often used interchangeably with *enkang*. Boma has its roots in Swahili and is the Swahili term for a Maasai household

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like netting around stronger Acacia support beams. Grasses and mud mixed with cow dung are used to thatch and cement the roof and walls. The houses are usually divided into two to three compartments for sleeping, as well as a hearth compartment for cooking, and pens for new-born calves (Fig. 2.7).

Many olmarei within an enclosure comprise an enkang or boma. Enkang are usually round in shape and structure (Fig. 2.8), and surrounded by both an internal and external thorn bush thicket where livestock are corralled to protect them against predation by wildlife. There are between 6 and 12 olmarei within an enkang, although recent research reveals that there is a trend towards olmarei with as few as two olmarei within the enkang (Thompson and Homewood 2002; Coast 2002). Characteristics of the enkang are: it is the joint unit for herding/watering and other livestock management and decision making strategies; it is a domestic self help unit and there is cooperation among and between each of the enkaji, especially with regard to food sharing (Bekure et al. 1991).

An agglomeration of enkang within a local area¹³ is known as a locality or enkutoto¹⁴. Characteristics of the enkutoto are: broader cooperation and information exchange between bomas; control and shared access of local grazing and water resources, and; it is often the core nucleus population for ceremonies and cultural practices as well as political discourse amongst elders and *laibons* (advisors).

The section or oloshon, of Maasai society is defined as “...territorial groups functioning as units in war, in allegiance to a particular religious leader and in performance of age-set and other ceremonies.” (Fosbrooke 1948: cited in Homewood and

¹³ The definition of local area is highly subjective. In this context local area would be used as the distance traversed within a short walk from the origin. Local area may also be delineated by micro watershed (i.e. the area between two streams).

¹⁴ *Enkutoto* are also known as *elatia*, depending on which part of Maasai districts you are in.

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Rodgers 1991: 44). The section is the largest spatial grazing unit that encompasses: broad ecological gradients, expanding the ecological resource base to allow for resource fluctuations; there is, theoretically, free access to all member of the section; it is the largest unit of traditional administration such as the setting the timing of cultural practices and asserting political affiliation, and; may be divided into sub-sections to encompass the variety of viewpoints. Additionally, “Maasai from one section do not graze their stock in another section’s territory unless exceptional drought or disease forces them to seek special permission to do so.” (Homewood and Rodgers 1991: 44). Within the study area, Maasai belong to the *Purko* section although they are *Laitaiyok*, *Kaputei* and *Loita* Maasai that travel north from the Tanzania and Westward from the Loita area during drought periods. Across both Kenya and Tanzania, there are approximately 15 different Maasai sections¹⁵ (Homewood and Rodgers 1991; Jacobs 1975).

Clans, Age Sets¹⁶ and Ceremonies¹⁷: Clan affiliation (olgilata) within Maasai society is passed on from father to son, where the son attains the clan of his father’s generation. Clans are not geographically bound and dispersed over different sections of the Maasai. The clan provides a, “network of influence and social obligation alternative to the section system” (Homewood and Rodgers 1991: 45). The role of the clan in maintaining livestock production strategies has been the subject of much debate amongst

¹⁵ Maasai sections encompass Ilpurko, Ilmatapato, Ilkeek-onyokie, Ildalat-le-kutuk (Ilkankere), Ildamat, Ilodo-kilani, Ilkisongo, Iloitokitoki, Iloitai, Isikirari, Isiria, Senenget, Ilmoitanik, Ilwuas-in-gishu (Uasin-Gishu), and Ilkaputiei.

¹⁶ It is important to note that the information I present here on clans and age sets are general notes and there are local variants of the details I describe.

¹⁷ For a more complete analysis of Maasai age sets and associated ceremonies, the reader is directed to Paul Spencers anthropological studies of the Maasai of Matapato (1988). For a more light hearted and easier account of Maasai society, the reader is directed to David Read’s semi autobiographical works (1979; 2000; 1982)

scholars (Homewood and Rodgers 1991; Spencer 2003, 1988; Fosbrooke 1948; Mol 1996). However, the consensus is that prior to the arrival of the British and the formation of the Maasai Reserves in 1904, Maasai clans would hold informal rights to grazing and water areas. There was an implicit assumption that although the clan would hold the rights over the use and control within the clan, they would not deny access to other Maasai clans, especially during times of environmental stress. Bekure et al. (1991: 31) suggests that:

“Cattle of clan-mates have the same basic branding (with each producer adding his unique identifier). Clan-mates have very strong mutual aid obligations. For example, if a man dies young with no brothers, his clan-mates are required to help raise his children and tend his cattle. If a Maasai becomes impoverished through drought or other misfortune, his clan-mates are bound to come to his aid. Clan-mates provide help in marriage (with negotiations, obtaining the necessary bride-price etc.); they are a locus of settlement of disputes (including death fines). When a producer needs wide support to solve any problem he will appeal to his clan mates. Thus, the clan has an important role in the wider political system. Although women are excluded from the age-set system, they have full recourse to their own clan-mates when in difficulty.” (31)

The male¹⁸ age sets¹⁹ of the Purko and other Maasai sections follow hierarchical age structures that divide a man’s life into a series of phases. Each individual is grouped amongst his peers and each group is separated by approximately 15 years²⁰ from herd boy to warriors to junior elders to senior elders (Homewood and Rodgers 1991: 49). The first age set is the *layiok* or uncircumcised youth age set. The literature on Maasai

¹⁸ Age sets are usually referred to men’s age sets. Women usually take on the age set of their husbands.

¹⁹ Within the study site, the following are a list of the age sets, beginning with the youngest first; Irratanya, Ilpetaa, Isalaash, Ilmeirishar, Ilkidotu, Iltuati, Ilnyankusi, Ilaimer, Iltalala, Iltuati, Iseuri average age is about 60 -65 years old, Ilnyankusi on average 75 to 90 years old, Iltareto over 100 years old.

²⁰ Fifteen years is an approximate time period. Depending on the clan and section, this may vary considerably.

anthropology (Homewood and Rodgers 1991; Spear and Waller 1993; Ole Saibull and Carr 1981; Spencer 1988, 2003) suggests that layiok are male children less than 15 years old and are considered to be under the care of their mothers and undertake the work of herding cattle (at the ages of between 10 and 15) and goats (children between the age of 4 and 10)²¹. However this characterization of children's activities is broad and discounts the varied activities (other than herding) that children engage in, such as trapping wild animals and birds, attending both primary school and informal nurseries, acting as messengers for elders, and assisting their mothers with household chores. At the age of 15, boys are initiated in the *enkipaata* ceremony, or pre-circumcision ceremony followed by the circumcision ceremony (*emuratare*), which applies to both men and women. Of particular interest to the livestock economy, initiates for circumcision must prove that they are suitable for the elevation from child to adult by herding large livestock over a long time (initiates herd cattle for seven consecutive days and undergo the ceremony on the eighth day), as well undertaking various livestock husbandry roles such as catching and injecting the cattle with trypanocides, mending broken limbs, and drawing blood from cattle for ceremonies.

The *ilmurran* or moran age set is attained between the ages 15 (at youngest) to 30 (at oldest) and are considered the physical guardians of Maasai society. The *ilmurran* are also known as the warriors in reference to their historical roles as guardians of the cattle, where they are called upon to defend the cattle against raiders to themselves perform the roles of cattle raiders (either to retrieve raided cattle or to increase their herd sizes through raiding other tribes cattle). Homewood and Rodgers (1991) suggest that, "murran spend much of their time traveling, visiting distant households, helping with herding and

²¹ Today, many children below the age of 15 are enrolled in primary schools.

feasting in the bush...(this is a form of) mobility (that) maintains a dynamic communications network” (Homewood and Rodgers 1991: 51). During moranhood, initiates move away from their household and live in warrior encampments, known as *emanyatta*. Throughout their murren period, age mates will slaughter domestic stock for food and live in relative isolation from the rest of the family.

At the end of moranhood, the Maasai celebrate the *eunoto* ceremony or warrior hair shaving ceremony. The stage marks the transition between junior and senior warrior hood (also known as junior elders). The senior warriors are now free to marry, and raise livestock of their own. After a period of another fifteen years, and after the man has married and raised children and livestock, he become part of the elders age set.

There are also ceremonies related to marriage and female circumcision, which had been declared illegal by the Government of Kenya, but these activities are still widespread throughout the study site. These ceremonies are organized over the course of several days. Honey and sugar are bought in large quantities to make beer and livestock are slaughtered to feed the many guests at the ceremony.

2.4 Environmental History of the Maasai Mara

The grassland landscape that covers much of the Maasai Mara National Reserve is the present day product of many shifts in vegetative cover over the last 150 years. These land cover changes as a result of changing human and elephant demography, fluctuations in the distribution of tsetse flies, and changes in the intensity and frequency of natural and anthropogenic fires. The following paragraphs describe how each of the agents affected

land cover at three different periods (pre 1850, 1850 to 1960, 1960 to 1980 and 1980 to present) (Tab. 2.4).

Prehistoric settlements and known land cover (pre 1850): Archaeological research around the Rift Valley of Southern Kenya has found at least 200 pre-historic settlement sites dating as far back as at least 2,000 years ago (Robertshaw 1995; Robertshaw and Brown 1990) around the Lemek Valley, 50 kilometers north of the Talek area. Surveys of prehistoric settlements patterns indicate settlement remains, notable charcoal concentrations from approximately 410 BC, pottery remains from 550 AD. This research uncovered, in part, a 2,000 year old pastoral settlement known as a Ngamuriak, which yielded data on the early spatial organization of pastoral homesteads (Robertshaw and Brown 1990). Little is known about the vegetative cover of the Maasai Mara prior to 1850, except that there were areas of heavy infestation of Tsetse fly along the thick riverine forests of the Mara River. Oral traditions of the Siria and Loita Maasai suggest that the Maasai were aware of the existence of this tsetse belt but did not document any problems with tsetse (Robertshaw and Brown 1990; Waller 1990, 2004a, 2004b).

From grassland to woodland (1850 to 1950): A survey of literature that documents the occurrence of tsetse fly in western Narok district that is inhabited by Maasai pastoralists suggests that towards the late nineteenth century, tsetse fly had infested small pockets of the district. These included the southern reaches of the Mara River, the Trans-Mara region, and southwards towards the border with Tanzania (Waller 2004b, 1990). By the early twentieth century most of what is today Narok district was covered by six different tsetse fly species²² (Lewis 1934 cited in Sindiga 1984). Of these six species *G. Pallidipes* is the most widespread throughout Kenya and the Narok District

²² *Glossina fuscipleuris*, *G. brevipalpis*, *G. longipennis*, *G. palpalis* *G. swynnertoni* and *G. pallidipes*

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(FAO 2002). The spread of tsetse flies from the downstream riverine areas of the Mara River were speculated to be a factor of the increased number of elephants that previously were hunted by the Ndorobo tribe (Sindiga 1984).

Although the spatial extent of tsetse fly expanded in the early 1900's there was not an epidemic of sleeping sickness, as an epidemic would involve changes in human and livestock ecology, soils, vegetation, and wildlife and the tsetse that infest on them. However, there is general consensus that there has been a significant increase in the amount of bushland and wooded savannas in the twentieth century from its original grassland state. The changes in land cover have been attributed to an ecological collapse when human and animal diseases spread through Maasailand in the 1890's (Sindiga 1987b). The rinderpest outbreak of 1891 resulted in the death of up to 90% of the cattle, buffalo, wildebeest and giraffe (Waller 1990; Wilson 1987). The loss of cattle herds led to famine amongst the Maasai that occupied the region resulting in high death rates. New diseases such as smallpox, brought by European colonialists in the early 20th century, exacerbated these losses.

The loss of large human and livestock populations resulted in land cover changes. The observed land cover changes were from savanna grasslands consisting of grasses such as red oat grasses (*Themeda triandra*), to wooded savannas and bushland such as Whistling thorn acacia (*Acacia drepanolobium*), which is suitable to harboring tsetse flies. The presence of certain wildlife species such as elephants, waterbucks, buffaloes and bushbucks are constant source of food for the tsetse fly (Wilson 1987; Sindiga 1984; Sinclair and Arcese 1995).

During the colonial period, the creation of the Northern and Southern Maasai Reserves in Kenya resulted in Maasai communities and their livestock being herded together in areas that the colonial administrators had drawn. “The general impact of this concentration of animals (and humans) in a comparatively smaller territory was overgrazing and the development of bush” (Sindiga 1987b: 186). The resulting land cover changes from grassland to bushland facilitated in the spread of tsetse.

Ford (1971 quoted in Waller 1990: 89-90) suggests a model to explain the slow spread of tsetse initially, followed by an increasing rapidity and intensity later on. Ford argued that,

“...the spread of tsetse came about as a result of contact between two previously separated ecosystems: bush-game-tsetse and cleared areas-domestic animals-(hu)man(s). Contact occurred when, as a result of drastic disruption and depopulation, previously occupied and cleared areas were abandoned and then reverted to bush land. This brought tsetse and its animal hosts in close contact with man and domestic animals, setting up a chain reaction which resulted in the progressive settlement and advance of bush clearing and re-settlement” (Waller 1990: 89-90).

These land cover changes have prompted overgrazing by livestock and wildlife in the plains areas, which was also reflected by the increases in the numbers of whistling thorn acacia trees (*Acacia drepanolobium*). As the Maasai tried to move their herding areas to higher slopes they converted the land cover to bush land. This bush land formed a suitable habitat for harboring tsetse flies and sleeping sickness (Sindiga 1984; Waller 2004b, 1990) The movement of Maasai livestock during this period and consequently the spread of tsetse is also a factor of the loss of land due to the creation of the MMNR.

From woodland to grassland (1950 to 1960): Dublin (1995) suggests that it was the colonial administrator's failure to recognize the dynamic state of the MMNR that led to an extreme reaction by scientists and conservationists when the woodlands began to decline in the 1950's. During this period, there was an increase in the number of anthropogenic fires set by: (1) the Maasai herders to improve grazing pastures by eliminating ticks and to eliminate bushland which harbored tsetse fly that transmitted sleeping sickness; (2) the Ndorobo hunter gatherers who started fires to collect honey; (3) park authorities conducting fire management activities to alter the available biomass and attract migratory wild animals that attracted tourists to the area, and; (4) European hunters.

Additionally, human and livestock populations began to increase substantially following their recovery from the rinderpest epidemic and resulted in the movement of elephants from forested areas outside the present day boundaries of the reserve to grasslands as this is where human and livestock populations began to grow rapidly. Dublin (1995) reports that the highest rates of land cover change were between 1961 and 1967 and continued up to the 1980's, where land cover changes from Acacia woodlands and Croton thickets to grassland areas. The frequency of fires was as high as three times a year, although there is little research that documents the spatial extent of these fires (Dublin, Sinclair, and Mcglade 1990).

Stable state grasslands (1960 to 1980): Between 1960 and 1980, the greater Serengeti-Mara ecosystem experienced some of the greatest changes. In 1961, the first wildebeest migration was recorded as wildebeest numbers recovered greatly from the rinderpest epidemic. Their numbers rose from a little over 200,000 to 1.2 million. Each

year, between July and October, which roughly corresponds to the start of the dry season; they migrate northwards from the Serengeti consuming any available biomass (Onyeausi 1989). Between 1960 and 1980, elephant numbers declined significantly because of high rates of poaching in the Serengeti National Park, reducing their numbers by 81%. The remaining elephants sought refuge within the MMNR because of the anti-poaching activities and high tourist traffic. Elephant habitat choice is limited to woodland areas where they find shade and forage on woody species such as Croton thickets (Dublin 1995; Dublin, Sinclair, and Mcglade 1990). These has resulted in a decline in the existing patches of woodland areas within the MMNR and they occasionally travel north to the woodland area immediately north of Talek along the Emarti hills or along the Isuria escarpment to the west of the study site.

Grassland to agriculture (1980 to Present): Recent research has revealed rapid land cover changes taking place 50-70 kilometers north of the MMNR, from natural savanna vegetation types to commercial scale wheat production (Serneels and Lambin 2001a, 2001b; Serneels, Said, and Lambin 2001). This research also indicates decreases in vegetative cover closer to the MMNR, around the Talek area. Scientists have identified the drivers of these changes as agricultural policy, increased private land tenure and market opportunities for mechanized agriculture (Homewood et al. 2001). The critical question derived from these analyses is, why there is also decreased vegetated cover around the Talek area, given that the drivers identified for the changes in areas further away from the MMNR do not reflect the current trends in the Talek area as there is a complete absence of subsistence cultivation of any type. To date, researchers have not suggested any possible drivers for the vegetation changes closer to the Reserve boundary,

other than speculating that these changes are attributed to the increase in human and livestock populations. Additionally, “It remains to be investigated whether the changes in land cover have had a measurable impact on the spatial distribution of livestock and wildlife, or have influenced total numbers of animal species through time” (Serneels, Said, and Lambin 2001: 3417).

2.5 Institutions within the Study Site: Formation, Identity and Operation

The study area, much like many other pastoral areas around large protected areas in East Africa, is a cultural landscape that has undergone numerous changes in its physical and socio-cultural character, especially within the last 50 years. Perhaps the greatest single change to occur within this landscape is the formation and continuation of formal institutions that claim management over the landscape.

Protected Area Institutions: In 1948 the British Colonial Administration established the Maasai Mara National Game Reserve as part of the Royal National Parks of Kenya. The Game Reserve was managed by the Game Department, although it was under the jurisdiction of National Parks Department. The area carved out in 1948 was an estimated 520 sq. kilometers (200 sq. miles) and encompassed the land between the Isuria Escarpment to the east, the Tanzania border to the south and the Mara River to the north. Safari hunting was prohibited in this area and limited safari camping was allowed.

In 1961, the control of the Reserve was brought under the control of the Narok County Council (NCC), a local government administration system, and the borders of the Reserve were extended east of the river to encompass an area of approximately 1,813 sq. kilometers (700 sq. miles). Under the rules of establishment of the National Reserve there

was to be no grazing by livestock or “human use other than development of appropriate facilities for tourists” (Talbot and Olindo 1990: 69).

The formal creation of the MMNR in 1961 was aimed at conserving the rich biodiversity found within the Mara-Serengeti Ecosystem and generating revenue from the proceeds of tourism related activities. The income from the proceeds of tourism related activities within Kenya, over the past 20 years have accounted for between half and one-quarter of Kenya’s GDP’s and attracts over 1 million tourists every year. Within the national context the MMNR accounted for as many as 180,000 visitors annually in 1990 to 133,000 in 1995 making the Reserve one of Kenya’s most frequented protected conservation areas (GoK 2001, Akama 1999). In 1984, three excisions of the Reserve were made along rivers so that the Maasai and their livestock could have access to the water. The new area for the Reserve was to be reduced to approximately 1,510 sq. kilometers (600 sq. miles) (Wilson 1987).

Protected areas in Kenya are today either managed through local government authorities or by the national government, through the Kenya Wildlife Service (KWS), a parastatal corporation headquartered in Nairobi. KWS is the only government mandated institution to oversee the protection and conservation of flora and fauna in the country.

The MMNR is not managed by the national government, but by a Maasai dominated local government authority, the Narok County Council (NCC) (Talbot and Olindo 1990). Lying immediately north of the MMNR is the Koyake Group Ranch (KGR). The KGR is one of a number of group ranches that are a product of the ‘Land Group Representatives (Ranches) Act’ of 1968. This legislation enabled rangelands, previously held as trust land by the leadership of a local district council, to be demarcated

into several communally owned group ranches (Galaty 1981b; Galaty 1992; Rutten 1992).

Communal Land Tenure Institutions: Group ranches were initiated in 1968 under the Kenya Livestock Development Program (KLDP) (Ayuko 1981). They are parcels of land, jointly owned by between 30 and 900 men as heads of families, and managed by an elected committee. The members hold a freehold title deed and herd their livestock collectively, but own them individually. All male individuals who were over the age of 18 years at the time of inception were registered as members of various group ranches. Some of the aims of the Kenyan Government in setting up group ranches were to:

1. Provide legal title to areas that the Maasai had historically used over centuries;
2. Increase the contribution of the Maasai peoples to the national economy through the commercialization of livestock production in the pastoral areas which was mainly subsistence, thus improving the earning capacity of pastoralists;
3. Reduce the stocking rates and, therefore, land degradation in the pastoral areas;
4. Guard against landlessness among pastoralists, as a result of haphazard allocation of grazing land to some people, and the risk of the majority receiving individual ranches too small to be viable.

Galaty (1992) suggests that Maasai did not have a clear understanding of all the consequences of group ranching and accepted group ranches in order to secure exclusive rights to grazing land, minimize encroachment by other people, and avoid the risk of losing more land to parks and game reserves. Generally, group ranches failed because of inherent difficulties within the group ranch concept, related to the prevalent climatic conditions in Kajiado and the disparity between the Government's and the Maasai's

objectives in keeping livestock. The Government's and Maasai objectives of keeping livestock were different. While the Maasai kept livestock for sedentary purposes (although this statement should not detract from the centrality of cattle in Maasai culture, ethnicity and identity) there was some commercial trade as well as barter (particularly in the very arid districts of northern Kenya and parts of southern Kenya. The government on the other hand expected the group ranches to produce beef commercially, with fewer animals, higher output per head of cattle and higher beef quality. The intrinsic attachments of cattle to the Maasai (Mol 1996; Saitoti and Beckwith 1980; Salvadori and Fedders 1973; Sankan 1971; Sassi 1979; Spencer 1988; Spear and Waller 1993; Galaty 1998; Galaty 1983; Hodgson 2001; Hodgson 1999a; Galaty 1989; Sindiga 1992; Brown 1993; Arhem 1989; Ole Saibull and Carr 1981; Chieni and Spencer 1993), was part of the reason that the Maasai were resistant toward commercialization. This resistance did not play favorably to the government's aim of commercializing traditional management of livestock (Kituyi 1985, 1990).

Other Institutions: Other institutions within the study area are local, national and international tourist enterprises. These tourist enterprises may be divided into two: (1) tour operators – who are responsible for ferrying tourists in vehicles or light aircraft to and from the Maasai Mara and take them on game drives inside the MMNR and; (2) tourist hosting institutions such as campsites and lodges. These range from low to high cost operations with bed night costs ranging from \$5 a night at campsites to well over \$1,000 a night at private exclusive luxury lodges. Their ownership and operation varies, with some local campsites managed by Maasai from within the study site, to large international conglomerates operating the larger lodges and luxury campsites.

Within the study area, well as local shops, bars, cafés and general merchandise stores that are owned and operated by elite Maasai and immigrant tribes such as the Kikuyu. There is a weekly vegetable market on Thursday in Talek and on Friday in Aitong (25 kilometers to the north), where livestock and other products are sold and traded. The market vendors usually move between the different centers located at the gated entrances to the MMNR, including Mara Rianda, Sekenani, Olaimutia and Talek.

Only a few hundred meters from the Talek center is the Talek Primary School. The school serves approximately 500 students between years 1 and 8 and aside from its educational missions, it also serves as the nucleus for political activities such as fund raising activities, political visits by members of parliament and government ministers, voting centers for the general elections and referendums. Neighboring the school is the area office for the Friends of Conservation (FOC) – a conservation management non-governmental organization with headquarters in Nairobi, London and Oak Brook, Illinois. FOC engages in a number of proactive conservation and community management activities to assist in the conservation of the Mara ecosystem. Current activities of the organization include a Maasai beadwork project conducted in cooperation with Basecamp explorer, an eco-tourism camp located close to FOC's Talek office. There are also agro-forestry projects and tree nurseries, community game scouts training exercises and an alternative fuel wood project. Many other international and national conservation organizations have some kind of presence in and around the MMNR. The Frankfurt Zoological Society (FZS) funds and operates a project aimed at surveillance and protection of Rhinos, while the World Wildlife Fund through the East Africa Regional Programme Office has an on-going project on the Mara River Basin

Management Initiative. Over the last 30 years the World Bank, the International Fund for Animal Welfare (IFAW), the Born Free Foundation, the African Conservation Center, the African Conservation Fund, the International Livestock Research Institute, the U.S. Fish and Wildlife Service, and various country offices of the World Wildlife Fund have all had some strategic or practical projects within the MMNR.

Institutional conflicts: Within the last few years there have been increasing antagonisms between group ranch officials, MMNR park authorities (the Narok County Council) and private tour operators over wildlife viewing fees gathered from tourists. Group ranch officials are upset over the Minister for Local Governments' directive that park authorities extract additional fees for tourist movements within group ranches. This has prompted ethnic Maasai Government Ministers to step in and assert that the payment be made directly to the group ranches and disbursed to local Maasai (Kemei 2005a, 2005b).

Historically there have also been antagonisms between the Narok County Council and the Kenya Wildlife Service over the management of the MMNR (Leakey and Morell 2001). Though little has been written about this antagonism because of the obviously political implications of local versus national government control, Leakey suggests that a large part of the antagonism is because of corruption²³ and mismanagement on the part of the Narok County Council. Given that park entrance fees have ranged from \$20 per tourist per day in the 1980's to \$40 today and the number of tourists visiting the MMNR range from between two hundred and three hundred thousand tourists a year, this is a large sum of money. During his tenure at Director of the Kenya Wildlife Service, Richard

²³ It should be noted that there has never been any evidence to suggest the extent of corruption or to identify specific individuals who were responsible for the mismanagement of funds.

Leakey sought to wrest control of the MMNR from the Narok County Council (Leakey and Morell 2001: 160, 209, 235-236, 272-273). This move ended without success but resulted in widening divisions between the County Council and the KWS – a division that is still evident today. Although the KWS has no active engagement in the management of the Mara, there is a KWS-run research facility in the park. Through the research station and the division of Ecological Monitoring at the KWS headquarters in Nairobi, there have been numerous baseline data collection activities such as aerial counts of key wildlife species and vegetation sampling activities.

2.6 Households, Families and Socio-Environmental Spaces

As mentioned previously, ten representative households were selected for the study. These families and households also served as the key focus units from which an understanding of the Maasai political economy of grazing and herding practices was understood. While each of the families histories demonstrate a number of different processes that brought them to the Talek area and that have shaped how they graze their livestock and interact with the protected area, these unique narratives are also representative of the other families within the study site, many of whom are related to each other. In the following paragraphs, I give a brief summary of three representative families that are composites of many different families. I describe their human and livestock composition, reasons for moving/settling in the study area, and their participation within formal and informal institutions. The names used here are synonymous common Maasai names and are used in place of those of the actual respondents. However, the information presented about the families is true and where

necessary, I have omitted any specific characteristics that may identify individuals or particular families²⁴.

Ole Saiyalel: The Saiyalel family is amongst the oldest and most respected families in the Talek area. Shura Ole Saiyalel moved to the Talek area in 1976 in search of greener pastures for his family's livestock during the last great drought. Prior to moving to Talek, Shura had never lived in one place for longer than 4 years and practiced nomadic pastoralism in the traditional sense – always moving with his family's livestock as a result of drought, flooding or outbreaks of disease. He is approximately 60 years old and has been widowed twice. His first wife died from cancer while his second wife succumbed to malaria. His present wife has just given birth to his sixth child, who has chronic chest problems. Shura is considered the head of the household, both for his nuclear family, but also for his larger extended family, including the children of his brothers and their wives. He is also responsible for two young boys who have been sent by their parents (friends of Shura) to the Talek area for primary school education. Combined the family owns 150 head of cattle and 200 sheep. Ownership is split unevenly between different members of the family, including his nephew, a driver with a local luxury tented camp, who owns the largest share including the two breeding bulls in the herd. Two of his nephews are the two Maasai from the local area to pursue higher education and he insists that all the children under his care attend educational institutions at whatever level. During periods of drought when milk yields are low, his oldest nephew uses the money (through tips) that he earns from chauffeuring western tourists on game drives to purchase packaged milk and maize meal for the children as well as purchasing

²⁴ Human Subject Research Protection for this research was filed by the Michigan State University Social Institutional Review Board (SIRB) # 05-533 on July 20, 2005 and subsequently renewed on July 14, 2006 and June 14, 2007.

veterinary drugs from shops in the Talek center. Herding is divided between a hired herder who is paid 2,000 Kenya shillings (approximately US\$30) to herd four days a week and the two young boys who have been sent by their parents to attend the Talek primary school.

Ole Nkiok: The Nkiok family, much like the Saiyalel family is also among the first families to settle in the Talek area. He moved to Talek in 1973 and prior to that worked formally as ranger with the county council between 1960 and 1970. He remembers shooting two rhino hunting poachers dead with his bow and arrows. Papet Ole Nkiok is now 72 years old and has three concurrent wives and eight children. His first wife is as old as he is and sells curios to tourists at the Talek park gate entrance hawking wares through the windows of tour vans, while his second wife lives at one of the lodges inside the park, where she runs a canteen for the tour drivers. His youngest wife lives at the boma and cares for the youngest children and cooks his meals. He has eight sons and 4 daughters from his three wives. Two of his older sons work at a tourist hotel in Naivasha near Nairobi. He currently has a little over a hundred cattle from a peak of 450 cattle that he had in the late 1970's. In the 1980's he lost half his herd to cattle raiders (ilmutendes) from Tanzania. Presently his favorite son herds the cattle during the weekdays, while his two other younger sons herd cattle on the weekends. He has very little supplemental income to provide fees for one of his sons who attends a secondary boarding school in Narok town. He attains most of his income from a small allotment of shares he has on land that houses a luxury lodge near the park.

Ole Silantoi: Unlike the previous two heads of households, Ole Silantoi is much younger. He was born in the early 1960's inside the MMNR at one of the tourist lodges.

He is the oldest son of the elder Ole Silantoi who was considered a Laibon (advisor) to the Maasai and was of the Ilnyankusi age set when he died. Ole Silantoi lives in one of the few brick houses with corrugated iron sheet roofs. He has built a large concrete water holding tank which holds rainfall runoff from the concrete structures. He also has a pick-up truck that he uses to transport live cattle to a lodge inside the MMNR where he has a contract to supply meat for the lodge staff. He has six nephews that undertake the herding of the almost 400 cattle and 400 sheep that he and his family own. Not all of his cattle are in one place and most of the stronger cattle were moved to Oldoinyo erinka, 40 kilometers north. His wife, mother-in law and two of his sister's work at home making traditional Maasai ornaments as part of a project organized by an eco-tourism lodge that sells these products to tourists, returning 70% of the value of the items sold to the women. Every morning his daughter and his niece walk the 5 kilometers to Talek center to sell the milk from the cows that they milked early in the morning and return with the household goods that they might need for the next few days, such as tea leaves, sugar, and vegetables. Ole Silantoi's truck makes him highly mobile and he travels frequently to other centers around the MMNR and Aitong to check the market prices for livestock and accordingly plans how much and what type of livestock he intends to either buy or sell in that month.

2.7 Generalizing the Study Area to Larger Pastoral and Protected Spaces

The selection of study site for this research is based on its unique characteristics as well as practical reasons. The MMNR was selected because it is *unlike the majority of protected areas in Kenya*. The MMNR is managed as a National Reserve by the Maasai

(through the local government authority, the Narok County Council) and not by the national government which manages National Parks. Relationships between Maasai pastoralists and the state in the study area can be viewed in two general ways. First, local Maasai see the MMNR as a state institution managed by the Narok County Council and comprised of park officials, elected officers and wildlife rangers. Second, the state has viewed Maasai as its constituents, responsible for their well-being. Thompson and Homewood (2002) and Talbot and Olindo (1990) describe how this responsibility was vested through the sharing of wildlife viewing fees in order to foster infrastructure development. This has yet to be fully realized because of the growing influences of entrepreneurs, local and government elites who control money flows to local Maasai (Thompson and Homewood 2002).

The Talek area can also be considered as *broadly representative* of other Maasai communities at the periphery of the MMNR, because they too are bordered by the park on one side and group ranches on the other. They maintain their primary focus on livestock production and periodically have antagonistic relationships with park authorities. Incidences of conflict between herders and the state across rangeland areas of Kenya are also very common, as reported by the national press and observed locally during the study period. Although the MMNR is unique in that it is a National Reserve, the findings of this study is *placed into the context* of historical and on-going research that examines conflicts between herders and state managed protected in other Maasai dominated areas of East Africa such as the Amboseli basin in Kenya (Western 1982, 1997), the Serengeti National Park (Neumann 1998, 2001, 2004b), and the Ngorongoro Conservation Area in Tanzania (Homewood and Rodgers 1991, 1987).

The Talek area of the northern MMNR was also selected because of my history of active research within the Talek area. This enabled me to ‘dwell’ in the same study site during the pre-dissertation fieldwork at various time periods between 2001 and 2004 and during the dissertation research period between August 2005 to August 2006 (Ingold 1987, 2000). This enabled me to gain close personal relationships with herders in order to understand the various social and ecological processes that influence herding strategies.

Figure 2.1: Monthly total precipitation. The gray bars represent the long term average total precipitation for the Narok meteorological station, while the black bars represent the actual recorded precipitation in the study area recorded at Hyena Research Camp – these data are from September to December 2005 and January to August 2006 (the duration of the study period). Total precipitation is significantly lower than the long term mean between November 2005 and January 2006 as a result of the failure of the short rains and resulted in drought

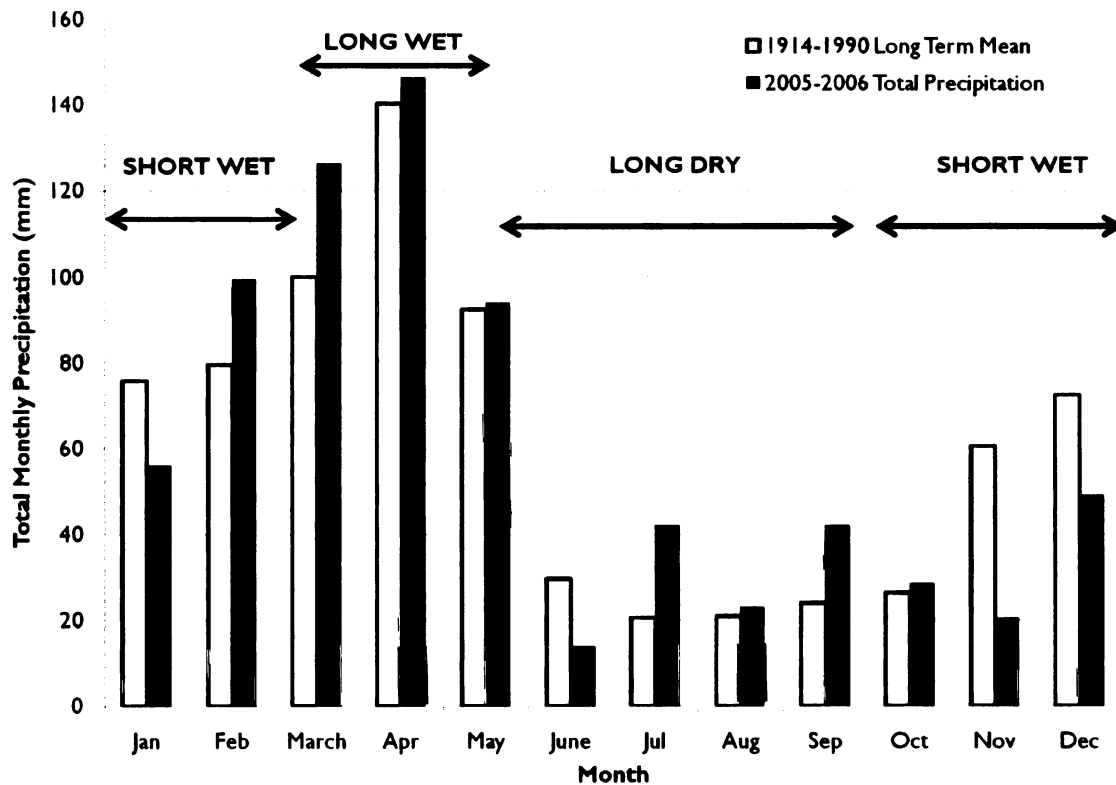


Figure 2.2: A Tourism establishment, with its relatively large infrastructure along the banks of the Talek River (Photo by author).



Figure 2.3: Exposed river bank along the Talek River. Sheep and goats can commonly be found in this area eating the calcium rich soils (Photo by author).



Figure 2.4: Mass migration of hundreds of thousands of wildebeest and zebra from the Serengeti National Park, Tanzania, to the Maasai Mara National Reserve, Kenya in August 2006 (Photo by author).



Figure 2.6: Maasai socio-spatial scales of organization (a schema) (Source: Bekure et al 1991: 21)

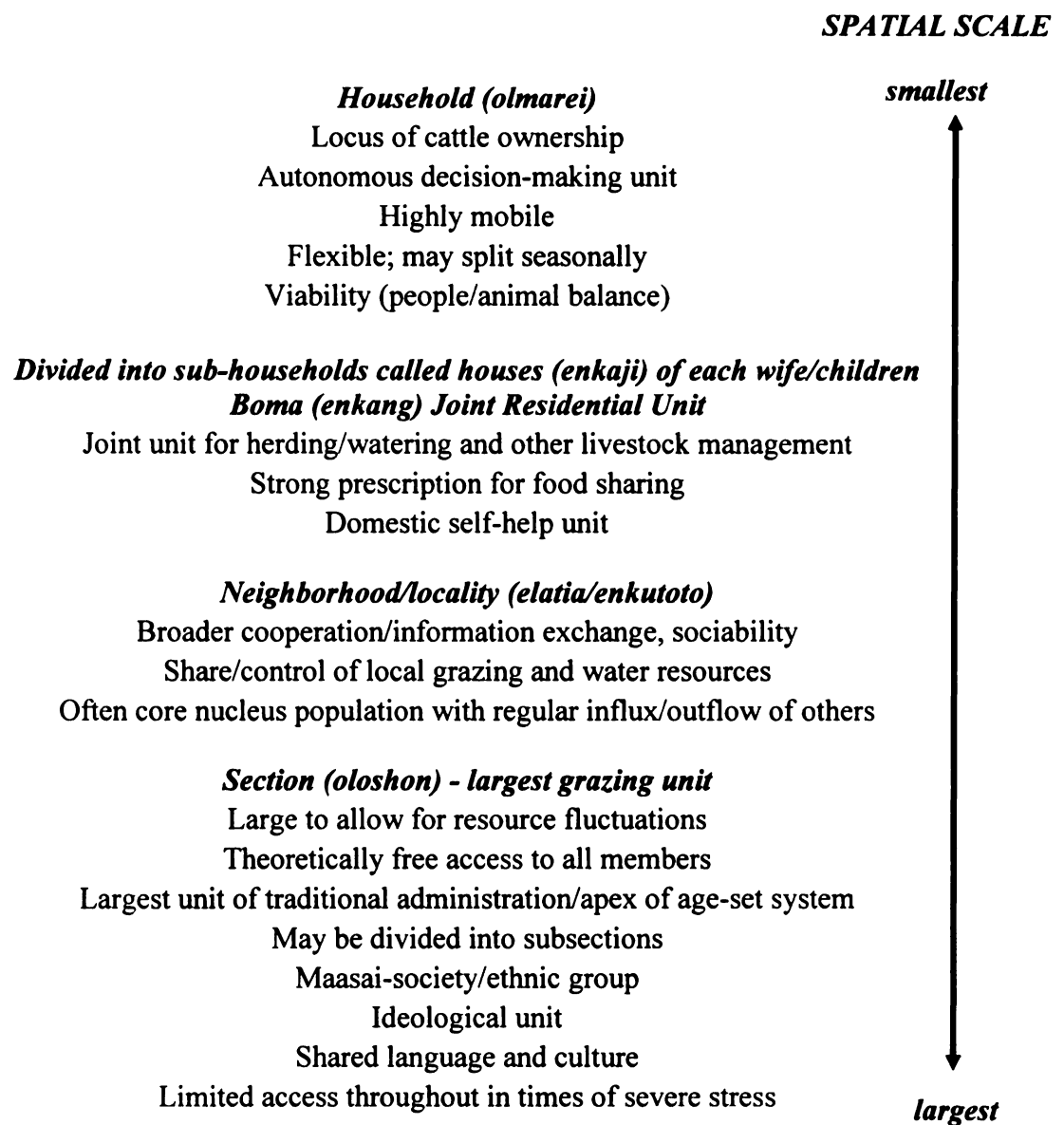


Figure 2.7: Variation in the layout of Maasai huts. Source: Spencer (2003: 44; 1988: 12)

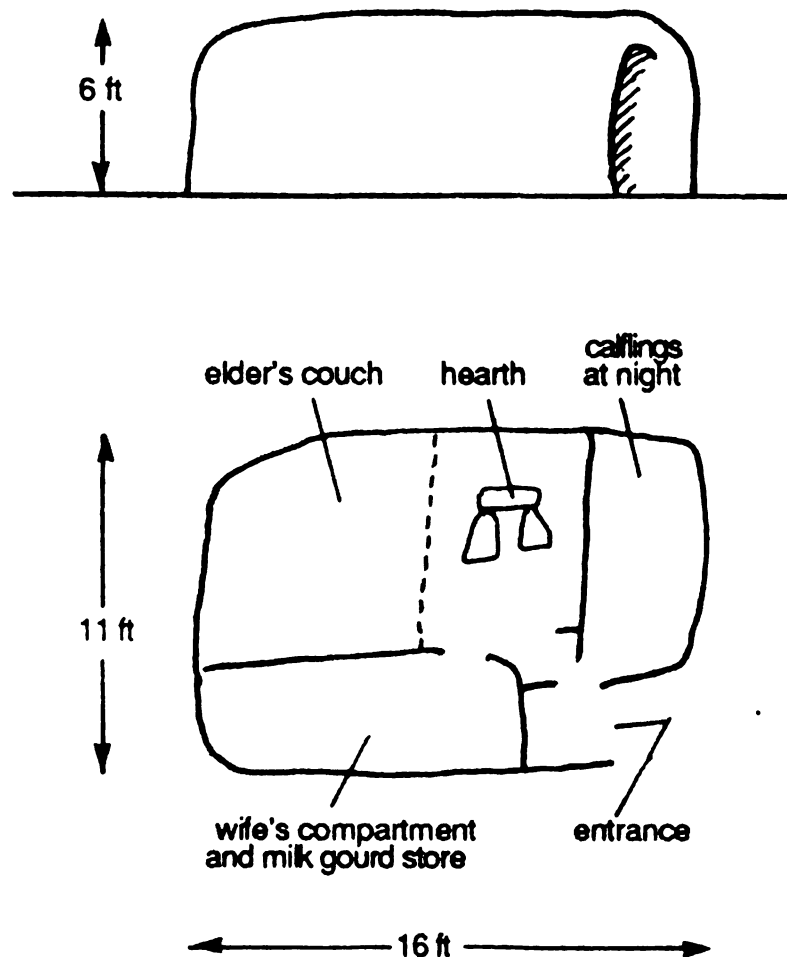


Figure 2.8: Diagrammatic representation of a typical Maasai boma. Source: Homewood and Rodgers (1991: 36)

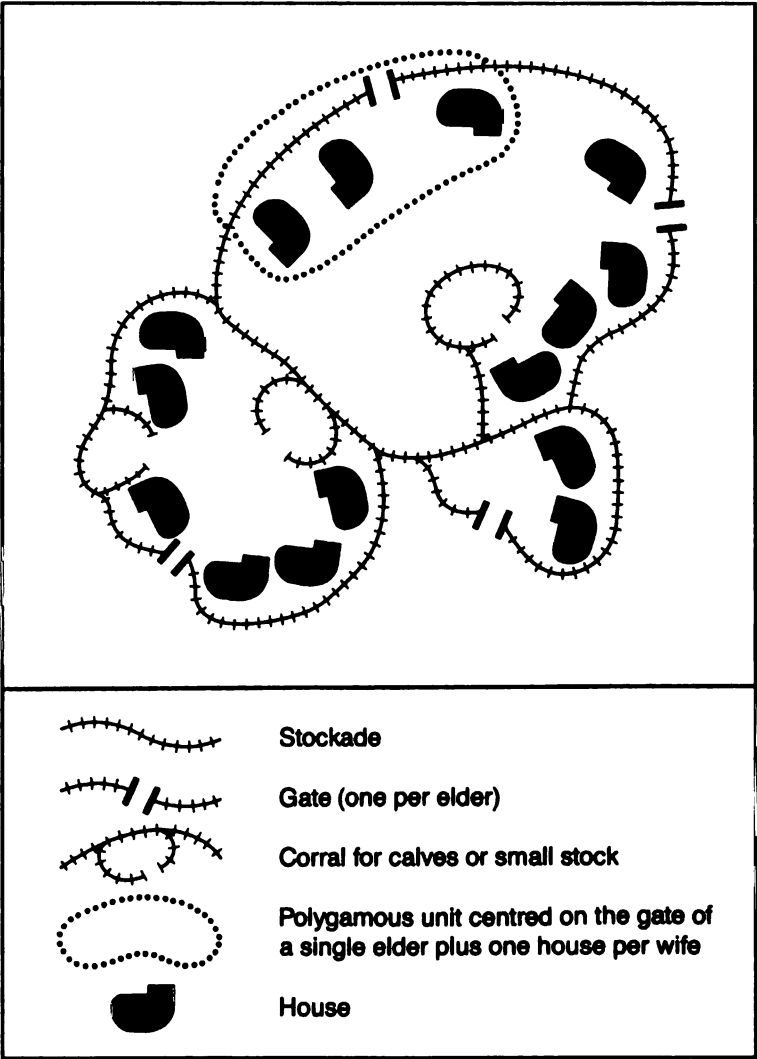


Table 2.1: Land cover categories and occupied area in 1976. Source: KREMU 1976

Land Cover Type	Area (sq. kms)	Hectares
Shrubland	2,210.66	221,066.47
Dwarf shrub grassland	1,802.22	180,221.63
Shrubby grassland\shrubland	975.82	97,581.69
Shrubby grassland	878.97	87,897.47
Grassland	679.99	67,998.61
Wooded grassland	337.25	33,724.80
Thicket shrubland	315.1	31,509.68
Shrubby riverine	238.86	23,885.55
Wooded riverine	162.17	16,216.57
Dwarf shrubland	113.34	11,334.02
Woodland	106.27	10,626.69
Grassy shrubland	19.97	1,996.84
Bushy grassland	3.14	313.77

Table 2.2: Land cover categories and occupied area for 2002: Source Africover 2002

LC ID	Land Cover	Area (sq. kms)	Hectares
RL-3	Trees and shrubs savannah	2,747.05	274,704.74
FR-8	Open low shrubs (65-40% crown cover)	2,262.93	226,293.17
FR-7	Open shrubs (45-40% crown cover)	860.32	86,032.22
FR-5	Closed to open woody vegetation (thicket)	583.25	58,324.95
AG-1	Rainfed herbaceous crop	484.02	48,401.67
FR-4	Very open trees (40-15% crown cover)	174.96	17,495.57
RL-2	Shrub savannah	169.12	16,911.66
AG-1C	Isolated (in natural vegetation or other)		
	Rainfed herbaceous crop		
	(field density 10-20% polygon area)	158.97	15,897.19
AG-1B	Scattered (in natural vegetation or other)		
	Rainfed herbaceous crop		
	(field density 20-40% of polygon area)	83.01	8,300.78
FR-3	Open trees (65-40% crown cover)	80.55	8,054.98
FR-6	Closed shrubs	56.35	5,635.34
RL-1	Open to closed herbaceous vegetation	40.08	4,008.36
RL-5	Open to closed herbaceous vegetation	38.35	3,835.03
	on temporarily flooded		
FR-2	Closed trees	28.11	2,811.12
FR-9	Closed trees on temporarily flooded land	21.32	2,132.07
RL-4	Sparse shrubs	13.63	1,362.54
UR	Urban and associated areas, rural settlements	1.62	162.43

Table 2.3: Livestock population numbers for inside and outside the MMNR: Source Broten and Said 1995

Year (Month)	CATTLE		SHEEP AND GOATS	
	Mara	Group Ranches	Mara	Group Ranches
1977 (Nov)	13,923	99,733	4,847	195,582
1980 (Oct)	9,688	144,314	4,580	104,459
1981 (Jan)	26,347	-	6,235	-
1983 (Feb)	30,698	-	5,288	-
1983 (Aug)	7,238	75,027	5,252	73,494
1985 (Apr)	14,675	149,661	9,080	107,273
1985 (Aug)	11,512	84,911	912	106,724
1985 (Dec)	1,268	70,650	27,326	84,132
1986 (May)	2,497	133,068	130	89,836
1986 (Aug)	12,401	106,004	9,415	109,115
1986 (Nov)	14,063	78,669	3,615	92,101
1987 (Apr)	4,782	96,340	5,259	107,915
1989 (May)	27,683	150,678	9,826	57,077
1989 (Aug)	27,479	162,444	2,332	87,889
1990 (Aug)	10,204	136,515	8,160	80,962
1991 (Apr)	15,043	130,712	8,100	75,015

Table 2.4: A brief environmental history of the Serengeti-Mara Ecosystem. Sources: (Homewood et al. 2001; Dublin 1995; Sinclair and Arcese 1995; Sinclair and Norton-Griffiths 1979)

Time Period	Vegetative Change	Explanation
1850-1950	Open Grassland to Woodland	Rinderpest epidemic of the 1890's which lowered human, livestock and wildlife populations. The intensity and distribution of anthropogenic fires decreased A concurrent decrease in the numbers of elephants killed by ivory traders resulted in the resurgence of bushland, which provided a suitable habitat for tsetse flies.
1950-1960	Woodland to Open Grassland	Increase in anthropogenic fires from herders, hunter-gatherers, hunting tourists, park authorities Increase in human and livestock populations following recovery from rinderpest epidemic
1960-1980	Stable State Grasslands	Increase in wildebeest numbers – start of the migration which reduced available off-take Decrease in elephant numbers due to high poaching in the Serengeti National Park
1980-Present	Grassland to Agriculture	Good economic climate and market opportunities for wheat in areas north of the MMNR Highly supportive agricultural policy Increased private land tenure

CHAPTER 3

Data structures, contexts and collection

3.0 Introduction

While the political ecology research framework has been useful in providing researchers with the variety of key concepts that improves our understanding of the processes and social dimensions of resource use, access and control, there is yet to be a refined focus on the many methods that are needed to unveil these complexities. Mixed method research is fast becoming the methodological core of human-environment interactions geography and in this chapter, I introduce the variety of methods, techniques and frameworks that were used to answer the individual research questions and thus form the structural base for the second part of this dissertation. In the following sections, I describe the methods used, justification for their selection, and a protocol for undertaking each of the methods. I conclude this chapter by providing an analytical framework for analyses, although the actual methods of analysis are described as part of the subsequent individual chapters that address the answers for each of the research questions.

Each research question was answered using a number of different methods and techniques which are necessary to understand the *combined* social and ecological processes influencing livestock herding strategies (Jiang 2003; Norgaard 1989; Scoones 1999). The use of mixed methods also served as a way by to ensure triangulation ‘cross-checks’ of empirical data (Adriansen 2003). While various social science methods are necessary to document indigenous technical knowledge at the local scale, these need to be situated within an understanding of landscape scale ecological processes that influence them, and vice-versa (Berkes, Folke, and Colding 1997; Kepe and Scoones 1999).

I employed the use of integrated geospatial technologies (Geographic Information Systems [GIS], Remote Sensing [RS] and Global Positioning Systems [GPS]) to extract spatial socio-ecological data and information and use these technologies to pitch spatial analyses of herding strategies (Turner 2003b). The use of geospatial technologies as research tools in existing *ecological* research around the MMNR is not new (Boydston et al. 2003; Oindo, Skidmore, and De Salvo 2003; Ottichilo, Said et al. 2000; Sitati et al. 2003). However, the use of these technologies to help understand complex *nature-society relationships* within the study site and for the larger livelihood system is relatively recent²⁵. This research therefore provides a detailed empirical set of data and observations from which to comment on the efficacy of these technologies with pastoralists-livestock-rangeland studies.

As part of my research, I paid close attention to the emerging issues identified by Turner and Taylor (2003) in the integration of geospatial technologies and nature-society research. These include: linking social and ecological patterns and processes at different spatial and temporal scales (Heasley 2003); understanding and acknowledging the social construction of land cover categories derived from remote sensing and GIS analyses (Robbins 2003a); using GIS to shift the scale from local production systems to regional political-economic scales to help contextualize socio-environmental change (Turner 2003b) and to merge these technologies with ethnographic research to help study cultural change and human perceptions as they relate to the landscape (Jiang 2003).

²⁵ The use of geospatial technologies to investigate nature-society relationships around the MMNR have been conducted by Serneels, Said and Lambin (2001) and Homewood et al. (2001) to examine land use changes in the Narok district and their associated effects on wildlife conservation. However, these studies rely primarily on secondary or derived data.

Social scientific methods were used to answer research questions that focused on the political-economic and socio-cultural components of the research objectives. These include: key informant interviews, informal daily interviews with herders, participant observation of herding practices and modes of livestock production. Data for the ecological component of this study was obtained from remotely sensed satellite imagery of vegetation indices and from behavioral observations of cattle, but was contextualized against the social conceptualizations of the periodicity of environmental changes.

As with most integrated research on resource utilization among local rural communities of sub-Saharan Africa, the methods used to answer the research questions are iterative processes, whereby answers and analyses from each of the research questions were used to reflect on the answers to subsequent research questions (Schönhuth and Kievelitz 1994).

3.1 The Cultural Context of Data Collection

Livestock, as I have discussed in greater detail in chapter 2, have high cultural, social, economic and political affinities to the Maasai. Hence, this study was dependent upon the mutual cooperation with the study households that are generalized in chapter 2. This led to the development of methods of data collection that did not detract or offend the Maasai and their affinities to livestock. In order to undertake the cattle tracking (Method 1 in this chapter), we sought the advice of the elder of the household and he or she selected the bull that would be 'cooperative' in putting the GPS on. Maasai only put cow bells (which the GPS is then affixed to) on oxen (bulls that have been castrated). Oxen were the preferred choice because they are usually the strongest animals in the

herd, are at the front of the herded group and are easier to handle. Uncastrated bulls are more difficult to handle. In some instances, it was too difficult to catch the oxen and affix the GPS unit. Whenever this occurred, we sought the assistance of a young male herder who would sing to the oxen to calm it down or rub it gently on the upper hind legs. Some households that we studied did not have oxen and agreed to let us put the GPS on uncastrated bulls and where there were no bulls or oxen, GPS units were placed on heifers and cows. As cattle are herded as a single group, there is relatively little variation in the shape of the group, except at watering sources. Hence, the path that cattle circumnavigate across the grazing day (the herding orbit), is well represented by placing a GPS collar on a single animal.

3.2 Data Collection Structure

The merging of cultural and individual contexts of data collection led to the development of a broad overarching structure to the way data was collected. To restate, the research questions were:

- (1) What are the patterns of pastoral livestock movement near the MMNR?
- (2) What are the:
 - A. ecological;
 - B. socio-economic and political-economic processes that influence livestock movement patterns?
- (3) When, where and why do grazing conflicts occur between herders and the state?

Two types of data sources were required to answer these questions: primary field-based data sources, and secondary (remotely sensed and existing literature) data sources (Table 3.1). Both types of data were used to answer each of the research questions, although the primary data is weighed more heavily than the secondary data.

3.3 Positionality of the Researchers

The role of the individual researcher is often overlooked in how the research is structured and undertaken. My history of research in the study site goes back to 1998 when I conducted my senior thesis research on human-wildlife conflict while at the department of geography at Eastern Kentucky University. Subsequent visits to the study site include a three month long field research period for my master's thesis between May and August 2001, monthly visits between May and August 2002, 2003, and 2004. Field testing of methods and preliminary permission to conduct the research was obtained in December 2004. I subsequently spent a year living in the Mara between August 2005 and August 2006. Many of the households that were a part of this study were not new to me, but this field period enabled me to incorporate a more focused and directed formal research program.

I am fluent in Swahili, the *lingua franca* of Kenya, but was initially limited in my ability to speak and understand Maa (or Kimaasai), the dominant language of the study site. I was able to speak Swahili with the younger Maasai and older men and women who had traveled frequently out of the study site. However, many respondents were only fluent in spoken Maa. Five Maasai research assistants between the ages of 25 and 35

were recruited to assist with translations, help familiarize myself with the local environmental history, provide logistical, field and procedural advice on how to approach families. This helped inform the ways in which data was collected. Three of the five research assistants were born and raised in the Talek area, while the fourth assistant was from *Nairagie Engare*, near Narok town, the district headquarters of the Narok district in which the study site is located and the fifth assistant was from *Suswa* approximately 40 kilometers before Narok town. None of my assistants had formal university education, but had completed their secondary school education. All of the assistants had some experience with research, either by being assistants for other researchers in the area, or government/non-governmental organizations such as enumerators for the Central Bureau of Statistics, and Food and Agricultural Organization of the United Nations and relief organizations like World Vision and Oxfam.

The study period was from August 29, 2005 to August 14, 2006. Data was collected for approximately 305 days. In order to experience a more thorough and lived experience of ‘dwelling’ in the field, a camp site was located at the border of the Maasai Mara National Reserve, 400 meters away from the first cluster of study households. The research team, which included me, a cook, two night guards and three research assistants stayed at the Sunshine Bush Campsite between August and November 2005. Between November 2005 and March 2006, the research team moved closer to the Talek center at an established campsite (Riverside Campsite). The primary reason for the move was the lack of water needed for cooking and cleaning when the Mpuuai River at the Sunshine Bush Campsite began to dry up and the water became stagnant and dirty. Between March and August 2006, I moved to the Fig Tree Lodge because of the tents we were

staying in began to leak with the onset of the rainy season and I needed more reliable electricity to begin compiling data that had been accumulating. The research assistants were lodged at the Talek center and felt more comfortable there. Between all three residences, my research assistants and I, always welcomed, and received many visitors as we encouraged an open door policy for residents of the study site to ask questions related to the research and any queries that they might have had of any of us.

3.4 Primary Data Collection

Four main methods were used to collect data while in the field. These were: (1) cattle mobility tracking; (2) daily herder interviews; (3) key informant interviews; and (4) household surveys. In the following paragraphs, I present a detailed description of the rationale used to select the households from which each of the methods was undertaken and the actual methods used. I pay particular attention to some of the problems I faced while following these protocols.

3.4.1 Method 1: Cattle tracking

The purpose of this method was to understand the spatially and temporally explicit patterns of livestock mobility (research question 1), I employed the use of Global Positioning Systems (GPS) units attached to cattle from ten representative households within the study site. In this study, I chose to study the movements of cattle alone and do not describe the movements of small stock (sheep and goats). The primary reason for choosing cattle is that they form the nexus over the contestations in rangeland environments (Lamprey 1983; Lamprey and Yussuf 1981) and are strongly rooted in the

environmental, cultural, social, political and economic structures of Maasai pastoralism (Spear and Waller 1993). The use of GPS units to gather and understand spatially and temporally explicit pastoral livestock movements has been in use for some time, however, the approach is the first of its kind where modified GPS collars were actually *attached to individual livestock*, instead of carried by herders or researchers as other studies have done (Adriansen and Nielsen 2002; BurnSilver, Boone, and Galvin 2003).

Protocol for recruitment of study households: There are approximately 189 households within the study area according to ground count conducted by the International Livestock Research Institute in late 2004. A Maasai household (singular *enkang*, plural *nkangitie*) is defined as, “a joint residential unit composed of several households (*olmarei*)...allowing for the cooperation over grazing and herding decisions” (chapter 2 and Coast 2002: 86). The household is built around a thorn bush enclosure, or corral, where cattle are held when they are not grazing. There is usually one large corral for cattle, and several smaller ones for sheep and goats. Newborn calves are often kept inside the *olmarei* until they are at least 6 months to a year old. The *enkang* is composed of between 3 and 25 *olmarei* depending on the size of the household which includes both family and non-family members (Fig. 2.7 and 2.8).

Given the limitations of time, research equipment and field logistics, ten households were selected as ‘representative’ households of the study area. All these households had some relationship (formal or informal) with each another. This was not realized at the time of selecting the households, but I still feel that these households were representative enough to answer the research questions. The criteria for selecting the household were: (1) a willingness to participate voluntarily in the study; (2) that the

household was no more than 2 kilometers from the border of the Maasai Mara National Reserve; and (3) more than 20 head of cattle. Compensation was offered in the form of a packet of the veterinary drug Veriben²⁶ for each time that a GPS was placed on cattle.

Protocol for tracking: A modified GPS collar was constructed to affix the GPS unit to an individual bull. A cow bell was purchased from the weekly market at the Talek center within the study site. Cow bells are locally manufactured from old rubber tires, iron rods and metal sheets. A canvas sleeve was fabricated to protect and hold the GPS unit. I used six Garmin eTrex 12 channel GPS units. Each GPS was then placed into a six inch by six inch zip-loc bag to protect the unit from water (both from rain and high river crossings) and dust (Fig. 3.1). The GPS units were then attached to the cow bells on bulls and held firmly by Velcro straps and duct tape (Fig.3.2). The GPS was placed on the bull before the cattle left their enclosures and removed when the cattle returned. The timing of placement varied across the duration of the study period. During the first month of the study the placement of GPS units onto cattle was particularly difficult. In a few instances the individual bull would get startled and bolt away whenever I or members of the research team would approach the animal. Whenever this happened, we used a lasso to hook the bull's leg and run after it until we could hold it down by the legs or the horns. The bulls would be particularly difficult to catch during the dry season as the frequency of injecting cattle with trypanosomes was higher. The injection is delivered intravenously into the jugular and causes discomfort to the bull. The bulls would regularly run away from the research team during the dry season until they became accustomed to individual members of the research team and the GPS collar.

²⁶ Veriben is a trypanocide that helps guard against trypanosomiasis and a curative for cattle already infected with the diseases. Veriben is the most common veterinary drug used within the study area. Further data on the frequency of injecting cattle and the prevalence of trypanosomiasis is given in Chapter 6.

The GPS units were set to collect one point documenting the northing and easting coordinates, altitude, speed, bearing, and distance. Initially the time interval for point collection was set to once every 30 seconds (between August and December 2005) and later reduced to once every 15 seconds (between January and August 2006). The data was downloaded on a laptop at the end of the herding day.

3.4.2 Method 2: Daily herder interviews

The purpose of this method was to understand the factors influencing livestock herding strategies, the decision-making strategies that influence herding strategies, the social and labor related processes of herding, and indigenous knowledge of rangeland environments I employed the use of daily herder interviews. These interviews served as one way in which to document how these different processes and knowledge structures interact and how they change with both time (seasonality) and spatial location (seasonal and temporary moves).

Protocol for the selection of herder interviewees: The selection criterion for this protocol was simply interviewing the herder responsible for herding cattle that particular day. The protocol also took into account the herders willingness to answer the interview questions. From the over 1100 daily interviews conducted, the herders declined to answer questions twice. In most cases, the research team was able to locate the herder before the cattle would leave. However, in a few instances the herder was unable to be located and the questions were addressed after the cattle arrived in the evening. In a few instances, the herders did not know where they intended to graze their cattle. In these instances, we noted this down as part of the additional notes on the form.

Protocol for the daily herder interviews: As soon as the GPS was attached to the bull, I or one of three Maasai research assistants sought out the herder for the day and asked them a series of questions, known as the pre-herding orbit report form. These questions addressed the following topics;

1. Where the herder intended to graze livestock that day;
2. How the herder characterized the habitat that the livestock would graze in;
3. What are the factors associated with selecting that particular grazing location;
4. Who made the decision on selecting the grazing location;
5. When the decision on grazing location was made;
6. Whether the herder/herding family had any contact with game rangers within the last week; and
7. What are the names, genders and ages of the herder(s)?

An example of the actual pre-herding orbit report form used in the study is shown in Appendix 1.

The same process was repeated in the evening, and similarly structured questions were addressed as part of the post herding orbit report form. These questions addressed the following questions;

1. Did all herders return together?

If not, why not?

2. Did you go to the same intended grazing location

If not, where did you graze and for how long?

3. At what time did the cattle graze the most

Where is this area?

4. Did you join herders from other households?

If yes, which households, how many cattle and herders?

5. How long did you undertake joint herding?

6. Did any cattle fall sick or show symptoms of any sickness?

If yes, how many cattle and what sickness/symptoms of sickness?

7. Did you encounter any game rangers while herding?

If yes, what happened?

8. Did you encounter any wildlife along the orbit?

If yes, which animals and what happened?

This process was repeated on a daily basis for each of the ten study households. Over the course of the study period, approximately 1108 pre and post herding orbit report forms were compiled for each of the herding orbits. In a few instances, post herding orbit report forms were not completed when the cattle returned to their enclosures. This occurred when there were heavy rains and herders would return straight to their huts. The forms were then either completed after the rains stopped, or the next day. In some instances, the research team was unable to locate the herder for the previous day because they had either traveled outside the study site or for some other reason we were unable to locate them. In this instance, we sought out herders who had joined that particular herd and directed the questions at them in order to get an approximate report and a note was attached to the orbit report forms indicating that way in which the data was collected.

3.4.3 Method 3: Key informant interviews

The purpose of the key informant interviews was to understand the historicity of livestock movements, settlement histories of the Maasai within the study area, drought coping strategies, human-wildlife-livestock conflicts, the local environmental history, and the nature of changing relationships between the Maasai and the park authorities. Key informant interviews are among the most common social-scientific methods that help elucidate social processes related to environmental resource access and control (Bassett and Zueli 2000), elucidate the power structures inherent in issues of control over resource utilization and determine the key actors or agents of resource utilization (Homewood and Brockington 1999; Ribot and Peluso 2003; Scoones and Cousins 1994).

Protocol for the selection of interviewees: Interviewees were selected based on the following criteria: (1) they had lived in the study area for at least 5 years; (2) had knowledgeable and evolving information on the issues that the interview sought to obtain; (3) were somewhat active in grass roots organization or had been part of larger political, economic or social structures that operate within the study area (such as being game rangers, county council officials, local organizing groups, conservation organizations, area chiefs, local committees for fund raising activities, community game scouts; and (4) showed a voluntary willingness to participate in the interview. Compensation was offered to the interviewees for their time in participation. The compensation offered was a Maasai *shuka* or cloak that is usually red in color with abstract designs on them. The *shuka* was chosen as it is given as a sign of thanks and respect.

Protocol for addressing the interview: A question guide for the interview was developed prior to beginning the research and revised over the course of the study. The question guide is shown in Appendix 2. The interviews were conducted approximately seven months into the field period and spanned five months (between March 10, 2006 and July 17, 2006). Following human subjects research protocols verbal consent was obtained from the interviewees because of the low literacy rate, especially among the older generation of Maasai within the study area (Appendix 3 and 4). The interview questions were structured with 40 questions ranging from their own personal settlement history, their changing livestock ownership patterns and the processes of conflict between herders and park rangers. The temporal period of data that the interviews sought to obtain was for the last 30 years and used key events in Kenya's history such as independence from Britain (1963), the death of Kenya's first President – Jomo Kenyatta (1978), land conflicts in the Rift Valley Province and the advent of multi party politics (1992). The interviewers also used an enumerator's guide for the 1999 population and housing census conducted by the Government's Central Bureau of Statistics (CBS) which lists other key events that interviewees would recall, dating from 1906 – 1993 (Kenya 1999). These events and corresponding years are noted in Tab. 3.2. Interviewees were first provided with background information on the study and asked for consent, written if they were literate or verbal consent if illiterate. The compensation was provided after they had completed the interview.

In total, 76 key informant interviews were addressed, at an average total time of 2 hours and 17 minutes for each interview to complete. Forty-one men at an average age of 69 years and thirty-five women at an average age of 58 years were interviewed.

3.4.4 Method 4: Household surveys

The main purpose of the household surveys was to collect, in a structured manner, the following categories of information related to the research questions:

1. Background and general information
2. Settlement history
3. Livestock ownership and composition
4. Land ownership
5. Livestock movements
6. Livestock production strategies
7. Livestock products
8. Park conflicts
9. Remittances and employment
10. Wildlife populations and environmental change
11. Household expenses

A household survey was designed to capture these different dimensions (Appendix 5). The survey was adapted from existing household surveys that the People, Livestock and Environment Theme at the International Livestock Research Institute have used in pastoral studies in the Kajiado district of Kenya (Kristjanson et al. 2002). However, many changes were made to the original survey design to cater towards a refined focus on the questions that this research sought to answer. These include expanding sections on livestock movements, settlement histories and remittances and

employment strategies of pastoralists. The use of household surveys in social scientific research is also well documented (Turner, Geoghegan, and Foster 2004; Gutman 2004; Steffen 2004). The household survey was designed to be addressed as a face to face interview because of the low literacy rate within the study area. The face to face format was also used because it allowed enumerators to rephrase questions in a way that would be properly understood by the respondents and it also gave the opportunity for respondents to ask questions related to the research. While the survey design is advantageous in terms of capturing a large, detailed and representative sample of the populations within the study area, it is very costly to administer in terms of resources (time spent on the survey as well as time spent in recruiting subjects and money) and is also physically and mentally exhausting on the enumerators.

Protocol for selection of subjects: Each *enjang* within the study area has multiple *olmarei*, that is, there are multiple household heads within a single *enjang* (the unit from which cattle tracking was undertaken in method 1). This is because different families or clan members may collaborate to build an *enjang*, but the maintenance of the household is left to the individual family members. The heads of *olmarei* may also be responsible for more than one individual household and often younger in age than the *Wazee*. The household heads in this instance were more aware of the monetary and tangible based aspects of production and exchange (sections 3, 4, 6, 7, 9 and 11 of the survey), while at the same time were knowledgeable on more general aspects of the survey (sections 1, 2, 5, 8, and 10). As a result the household heads were usually young males responsible for the maintenance of their individual household that encompass mostly, though not exclusively nuclear family members. These household heads may be subordinate to the

older males in the family, often referred to as *Wazee*, who are often elders and leaders within their age sets.

Protocol for administering the survey: Each household head was approached a few days in advance to determine whether they would be willing to participate in the study. They were briefed on the duration of the survey, what was expected of them (the structure of the questioning, and a brief description of the categories of information that were being asked) and informed on the type of compensation offered for their time. After the preliminary agreement to participate in the survey, the research team scheduled 2 or 3 household heads that the enumerators would interview. Before administering the survey, the enumerator would read the consent procedure in its entirety and attain a verbal consent if the junior household was literate or a written consent if they were literate. Household surveys were addressed to 111 households from the estimated 140 households within the study area. The average time taken by the enumerators to complete the survey was 2 hours and 25 minutes. The average age of the household heads was 38 years and 104 of household heads were male and 7 female. Most of the surveys were conducted between 8:00 am and 2:00 pm, when the livestock had left their enclosures and before they returned in the evening.

3.5 Secondary Data Collection

Two main types of secondary data were collected that helped answer research questions 2a, 2b and 3. These are: (1) the acquisition of remotely sensed satellite imagery; and (2) the collection of archival literature from both governmental and non-governmental sources.

3.5.1 Method 5: Remotely sensed imagery

The use of satellite remote sensing data is common in studies of environmental change and provides the most reliable and accurate estimates of changing environmental conditions as well as identifying discernible human and physical features and landscape modification (Justice et al. 1998). However, the use of satellite remote sensing to detect changes in *rangeland conditions* is problematic (Turner and Congalton 1998). In East Africa, this is because of two main reasons. First, the spectral wavelength classifications between grassland/bushland and bare ground are very close together, especially during drought periods. As a result there are frequent misclassifications between the two land cover categories (Butt and Olson 2002). Second, the high degree of inter-annual variability makes comparisons of environmental change between years problematic and inconsistent (Weier and Herring 2006)

Types of data: Two types of satellite imagery were used to collect data on: (1) the ecological dynamics within the study site and; (2) to delineate physical and social features on the landscape, such as rivers, roads, enkangitie and village centers. Ecological dynamics are measured by capturing Normalized Differential Vegetation Indices (NDVI), which is an estimate of the density of plant growth on the ground and its condition. These quantitative indices were captured at high temporal and low spatial resolutions. Delineating social and physical features on the landscape was done through multi-band satellite imagery at high spatial and low temporal resolutions and used to qualitatively map the landscape. The map formed the base from which on the ground data could be registered to and was manipulated as more spatial data were added.

Data sources: Data for NDVI was obtained from NASA's Moderate Resolution Imaging Spectroradiometer (MODIS) sensor on board the Terra EOS (Earth Observation System) satellite (1995). This sensor collects the NDVI data at a temporal resolution of 16 days and a spatial resolution of 250 meters and acquired from the NASA Land Processes Distributed Active Archive Center (LP DAAC). Data granules were obtained from 2005 Julian day 209 (July 28, 2005) to 2006 Julian day 225 (August 13, 2006).

Data for delineating the social and physical features of the landscape was obtained from the EOS Landsat 7 and Landsat 5 satellites. The data are at 30 meter resolution for multi-spectral bands and 15 meter resolution for panchromatic bands on Landsat 7. Data were obtained for path 169, row 61 for January 28, 1986, January 06, 1995, January 27, 2000 and December 06, 2003 and were acquired from the Center for Global Change and Earth Observation (CGCEO) at Michigan State University and the GIS services divisions of the International Livestock Research Institute.

3.5.2 Method 6: Archival and contemporary non-governmental and governmental literatures

Published literature was collected to understand some of the historical and contemporary patterns, processes and policies related to pastoralism, livestock development and conservation around the world (global scale) in Kenya (national scale), the Rift Valley Province (sub-national scale) and the study site (local scale). This data was collected in order to contextualize the current trends observed at the local scale to larger political and economic structures and attention was given to collecting all the

relevant legislation and legal rhetoric that is used in conservation, pastoralism and livestock policies.

Data types and sources: The types of data collected and their sources are shown in Table 3.3. The data were obtained through published materials from each of the respective institutions through either print or electronic media. In some cases the literature was specific to the study site, though the study site was mentioned as part of the two large pastoral districts in the south of Kenya that are largely Maasai dominated (Narok and Kajiado districts).

3.6 Analytical Framework

Because this dissertation relies on a mixed methods approach to collecting data, no single method of analysis was suitable. Rather a '*suite*' of methods of analyses was employed to answer each of the individual research questions (Tab.3.4). I separate spatial from statistical analyses as some quantitative data are analyzed independently before the outputs are used as an input into different spatial analysis methods. The first stage of analysis was to organize and structure the raw data in ways that could easily be used as inputs into different analyses techniques. The specific techniques used in statistical analyses varied according to what variables are being tested and is described in greater detail as part of the individual chapters.

Spatial analyses were conducted on all data collected within and outside of a Geographic Information System (GIS) platform. GIS was used as a visual integration tool to link data collected from various qualitative methods. For example, in research question 2a, I rely on Maasai narratives of settlement histories (from the key informant

interviews). A map of historical settlements was drawn within a GIS in order to create spatial references to these narratives. Critical to the GIS based spatial analyses were the various pre-processing procedures to format the data so that it could be read and easily manipulated within the GIS. Other pre-processing stages included coordinate matching, clean and build functions on vector data and clipping where necessary.

Before qualitative analyses were undertaken, I transcribed and compiled all field notes from the remote sensing data, and household surveys into a word processor using voice recognition software. Qualitative analyses were conducted using a variety of techniques such as coding, texture analysis, case displays, and looking for trends in the interview, focus group or informal meeting data based on context. These qualitative analysis techniques have been summarized by Limb and Dwyer (2001) and described more extensively by Rubin and Rubin (1995) and Miles and Huberman (1984).

Figure 3.1: A sample cow bell that was purchased from weekly markets to prepare the GPS collar (A); the Garmin eTrex Legend GPS unit (B); the canvas collar to scale with Velcro straps (C); 1.5 inch wide duct tape (D)

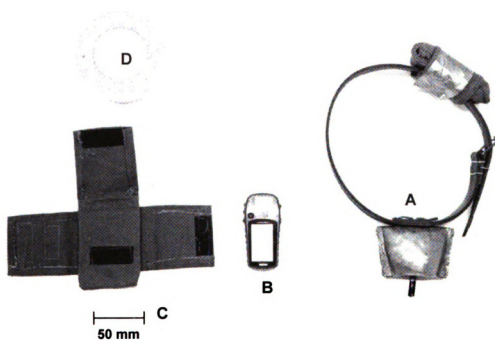


Figure 3.2: GPS collar attached to a young bull (Photo by author).



Table 3.1: Methods of data collection used to answer each of the research questions

Methods of Data Collection		Research Question			
		1	2a	2b	3
PRIMARY DATA					
1	Cattle Tracking		X	X	
2	Daily Herder Interviews		X	X	X
3	Key Informant Interviews		X	X	X
4	Household Surveys	X	X	X	X
SECONDARY DATA					
7	Remotely Sensed Satellite Imagery			X	
8	Existing Literatures		X	X	X

Table 3.2: Historical calendar of events for the Narok District (1906 – 1995). Source: GOK (1999)

YEAR	EVENT/AGE GROUP
1906	Famine
1907	Cattle disaster – liver flukes (olomotori)
1926	Year of the locust (Olmaati)
1937	Cattle disaster
1940	Outbreak of malaria (Olaarile Tiagoenong)
1943	Tea famine (Olamayu leshal); Maasai Mara reserve was started; upgrading of literkeyiami
1944	Morijo Loita school was opened; fifth in the district; compulsory education; fifteen children ran away leaving only five
1945	Likalikah (now Nyangusi) ceremony of Emnoto
1946	District Commissioner of Narok Major Grant is killed by a Maasai moran; Laibon family Ole Senteu is caught and hanged
1947	Two groups of Nyangusi age group fight at Loisiusiu-Narok; Ilkalikal and Ilkamaniki
1948	Circumcision of group at Ilkamaniki
1952	State of emergency started; many people taken to detention camps at Entara near Narok
1954	The Mau Mau leader in Narok district is killed (Ole Kisiu)
1955	The second Mau Mau leader in Narok is killed (Ole Nkapiaia); Taro age set begins
1956	Compulsory education of Maasai girls in the district ; At Narok primary School boarding begins for classes 1-8
1957	Second primary boarding school started by the Catholic Mission at Narok – St. Marys Primary School
1958	Eunoto ceremony of Ilkamaniki age group
1960	Masikonde primary school at Narok opens; widespread famine
1961	Keekorok lodge opened; famine Olameyu lepiruki
1962	Long rains Olarilonkitutu
1963	Iseuri (Iltiyogo) circumcision ceremony
1964	Road construction (Sekenani, Talek, Aitong)
1966	Eunoto ceremony of Iltiyogoni age group
1967	Eunoto Iltiyogoni cultivation started
1969	Paramount Chief Kundai Ole Sankale dies
1970	Circumcision of Rambau age group; civil war with neighbors (Lymbwa)
1972	Serena lodge built
1973	Eclipse of the sun
1976	Famine; Nado-Etolit; Enkana Olorikan (Ilterekeyiani) age set
1980	Aitong cattle dip begins
1982	Aitong primary school opened
1984	Circumsion of kishili age set; famine; olameyu Lenado tolit
1986	Talek Primary School opened

1987	Olchokit Supat Secondary School and Lemek Secondary School open
1988	Mara Rianda Secondary School opens; Enkang Olorikan ceremony of the Irampau and Ilkiropi age groups (Ilkitoip circumcision ceremony of Ilemeoson)
1991	First revenue sharing from Narok County Council (19% of Revenues from MMNR); Mara Paradise lodge opened
1992	Multi-party elections; formation of Olchorro-Oruwua Association
1993	Outbreak of malaria (esoolosh)
1994	Arrival of white rhino in part of Olchorro-Oruwua Association
1995	Koiyaki-Lemek Conservation Area begins in Aitong

Table 3.3: Types of data and sources for archival and gray literatures

Type of Data	Source of Data
Conservation Legislation	Narok County Council Kenya Wildlife Service Government of Kenya (Ministry of Environment and Natural Resources) United Nations Environment Programme
Conservation Policies	African Conservation Center African Wildlife Foundation World Wildlife Fund International Union for the Conservation of Nature
Pastoralism & Livestock Development Policies	Narok District Development Plan Narok County Council Government of Kenya (Ministry of Fisheries and Livestock Development)

Table 3.4: Types of data analyses used to analyze each of the data collection methods

Data Collection Methods	Data Analyses Methods		
	Spatial	Statistical	Qualitative
Cattle Tracking	X	X	X
Daily Herder Interviews	X		X
Key Informant Interviews	X	X	X
Household Surveys	X	X	X
Remotely Sensed Imagery	X	X	X
Existing Literatures	X		X

CHAPTER 4

Pastoral herd management, drought coping strategies, and cattle mobility around the Maasai National Reserve, Kenya*.

* This chapter has been submitted to the *Annals of the Association of American Geographers* and includes A.M. Shortridge and A.M.G.A. WinklerPrins as co-authors. It therefore follows a different formatting structure than previous chapters.

Abstract

Livestock mobility facilitates an opportunistic grazing management strategy that pastoralists employ to counter environmental variability in rangelands. This can be achieved by moving livestock to temporary camps that are closer to areas of under-utilized forage during times of drought. In areas where pastoralists border large protected areas, movement into protected areas is also a common strategy. The aim of this study is to test hypotheses of herd relocation and effects of seasonality and herd size on spatially explicit parameters of cattle mobility for Maasai pastoralists along the northern border of a protected area in Kenya. Modified GPS collars were placed on cattle from ten Maasai households that recorded three parameters of mobility. Data were grouped by two constraints: seasonality and herd size and tested against the two types of enclosure locations (temporary camps and permanent settlements). Hypotheses were formed on the basis of the current knowledge within the literature and analyzed using a series of ANOVA tests. Results suggest that household relocation reduces the stress faced by pastoralists and their cattle during the drought by: (1) lowering the average total daily distance and time traveled by cattle; (2) directing cattle towards the protected area; and (3) concentrating cattle grazing in distinct areas within the protected area. Herd size was found to have no effect on duration of travel for pastoralists that choose not to relocate during the drought. The research demonstrates how the use of modified low-cost GPS collars can be an effective tool at capturing parameters of mobility and to infer pastoralist-livestock-rangeland relationships.

Key Words: Mobility, Drought, Seasonality, Herd Size, Pastoralism, Maasai, GPS, Cattle

4.0 Introduction

The dynamic relationships between pastoralists, livestock, and the environment have long been of interest to both natural and social scientists when examining the access to, use of, and control over environmental resources by pastoralists in rangelands (Behnke, Scoones, and Kerven 1993; Ellis and Swift 1988; Scoones 1994b). Livestock mobility is indicative of how these relationships may be characterized and better understood against changes in the resource base and livelihood system (McCabe 2004; Bassett 1986; Swallow 1994).

A broad and extensive literature documents how pastoralists use mobility as a social and ecological strategy to counter the effects of environmental variability (e.g. Oba and Lusigi 1987; Scoones 1995; Fratkin 1991a; McCabe 2004; Behnke, Scoones, and Kerven 1993). One of the ways this can be achieved is by moving livestock closer to under-utilized areas of forage during times of drought (Niamir-Fuller and Turner 1999; Fratkin 1991a; Homewood and Lewis 1987a; Lamprey and Reid 2004). These areas are distant from permanent settlements and pastoralists must base livestock in temporary camps for the duration of the drought. In other instances, where pastoralists reside close to protected areas such as national parks, protected areas may be used as foraging sites during drought periods (Turner 1999b; Brockington and Homewood 2001). However, there is little empirical evidence to indicate how: (1) relocating from permanent settlements to temporary camps alters patterns of mobility and reduces the effects of drought on livestock; and (2) the periodicity of livestock movement into protected areas changes with seasonality and herd size.

Through a case study of cattle micro-mobility that documents the grazing orbits, or the daily scale movements of livestock about the household, of Maasai pastoralists in southern Kenya, we frame and test a series of hypotheses on how patterns of mobility differ between permanent settlements and temporary camps. Using three parameters of mobility (average total distance, duration of travel and mean direction of travel), we also consider how patterns of mobility change by season and herd size.

This paper contributes to the literature on pastoralism and drought coping strategies in rangelands in three ways. First, we provide a more rigorous methodological structure for collecting and analyzing data on cattle mobility than current approaches. Second, we describe how the pastoralists' decisions to relocate from permanent settlements to temporary camps during drought periods alter parameters of mobility. Finally, we illustrate seasonal variability in the movement of pastoralists' cattle into a protected area. These contributions enhance our knowledge on pastoral livestock mobility strategies by providing empirically derived information on livestock movement at fine spatial and temporal scales. This information is critical to attempts at forming theoretical approaches to understanding pastoral livestock mobility with the goal of encouraging development practices that accentuate the "self-evolution of pastoralism towards an economically, socially and environmentally sustainable livelihood system" (Niamir-Fuller and Turner 1999: 31).

4.1 Drought coping strategies: the role of mobility

The role of livestock mobility in reducing risk has generally been perceived as a spatially and temporally flexible way by which adaptive strategies can be achieved

(Swallow 1994; Niamir-Fuller and Turner 1999; McCarthy et al. 1999). Opportunistic use of forage is the most common adaptive strategy that pastoralists employ (Niamir-Fuller 1999a; Westoby, Walker, and Noymeir 1989a). Variability in forage resources combined with: (1) socio-economic strategies such as alternative income sources, herd diversification and the sale of livestock (Oba and Lusigi 1987; Little, Barrett et al. 2001) and; (2) socio-ecological strategies such as tracking or advance scouting by pastoralists to determine where forage is available during the drought (Niamir-Fuller 1999b), collectively produce different patterns of mobility. For example, Bassett (1986) has shown that Fulani herd movements conform to ‘pendulum movements’ where grazing locations change frequently both within and between seasons, and that herd movement is driven largely by, “... the lack of tsetse fly,...low population densities, available surface water, ... the abundance of palatable perennial grasses,...and labor considerations” (Bassett 1986: 247-48). Similarly, Turner and Hiernaux (2002) determine, through the use of ‘grazing itineraries’ that livestock movements across an agro-pastoral landscape in Niger are determined by, “natural and anthropogenic paths” and that these movements reflect, “not only the goal of minimizing walking times while maximizing fodder intake, but also to provide a range of fodder types; to minimize livestock loss...; to lower the physical demands on the herder; and to avoid or encourage social contact with other people” (Turner and Hiernaux 2002: 381-82).

4.2 Protected areas as grazing reserves

During periods of drought pastoralists traditionally access drought grazing reserves that are rich in biological diversity and extend over a range of ecological niches

(Anderson and Grove 1987). In many newly independent sub-Saharan African countries, large protected areas (PAs) were carved out of areas that pastoralists used as drought grazing reserves in order to serve the twin aims of conserving biodiversity and generating foreign exchange (Talbot and Olindo 1990). The creation of PAs led to the forced removal of pastoralists and their livestock from PAs to their peripheries (Lindsay 1987; Collett 1987; Peluso 1993). Additional constraints were placed on traditional modes of pastoral production. State-sponsored policies encouraged sedentary agriculture over pastoralism (Rutten 1992) and resulted in land-cover changes from savanna vegetation to cropland (Serneels, Said, and Lambin 2001). At the same time, there were misplaced beliefs that livestock grazing in and around protected areas would threaten the integrity of conservation areas through overgrazing, without an understanding of the complex dynamics of pastoral herding (Homewood and Rodgers 1991, 1987; Behnke, Scoones, and Kerven 1993; Ellis and Swift 1988; Scoones 1994a). Collectively these dominant perspectives and state policies resulted in reducing the viability and flexibility of the pastoral livelihood system (Sørbo 2003). Faced with reduced flexibility, pastoralists have selectively utilized grazing resources inside PAs during periods of drought, despite prohibitive ordinances, heavy fines and disciplinary measures (Bedunah and Schmidt 2004; Neumann 2001; Brockington 2002). Pastoral households that have their permanent settlements further away from PAs are likely to relocate their livestock enclosures closer to PAs, or in some cases may even relocate herds inside the parks. The aim of relocation is to alleviate strain on both livestock and herders by reducing the distance and duration of travel while taking advantage of forage resources inside PAs.

The literature generally lacks examples of explicit tracking of livestock movement into PA's and the particular processes driving this movement for individual households. Most implicit accounts of livestock mobility into PAs have come from food security institutions like the Famine Early Warning System (FEWS) and international conservation organizations, and cite 'prolonged drought' as the major reason for incursions into PAs (FEWS 2005; Allen 2006).

4.3. Effects of increased mobility on livestock and pastoralists

Scientists and range managers have evaluated risks associated with drought largely through estimates of stock losses (Fratkin and Roth 1990; Scoones 1992; Homewood and Lewis 1987a; McCabe 1987). The consensus is that the adoption of a 'movement strategy' away from drought-affected areas towards areas of better forage increases the probability of survival, and that herd owners who, "[do] not move their cattle during the drought [suffer] very high levels of mortality" (Scoones 1992: 307).

Determining the effects of increasing the distance and duration of travel for livestock during the drought are hard to estimate given the difficulty of keeping track of livestock as herders move frequently across large areas. Western and Finch (1986) studied the physiology of cattle by simulating drought conditions (food and water deprivation) to determine the effects of increased distance traveled on a ranch in Southern Kenya. Doubling the distance walked by steers from 8 to 16 kilometers did not yield significant differences in weight loss. Additionally, "steers traveling the longer distance walked more slowly, so that their total metabolic expenditure while walking may have been less" (Western and Finch 1986: 84). Based on this and other experiments, they

suggest that “risks can be minimized and production maximized on heterogeneous pastures by optimizing migratory pathways between quality patches” (Western and Finch 1986: 87).

When pastoralists enter PA’s to access historical drought grazing reserves they are faced with additional risks, such as depredation of livestock by wildlife (Kolowski and Holekamp 2006), increased epizootic disease transmissions (Prins 2000; Bourn and Blench 1999), and conflicts with protected area managers (Neumann 2001).

The impacts of these risks vary with drought intensity. Disease transmissions and livestock-wildlife conflicts are likely to increase as watering sources dry up and dietary overlap occurs (Prins 2000). The frequency of depredation of livestock by wildlife is found to be lowest during the dry season and higher in the wet season, and that attacks by wildlife on livestock are as common for herds grazing during the day as for attacks on livestock enclosures at night (Kolowski and Holekamp 2006). Conflicts with protected area managers have been particularly violent in East Africa (Neumann 2001; Brockington 2002). Game rangers are well armed and feared by herders who are mostly young children.

4.4 Methods and models for understanding livestock mobility

In many studies on how livestock mobility facilitates opportunistic grazing, mobility is derived through indirect measures of livestock mobility that are captured from social scientific participatory rural appraisals (PRA’s) such as key informant interviews and participatory observation (Waters-Bayer and Bayer 1994; Waters-Bayer, Bayer, and Lossau 1995), or through categorical household surveys (Homewood and Lewis 1987a).

In some cases, these proxy sources on livestock mobility are transformed, mapped, and analyzed within a database or cartographic tool such as a geographic information system (GIS).

As an alternative to these proxy measures, direct sources of livestock location and mobility are obtainable using Global Positioning Systems (GPS) technology. GPS receivers on livestock have been used within controlled ranching environments and agricultural experimental stations in the United States. Several animal science researchers have conducted controlled experiments to understand grazing behavior and the impacts of cattle trampling and grazing through the use of GPS collars (Agouridis et al. 2004; Ganskopp 2001; Brosh et al. 2006; Turner et al. 2000; Ungar et al. 2005). The work of zoologists and biologists to record animal movements led to the Macaulay Land Use Research Institute conference on tracking animals with GPS (Gordon 2001), which documented some of the most effective ways of understanding animal movement patterns and resource utilization trends. Both the animal science researchers and zoologists have relied on GPS units that are both expensive (\$1,500 to \$5,000) and bulky (200 grams to 2 kilograms) (LOTEK 2007).

In general, we perceive a gap in the focus and methodology between social scientists who seek to understand pastoralism and livestock herding strategies, and natural scientists who seek to understand animal behavior, movement, resource extraction and energy utilization. Explicit spatio-temporal tracking of pastoral livestock has received little attention from researchers in either domain. This is partly due to the high cost and difficulty of field research and a laborious data collection structure.

There are, of course, exceptions to this general observation. Kawamura et al. (2005) outlined a methodology for quantifying grazing intensities of sheep in an enclosed ranching area of Inner Mongolia, China. Small and portable GPS receivers were attached to sheep over a five day period; the location data was matched to Normalized Differential Vegetation Indices (NDVI). Areas of high grazing intensity were identified enabling scientists to determine how different degrees of grazing intensity influenced the amount of available biomass.

In Senegal, Adriansen and Nielsen (2002; 2005), employed a relatively inexpensive handheld GPS to collect spatio-temporal information of grazing locations, perceptions and practices of livestock mobility by Fulani pastoralists. Coordinates were recorded as the herd owner walked alongside cattle ‘herd follows’ from a single household, once a week for three years.

The same approach has been used by Coppolillo (2000; 2001) in Tanzania to understand cattle productivity and herding practices of the sedentary Sukuma agro-pastoralists. In this study, explicit spatial and temporal herd locations were extracted on an hourly basis, and, “more often, when herds were moving quickly or changing directions frequently,” for 26 different households (Coppolillo 2000: 535). Finally in Kenya, BurnSilver et al. (2003) merged 61 ‘herd follows’ from 39 households with Normalized Differential Vegetation Indices (NDVI), and additional geospatial layers such as soil and elevation, to produce heterogeneity indices so as to understand pastoral livestock mobility as a function of landscape heterogeneity.

Each of these studies successfully incorporated explicit spatio-temporal data on livestock mobility to fit the aim of their respective research foci. However, to explain

livestock mobility at fine scales of space and time and within the context of seasonal variability, we find shortcomings in these existing methods on: (1) the way in which data are structured and collected; (2) how accurately the data represent pastoralist managed mobility; and (3) how well the data reflect the high degree of environmental variability observed in rangelands. This paper addresses these shortcomings by providing: (1) a collection methodology designed to obtain high frequency repeated observations of cattle movements; (2) repeated observations for multiple households across multiple seasons; and (3) data structuring, manipulation, and analysis methods for exploring mobility characteristics. The use of portable GPS receivers attached to individual cattle to record spatially and temporally explicit data provides an unparalleled source of mobility data that is sufficiently complete, valid, and precise enough to examine important characteristics of pastoral herd mobility.

4.5 Study Area

The region chosen as a case study to delineate patterns of mobility lies at the northern border of the Maasai Mara National Reserve (MMNR) in southwestern Kenya (Fig. 4.1). The MMNR forms the northernmost extension of the greater Mara-Serengeti ecosystem and is considered “one of the richest assemblages of wildlife in the world, and supports about 237 herbivores per square kilometer, making it one of the most productive natural terrestrial ecosystems” (Waithaka 2004: 79).

Maasai pastoralists reside with their livestock (cattle, sheep and goats) in communal areas and share grazing resources along the northern and eastern borders of the MMNR. The Maasai of this area are semi-nomadic; they shift their herds and form

temporary livestock enclosures during times of drought and also maintain semi-permanent home bases. At the center of the study site is a small village center which has numerous small general purpose merchandise, shops and bars. Most Maasai males engage in either herding activities or are employed in tourism establishments within the study site (Thompson and Homewood 2002). Both males and females engage in herding although the number of females herding cattle and sheep is much lower than males. Young males (between the ages of 6 and 12) herd the small stock (sheep and goats), while males between the ages of 12 and 35 conduct the bulk of the cattle herding. Occasionally, older males will undertake herding responsibilities in dry periods and more regularly in the drought. The main cattle breed in the study site is the East African Zebu and the majority of cattle within a typical herd are heifers and uncastrated bulls forming a smaller percentage of the herd (Lamprey and Reid 2004).

Altitudes within the study area range from 1,501 to 1,985 meters above sea level and the landscape can be broadly divided into three zones: the upland zone to the north dominated by a tsetse infested Acacia woodland comprising *Acacia geradii*²⁷, *A. drepanolobium*, and *A. xanthopholea* species; the lowland grassland zone to the south dominated by red oats grasses (*Themeda triandra*), thatch grasses (*Hyparrhenia* spp.), sweet pitted grasses (*Bothriochloa insculpta*) and *Pennisetum* spp.; and the riverine zone in the middle which is dominated by *Croton dichogamus*, *Grewia bicolor* and *Cordia monoica* shrubs that line the numerous seasonal streams, known locally as *luggas* (Heady 1960; Pratt, Gwynne, and Blackie 1977; Lamprey and Reid 2004). There is only one perennial river, the Talek River, which is also the delineating feature for the border of the MMNR across much of the study area.

²⁷ Botanical information was obtained from Sinclair and Arcese (1995) and Dharani (2002)

Nocturnal temperatures range from a minimum of 10 degrees Celsius in July to a maximum of 20 degrees Celsius in January, while maximum daytime temperatures range from 20 degrees Celsius in July to 35 degrees Celsius in February. Precipitation is bimodal, corresponding to a single long dry season between May and August/September, short rains between November and January, and long rains between March and May (Lamprey and Reid 2004). Rainfall is highly discontinuous and loosely associated with the movement of the Inter-Tropical Convergence Zone (ITCZ) as it alternates north and south of the equator (Broten and Said 1995; Pennycuik and Norton-Griffiths 1976; Sinclair 1979). The average annual rainfall within the study site ranges from 300 mm to over 1200 mm, with long term average of approximately 750-800 mm. During the study period, the short rains that are usually expected between October/November and January/February failed and the study area experienced the worst drought in 25 years. This drought was widely reported by the global news media (Zarifteh 2006; Allen 2006; Mynott 2006) and drought alerts were issued by the UN World Food Programme (WFP 2006) and the Kenyan Government (Bosire and Lee 2006). Concurrently, the National Aeronautical and Space Administration (NASA) Earth Observatory System (EOS) produced Normalized Differential Vegetation Index (NDVI) anomalies for the region and, quoting the Famine Early Warning System (FEWS) stated that, “rainfall totals for the year were only 20-60% of normal, depending on the region,” and, “...by the end of January 2006, millions were in need of food aid, particularly pastoralists who depend on rain-fed pasture lands to maintain their livestock” (NASA 2006).

4.6 Parameters and constraints on mobility

In this section, a description is provided for each of the parameters of mobility that are used in the study. Also discussed is a clarification of the meaning of mobility and descriptions of the various constraints on mobility. The constraints described are not specific to the study site and may be relevant to other types of pastoralism. However, examples are drawn from this study of Maasai semi-nomadic pastoralism to demonstrate how and why these parameters and constraints are necessary to understanding pastoral livestock mobility and drought coping strategies. The unit of analysis for this study is the grazing orbit which is defined as the path that cattle circumnavigate from their enclosures to grazing and water resources and back to their enclosures in a grazing day. Individual grazing orbits can be measured through parameters, and the distributions of these parameters for an orbit vary according to season, enclosure location, and herd size.

4.6.1 Parameters of mobility

We rely on three parameters of mobility to help describe the movement of pastoralists' cattle: average total distance, average total time, and mean bearing. Distance (d) and time (t) refer to the length and duration of an orbit. These measures are indicators of how far and how long it takes cattle to access forage, water, or salt licks and return back to enclosures. The mean bearing direction of travel (μ) refers to the mean angle in degrees from the livestock enclosure to the point of furthest travel, in a straight line distance from the enclosure. Mean direction is unique to each particular orbit and household and in order to characterize variability across orbits we rely on the circular

variance to measure the spread of the bearing direction around the mean across multiple orbits.

Enclosure location: Enclosure location is defined as the site of origin and termination for an orbit. Enclosures are divided into two types: permanent settlements and temporary camps. Permanent settlements are where most of the household infrastructure is located, such as dwelling units, water storage facilities. Permanent settlements are also where most of the members of the household sleep and where inputs to maintain livestock production such as spraying are located. The enclosures that hold cattle and small stock in permanent settlements are more rigidly built and continually maintained to prevent attacks from predators. Temporary camps are hastily constructed thorn-fence enclosures that hold cattle for the duration of a short-term relocation that typically lasts between one and three months. Camps hold less infrastructure and only active herders and support persons reside in them.

We distinguish between these enclosure types in order to test for significant differences in measured mobility patterns. In general, the literature suggests that pastoralists move from their permanent settlements to temporary camps in order to operate in closer proximity to areas of available forage and thus minimize both human labor and stress on the cattle during times of drought and other difficult periods (Little, Mahmoud, and Coppock 2001; Paul et al. 2006).

At the onset of the study (August 2005), all ten households were classed as permanent settlements. Over the course of the study, several households employed various strategies to cope with the failure of the rains and the subsequent drought. These strategies included: (1) relocating the entire household for the duration of the drought and

then moving back to the initial location at the start of the wet season (Bassett 1986); (2) splitting²⁸ and relocating the household and cattle into groups of different herd sizes for the duration of the drought and reforming at the start of the wet season (Grandin 1988); and (3) splitting from a permanent settlement at the start of the drought and forming two temporary camps that then relocate at the start of the wet season as permanent settlement. These strategies are illustrated in Fig. 4.2.

4.6.2 Constraints on mobility

Seasonality: Pastoralists within sub-Saharan Africa inhabit arid and semi-arid regions where the quantity and quality of forage is driven by highly variable and seasonal rainfall (Galvin et al. 2001; Coe, Cumming, and Phillipson 1976; Coughenour et al. 1985). We contend that livestock management strategies, as documented in key informant interviews and expressed by the measured parameters of herd grazing orbits, adapt to seasonal variation in forage availability. To evaluate livestock mobility responses to seasonal environmental stress, we divide the study period into three categories: wet, dry, and drought seasons.

Defining and delineating breakpoints in seasonality is a difficult and subjective undertaking (Ofori-Sarpong 1985). The breakpoints that we use in this study are derived from Normalized Differential Vegetation Indices (NDVI), on the ground local observations, local perceptions and practices of livestock production associated with

²⁸ Herd splitting is also known as herd fission (Bassett 1986: 247)

seasonality, popular news media accounts, and temperature and precipitation measurements²⁹.

Based on this information we assigned seasonal breakpoints for the study period as: dry season between August 2005 and mid January 2006; drought season between mid January and mid-February 2006; wet season between mid-February 2006 and late June 2006; dry season between July and August 2006. These seasonal breaks are shown in Fig. 4.3, where they are displayed with daily maximum temperature and daily precipitation. The wet season is associated with low daily maximum temperatures and high precipitation. Dry season is associated with high temperature and low precipitation. Drought is associated with maximum temperature and lowest precipitation (c.f. Altmann et al. 2002)

Herd size: The size of a cattle herd typically varies from < 10 to > 1000 and is dependent upon the pastoral group and its associated social, cultural and economic affinities (Gilles and Gefu 1990; Sandford 1983; Dahl and Hjort 1976). Herd sizes may vary according to the number of permanent and transient people within the household, the ability and income of individuals within the household to purchase new stock or to trade old stock for new stock (McCabe 2004; Bekure et al. 1991; Grandin 1988; Sutter 1987). Herd size has been used a surrogate for wealth in many pastoral studies (BurnSilver, Boone, and Galvin 2003; Sutter 1987) and can be used to infer how wealth influences mobility patterns. In this study, we divide herd sizes into three categories: small (less than 60 head of cattle); medium (between 60 and 150 head of cattle); and large (over 150 head of cattle). These categories are chosen to best encompass the variability observed in herd

²⁹ The Hyena research camp is a long term behavioral ecology study of the spotted hyena in the Talek area inside the Maasai Mara National Reserve. Temperature and precipitation measurements are recorded daily and the instruments are located in the center of the area used in this study.

sizes documented during preparatory fieldwork and verified during the yearlong study period. During exploratory fieldwork, we found that the mean of herd sizes is approximately 201 head of cattle, with a standard deviation of 206. Herd size classification changed dynamically during the study as households split and (re)merged in response to the drought.

4.7 Hypothesizing mobility

In this section we develop hypotheses about the relationships between each of the three parameters of mobility and the two constraints on mobility. Additionally, these hypotheses are framed against the two enclosure locations: temporary camps (cattle that moved), largely due to drought although not exclusively, and permanent settlements (cattle that did not move) (Tab. 4.1).

4.7.1 Hypothesizing parameters against seasonality

We hypothesize that during the wet season the average total distance and average total time of travel are low for both permanent settlements and temporary camps, because forage is available closer to the household. Exploiting nearby resources is both a labor saving exercise and production maximization strategy: younger herders can herd the cattle closer to the settlements, freeing older herders for other activities such as moving cattle for sale at market centers (Evangelou 1984); and less energy is expended by cattle moving to grazing areas closer to the permanent base (Western and Finch 1986) and this energy may be devoted to increased milk production (Coppolillo 2000; Homewood and Rodgers 1991).

Average orbit distance and average orbit duration are hypothesized to increase during the dry season and reach peaks during drought conditions. This is because as environmental conditions transition into the drought, most of the available forage closer to the settlements is exhausted and cattle must travel to unexploited grazing areas further away. This phenomenon has been documented extensively within the literature for pastoralists in various parts of sub-Saharan Africa (e.g. Bassett 1986; Coughenour 1991; Coppock, Ellis, and Swift 1986; Homewood and Lewis 1987a; Scoones 1992).

We hypothesize that the mean direction of travel for cattle during the wet season is the least concentrated (high variance) since forage is not a limiting factor and surface water is likely to be abundant in the many intermittent seasonal streams that dissect the study area. We expect this to hold true for both permanent settlements and temporary camps. However, for the dry seasons and extending into the drought, we expect that the direction of travel is highly concentrated (low variance) as forage and water sources are likely to be found in distinct areas that serve as directed targets for each orbit. Bassett (1986), Coppolillo (2000), Western and Dunne (1979) and Coppock et al. (1986) have demonstrated greater concentration by pastoralists, for both settlement relocation and livestock mobility in West and East Africa. Hypothesizing greater concentrations during these periods assumes that the wet season is regular and precipitation is more or less continuous, such that vegetation productivity is high and an adequate amount of surface water collects in seasonal streams.

4.7.2 Hypothesizing parameters against herd size

We hypothesize that for both types of enclosure locations, the average daily total time of travel and distance will be lower for small and medium sized herds than large herds. This is because smaller herds are easier to maneuver than larger ones and cattle may be directed to and from forage areas with greater ease and less labor strain on the herder, enhancing forage intake. As herd size increases, the amount of forage needed to sustain the herd is greater and less likely to be found closer to the enclosure, increasing the length and duration of travel. Coppolillo observed complicated relationships between herd size and productivity noting that “herd size did not affect intake rate but large herds spent more time walking and less time feeding” (Coppolillo 2000: 550).

We expect that small and medium herds will have a higher degree of concentration (lower variance in the mean bearing) than large herds, for both permanent settlements and temporary camps. Field observations suggest that small and medium sized herds are easier to manage; additionally we believe that the same set(s) of herders are likely to herd cattle of small and medium herd sizes and thus are likely to revisit the same areas (areas that they have scouted previously for higher vegetation productivity) (Niamir-Fuller 1998). Grouped orbits of large herds are likely to have lower concentration values and a higher variance as herders adjust orbit patterns over time in response to the spatial and temporal heterogeneity of suitable forage.

4.7.3 Hypothesizing parameters against enclosure location

We expect that the distance and time parameters will be significantly higher for permanent settlements compared to temporary camps, regardless of herd size and

seasonality as pastoralists move their cattle closer to areas of sufficient forage, and thereby lowering the orbital average total time and distance. Additionally, orbits originating from temporary camps are likely to visit areas that herders have scouted in advance to determine if sufficient forage can be accessed within a grazing day from the temporary camps (Niamir-Fuller and Turner 1999: 37).

We expect the mean bearing (μ) to be significantly different between the two enclosure locations and across the seasons and herd size groups as herding strategies would reflect the changing realities of forage location.

4.8 Methods

4.8.1 *Data collection*

Data were collected from ten Maasai households out of approximately 140 total households, as part of existing research which examines, through a political-ecological framework (Robbins 2004; Zimmerer and Bassett 2003) the patterns and driving processes of pastoral livestock movement (Little 2003; Turner 1999b). Cattle herd sizes from the ten households varied from 45 to 250, with an average of 150 head of cattle per household. These households were selected based on three broad criteria: willingness to participate in the study; location within two kilometers of the border of the MMNR; representative variability in herding strategies and herd size/composition. Information on household characteristics that helped determine which households were selected for the study was gathered during earlier studies in 2001 and supplemented with subsequent field visits to the study site between 2002 and 2005. The sample size was restricted to ten households because logistical constraints limited the number of households that could be

reached before the cattle left in the morning. Additionally, these households served as the units of analysis for household surveys and key informant interviews³⁰. A larger sample would have limited the frequency and detail of information obtained from interviews and surveys and we would not have been able to synthesize household-level herding management strategies with orbit characteristics.

Cattle mobility measures were obtained from direct sampling of animal locations throughout their daily movement. Locations were recorded using a Garmin eTrex legend 12 channel GPS receiver (at a cost of < US\$120 each), which was enclosed in a plastic bag and a canvas pouch to protect the equipment. This assembly was taped to the cow bell. The receiver was powered by two rechargeable AA 2500 mAh batteries that typically lasted between 15 and 18 hours. The GPS receiver was set to log the date, universal time, northing, easting, elevation, speed, distance, time increment³¹ and bearing at 15 second intervals. One GPS unit was placed on a single uncastrated bull from each of the Maasai households before the herd left the cattle enclosure in the morning (usually between 7 and 9 am) and removed when the herds returned after the grazing day (usually between 6 and 8 pm). Each resulting path of points collected over the grazing day, referred to as the grazing orbit (Fig. 4.4), was then downloaded and stored as Unicode text files using the OziExplorer™ GPS software each evening. Data were collected daily between August 2005 and August 2006 for herds from the ten households comprising the

³⁰ Human subjects research was approved through the Michigan State University Social and Behavioral Sciences Institutional Review Board #05-533 on June 16, 2005 and subsequently renewed on June 13, 2006 and 2007 under the title “Grazing on the Edge: Competition, Conflict and Socio-Ecological Complexity in Pastoralists Herding Strategies around the Maasai Mara National Reserve, Kenya.”

³¹ In this context time refers to the time, in seconds, from the previously captured point. Although the GPS was configured to collect one point every 15 seconds, in some instances, largely due to poor reception from in-situ and atmospheric effects, the time interval varied.

study site; between two and six grazing orbits were captured per day, constituting a total of 1118 grazing days.

Potential sources of error in the GPS data include: (1) atmospheric conditions such as heavy cloud cover or heavy rainfall (Solheim et al. 1999); (2) local environmental effects such as the scattering of the satellite signals when cattle were under dense canopy (Liu 2002); and (3) in-situ effects, such as the power on the GPS inadvertently switching off (Kawamura et al. 2005), poor placement of the GPS on the cow bell, and the effect of covering the GPS units for protection.

Measures were taken to document the magnitude of these error sources, and to remove non-representative data. We manually plotted each grazing orbit and discarded incomplete grazing orbits and grazing orbits with excessive spatial scattering. We conducted field trials at the beginning of the study (August 2005) to determine the effects of the canvas casing on the accuracy of the GPS units. The canvas housing did not substantially reduce the accuracy of the GPS receiver. Units with the housing were comparable (standard deviations of 15 meters) to receivers without the canvas. Additionally, we placed GPS collars on multiple cattle within the same herd to determine if the grazing orbit of a single bull was representative of the orbit of the entire herd. The grazing orbits were found to be within a standard deviation of 30 meters from each other. Since the typical width of a medium sized herd is 50 meters, we accepted this source of error.

4.8.2 Processing and analysis

Each grazing orbit consisted of thousands of spatial locations, each with associated attributes. Grazing orbits were coded by household, household type, season, and herd size. Data files were then transferred to a Microsoft Access™ database and coded according to which household the data was obtained from, the season, and the size of the herd. Text files were then merged for each household, and then for each month and translated into STATA/SE™ version 7.0 to undertake the analyses (StataCorp 2005). Subsets of the original dataset containing 2.76 million data points of the orbits were created by grouping each of the parameters by the date and then further sub-dividing by the seasonal breaks and herd size classifications³². This produced a dataset of total distance (d) and total time (t), for each grazing orbit to produce a total of 1118 grazing day variables. A testing framework was then devised to outline the hypothesized relationships and statistical tests used to either accept or reject the hypotheses (Tab. 4.1).

A series of one-tailed ANOVA tests was conducted to determine significant differences between the average total distance (d) and time (t) against seasonality, herd size and by household type. Bonferroni posthoc statistics for multiple comparisons were calculated to determine mean difference at the 95% confidence level was calculated in SPSS 14.0 (SPSS 2005). A difference of means test was conducted in STATA to determine significant differences between household type and the parameters of mobility, for each season and herd size grouping.

The third parameter (the direction that cattle travel within a grazing day) is an angular circular distribution (0°- 360°). The probability distribution for this type of data

³² This was calculated using the 'summarize attributes' tool as part of the Animal Movements extension (Hooze and Eichenlaub 2000) for ArcView™ software (ESRI 1996)

is the unimodal equivalent of the normal distribution known as the von Mises distribution. To calculate the mean bearing (μ), circular variance (s^2) and the concentration (r) against seasonality, herd size and by household type, we relied on Oriana™ software version 2.02 (KCS 2005). The circular mean and variance are interpreted in similar fashion as noncircular distributions, but are calculated differently. To test whether the mean angles for each constraint and enclosure location differed significantly we performed Watson-Williams F-Tests (Fisher 1993; Batschelet 1981). The assumptions of the F-test are that: (1) the data are independently drawn and follow a von Mises distribution; and (2) that the samples are sufficiently large (more than two) (KCS 2005).

4.9 Results

4.9.1 Seasonality against permanent settlements

The results of the ANOVA test suggest that the average total orbit time differs significantly between all three seasons (Tab. 4.2) ($F = 27.992$, $p > F 0.001$). The average total time of travel is 11.09 hrs in the wet season, 12.01 in the dry season and 12.87 hours in the drought season. Hence we accept hypothesis 1 and conclude that time of travel is lowest in the wet season and highest in the drought for permanent households.

We do not find a significant difference between how far cattle walk in the wet versus the dry seasons (12.90 vs. 12.85 kilometers), but identify a significant difference between dry season and drought orbit length (12.85 vs. 16.57 kilometers). We therefore reject hypothesis 2 as significant differences are only noted between the dry and drought season.

Analyses of the bearing show significant differences between the wet (187.5°) and the dry seasons (251°) (Fig. 4.5). However, only a minor and statistically nonsignificant difference exists between the mean bearings of the dry and drought seasons (251° vs. 245°). We also find that the direction of travel is highly concentrated about the mean in the drought ($s^2 = 0.14$) and less concentrated about the mean in the dry and wet seasons ($s^2 = 0.71$ and 0.67 respectively). We therefore reject hypothesis 3, but note the high difference in the variance for the drought and similarities in the variance for the wet and dry seasons.

4.9. 2 Seasonality against temporary camps

The same parameters and test procedures were repeated for temporary households across the three seasons (Tab. 4.3). We found the average total time of travel decreased by 1.73 hours between the dry (12.31 hrs) and drought (10.57 hrs) season. This difference is significant in a two-tailed difference of means test, but the direction is opposite to the hypothesis and we reject hypothesis 1. There were nonsignificant differences in the total distance traveled between all three seasons ($F = 0.89$, $p > F 0.413$), and therefore we reject hypotheses 2.

The mean direction that cattle travel from temporary households travel in the dry and drought periods are similar (247.17° vs. 246.02° respectively), as is the variance (0.19 vs. 0.14). However, in the wet season orbits from these households are more likely to travel towards the south (193.25°) and with a higher variance (0.42) and therefore we accept hypothesis 3.

4.9.3 Herd size against permanent settlements

There are no statistically significant differences between time of travel and herd size ($F = 3.13$, $p > F 0.045$) (Tab. 4.4) and thus we reject hypothesis 4. The average total daily distance traveled for cattle differs significantly ($F = 10.883$, $p > F 0.001$) between herd sizes, especially between small and medium herd sizes (12.13 vs. 13.60 kilometers) and between small and large herd sizes (12.13 vs. 13.15 kilometers), but not between medium and large herd sizes (13.60 vs. 13.15 kilometers). Hence we reject hypothesis 5, but note that medium and large herd travel similar distances for permanent households.

The mean bearing is different and significant between orbits for all three herd sizes, with small herd sizes recording a mean bearing of 229° , medium herd sizes 264° and large herd sizes 154° . The data are most clustered about the mean for medium herd sizes ($s^2 = 0.44$) followed by small herd sizes ($s^2 = 0.49$), while the mean direction of travel for large herd sizes is least concentrated ($s^2 = 0.73$). We therefore reject hypothesis 6, but note the high directional variability in orbits of large herd sizes.

4.9.4 Herd size against temporary camps

Significant differences are found ($F = 10.91$, $p > F 0.001$) in the average total time of travel between small and medium herd sizes (10.96 vs. 12.63 hours), and between medium and large herd sizes (12.63 vs. 10.21 hours), but no significant difference exists between small and large herd sizes (10.96 vs. 10.21 hours), and therefore reject hypothesis 4 (Tab. 4.5). The average total distance traveled demonstrates the same relationship and is significant ($F = 14.592$, $p > F 0.001$) between small and medium herd sizes (12.16 vs. 15.51 kilometers), and between medium and large herd sizes is (15.51 vs.

12.14 kilometers). Average total distance traveled between small and large herd sizes is not significant (12.16 vs. 12.14 kilometers). Here we note the large difference between small and medium herd sizes and the lack of difference between medium and large herd sizes and reject hypothesis 5.

The mean direction of travel across herd sizes from temporary households also shows significant differences. The mean bearing calculated for small herd sizes is 179° , while medium herd sizes have a mean bearing of 255° and large herd sizes a mean bearing of 245° . The data are less clustered about the mean for small and large herd sizes ($s^2 = 0.20$ and 0.23 respectively), while medium herd sizes were most concentrated around the mean ($s^2 = 0.05$). We therefore reject hypothesis 6 and note the surprisingly high degree of concentration for medium herd sizes and the similarity in concentration, though not mean bearing between small and large herd sizes.

4.9.5 Comparisons between enclosure locations

Seasonality: We hypothesized that significant differences in the orbit duration and distance would exist across the three seasons, with lower average values for temporary households than permanent ones. However, we find that the only significant difference in the total time of travel by season occurs during the drought where the time of travel is found to be 0.67 hours higher for permanent households ($t = 3.44$, $p > t 0.001$). The total distance is 3.53 kilometers higher for permanent households ($t = 3.92$, $p > t 0.001$), which is also recorded during the drought (Tab. 4.6). Hence, we only accept hypotheses 7 and 8 for the drought. Interestingly, we find no significant differences in the mean bearing

between any of the seasons, where the bearings are almost identical within seasons regardless of the household type. We therefore reject hypothesis 9 for all seasons.

Herd size: Time of travel is found to be 1.34 hours higher ($t = 3.82, p > t 0.001$) for large herd sizes originating from permanent households, while the total distance traveled is 1.02 kilometers longer ($t = 2.18, p > t 0.001$) for large herd sizes originating from permanent households) (Tab. 4.7). Mean bearings between temporary and permanent households are significant only for medium herd sizes and accept this hypothesis, while we reject the other hypotheses as significant differences are observed for small and large herd sizes.

4.10 Discussion

As with other studies that have examined pastoral livestock mobility, we find that parameters of mobility are highly variable between the seasons, herd sizes and enclosure locations (Bassett 1986; Coppolillo 2000) (Tab. 4.8). This is not surprising given that the individual characteristics of a household, coupled with landscape heterogeneity, will affect the decision-making strategies that synergistically produce patterns of cattle mobility.

An important finding is that pastoralists herd their cattle towards the MMNR irrespective of seasonality and herd size constraints. Since all settlements and camps are located two kilometers north of the MMNR, we find that cattle movement into the park between bearing directions 150° and 270° occurs frequently. This suggests that movement into the protected area takes place year round and not just during periods of drought. This finding is significant because drought is commonly cited as a primary

reason for encroachment into PA's in other developing countries (Sweet 1998; FEWS 2005; Bedunah and Schmidt 2004). The distribution of movement into the MMNR varies between seasons and the actual grazing locations can be imputed from the circular variance measures and the distance traveled.

4.10.1 Effects of seasonality on mobility

Four main findings are evident when we examine mobility parameters by season. These findings take into account both significant and non-significant results.

Seasonality has the greatest effect on the duration and distance of grazing orbits for cattle that do not relocate during the drought. The distance traveled for cattle from permanent settlements also increases dramatically between the dry and the drought season. This suggests that households that do not invest in setting up temporary camps are likely to face greater stress on their cattle and herders. However, we are not able to ascertain from this analysis why permanent settlements do not relocate during the drought.

There are no significant differences in the distance that cattle travel between the wet and dry season for permanent settlements. We speculate that the quality of forage in the wet season may have been poorer due to the lag between rainfall and vegetation growth, particularly since unusually strong drought conditions preceded the wet season.

Cattle from temporary camps show no significant differences in the distance traveled between any of the seasons. This suggests that herders from temporary camps continually adapt their strategies to minimize orbit distance. This is likely attributed to cattle exhausting wet season grazing zones, before moving to dry season grazing zones

located further away. Once dry season grazing zones are exhausted, cattle are then directed to the last reserves of forage in specialized drought grazing areas and thus reflects a strategy of continual movement (Oba and Lusigi 1987). Such a strategy would explain the observed pattern and is similar to the 'pendulum movements' that Bassett (1986) documents in West Africa.

Grazing direction is least concentrated during the wet season and most concentrated during the drought. Mean bearing is also indicative of movement into the MMNR (towards the south and south-west) but movement also occurs in other cardinal directions during the dry and wet season. Maasai pastoralists who chose to relocate to temporary camps prior to the drought (i.e. during the dry season) exhibit a much lower variance suggesting that they have already scouted these locations in advance and direct the cattle towards these reserves. Regardless of the type of base, the direction that cattle travel in the drought is most concentrated and the mean bearing direction is still towards the MMNR.

4.10.2 Effects of herd size on mobility

Results for herd size constraint by enclosure locations reveal that none of the hypothesized relationships were true. However, closer examination of the statistics reveals the following.

Herd size has no effect on duration of travel for permanent settlements. This suggests that irrespective of herd size, labor is not a limiting factor in the herding strategies of permanent settlements. Since permanent settlements have a larger infrastructure base, which includes more herders available to assist in cattle movement

and management decisions as knowledge is shared and disseminated rapidly such that cattle reach grazing locations quickly.

Medium herd sizes are least flexible in their strategies. Medium herd sizes show the highest significant differences when compared against small and large herd sizes for distance (for both temporary camps and permanent settlements) and time (only for temporary camps). This is attributed to the ease of herding. Small herds usually require one herder, while large herds may have two or more herders. Circular variance is also low (but not as low as for medium herds for smaller herds), and is attributed to the ease with which pastoralists are able to defend the herd from attacks by wildlife, as are those for large herds, which have two herders. We speculate that due to their limited resources (both labor and income); temporary households are less flexible in their strategies, and concentrate grazing destinations for medium sized herds in distinct areas.

4.10.3 Effects of herd relocation on mobility

Two notable findings are clear when we compare mobility parameters against the enclosure type.

Cattle from temporary camps and larger sized herds spend less time grazing and cover shorter distances in the drought than cattle that did not relocate. The rationale to relocate during for the duration of the drought does result in reduced strain, and large herd sizes are likely to benefit from the reduced strain. Field observations suggest that cattle from temporary camps move towards the tall grass plains deep inside the MMNR towards the confluence of the Talek River and a seasonal stream. This area is dominated by *Themeda triandra* grasses that are highly suited to cattle in the drought.

There is no difference in the mean bearing direction between orbits for both enclosure type and seasonality. The similarity between the mean bearings suggests that cattle depart from their enclosures without great variation in the direction of travel, which is towards the MMNR. Additionally, during the drought, circular variance for both household types is very low suggesting that movement is more concentrated. Based on our informal interviews with herders and field observations, we believe this is because forage is found in distinct places inside the MMNR and herders direct their cattle towards these places with the aim of reaching that location, grazing at that spot before returning directly back to the household. This may also account for the lower distances and times noted earlier.

4.11 Conclusions

The aim of this paper was to determine how parameters of mobility changed with seasonality and herd size for permanent settlements and temporary camps. We sought to achieve two objectives: (1) to determine how relocation of cattle to temporary camps reduces the effects of drought and; (2) to determine the periodicity of cattle movement into protected areas. A methodological aim was to investigate the efficacy of modified GPS collars to directly capture parameters of mobility. We collected over 2.76 million data observations associated with grazing orbits taken for ten Maasai households over 12 months. Orbit level mobility parameters were grouped by season, settlement type and herd size. We then evaluated these metrics by use of ANOVA tests.

The results of the first objective suggests that household relocation reduces the stress faced by pastoralists during the drought by: (1) lowering the average total daily

distance and time; (2) directing cattle towards the inside Maasai Mara National Park (MMNR) and; (3) concentrating the direction to distinct grazing zones inside the MMNR. The statistical findings indicate that permanent settlements that do not relocate face the highest degree of stress on their cattle. However, we do not as yet understand why herd managers from these settlements chose not to relocate their herds.

For the second objective, the results also indicate that livestock movement into the MMNR occurs during the wet, dry and drought periods, but the direction of travel is more diffuse in the wet and the dry season, with movement during the drought being most concentrated. For all three seasons, the mean bearing is indicative of movement towards tall grass plains inside the MNNR.

This paper also demonstrated the use of a modified low cost GPS collar as an effective tool to capture parameters of mobility. The methodology employed, though labor intensive, provides an unparalleled dataset that contains much more detailed information about herd movement than has been previously collected. The data are amenable to a rigorous testing paradigm to identify critical mobility parameters.

Our findings have raised new questions on possible social and ecological driving processes that produce the observed patterns. Analysis of GPS derived data is good at identifying patterns and correlations, but it is limited in terms of explanatory power. This analysis can be greatly complemented by integrating herder knowledge to understand where preferred grazing patches are located (Oba 2001). This information would lead to hypothesis development on how herders respond to environmental variability that is rooted in a grounded theory approach (Glaser and Strauss 1967; Strauss and Corbin 1997).

We have speculated that forage availability and quality are necessary drivers of herd management and mobility decisions. Future research should incorporate the use of remotely sensed imagery that captures vegetation data at finer scales of time such as the MODIS Normalized Differential Vegetation Index (NDVI) which has been shown to be positively correlated with rainfall and net primary productivity (Justice et al. 1998). MODIS data is globally available for 16 day composites at 250 meter resolution and therefore provides an excellent means for linking GPS-derived grazing orbit patterns to ecological process. This combination would facilitate a 'pattern to process' approach that is common in many nature-society studies (Skole et al. 2004; Campbell et al. 2005; Sheppard and McMaster 2004).

We have relied on only three parameters of mobility that were collected the GPS unit. Additional research should consider incorporating parameters such as elevation and slope derived from digital elevation models (DEM's). These measures may be included alongside bearing to determine the role that upland areas and local topography play in drought coping strategies.

While this study only considered two main constraints on mobility, there are of course other factors that help explain patterns of mobility. These include, but are not limited to, land cover, soil type and soil moisture, settlement density, distance from the household, distance from water, presence of barriers particularly in areas where sedentarization has resulted in individualization and the imposition of fences. Collectively these constraints could help explain the dynamic nature of pastoral mobility to a much greater extent and provide an empirical basis for collective bargaining, conflict prevention and resolution.

The impacts of drought on pastoralists have largely focused on stock losses. Although stock losses are an important means by which to quantify the effects of drought, this research has demonstrated that parameters of mobility derived from cattle are also important indicators. Future research should combine estimates of stock losses with parameters of mobility to unveil the impacts of drought on pastoralist herding strategies.

The research has answered calls for a more comprehensive investigation of the mobility paradigm in studies of pastoralism. These results will stimulate additional research that moves towards a methodological and evidence based approach which, through repetitive, comparative and representative studies leads us back to theory development. This will facilitate a more thorough and practical framework for studying pastoralism and attaining the broad and elusive goal of environmentally sustainable development in rangelands.

Figure 4.1: Study site in national and local contexts. Map 1: Kenya showing the study region in south western Kenya within the Narok district of Rift Valley Province. Map 2: The Maasai Mara National Reserve (MMNR) along the Kenya-Tanzania border – the MMNR lies north of the Serengeti National Park in Tanzania. Map 3: The study site showing the Talek village center, perennial rivers, seasonal streams and 100 meter contour intervals.

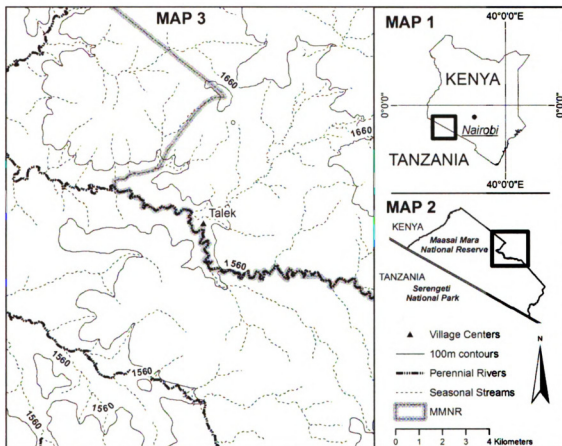


Figure 4.2: Representation of herd relocation, herd splitting and relocation, and herd splitting and reformation across the seasons. Drought losses are expressed in negative parentheses.

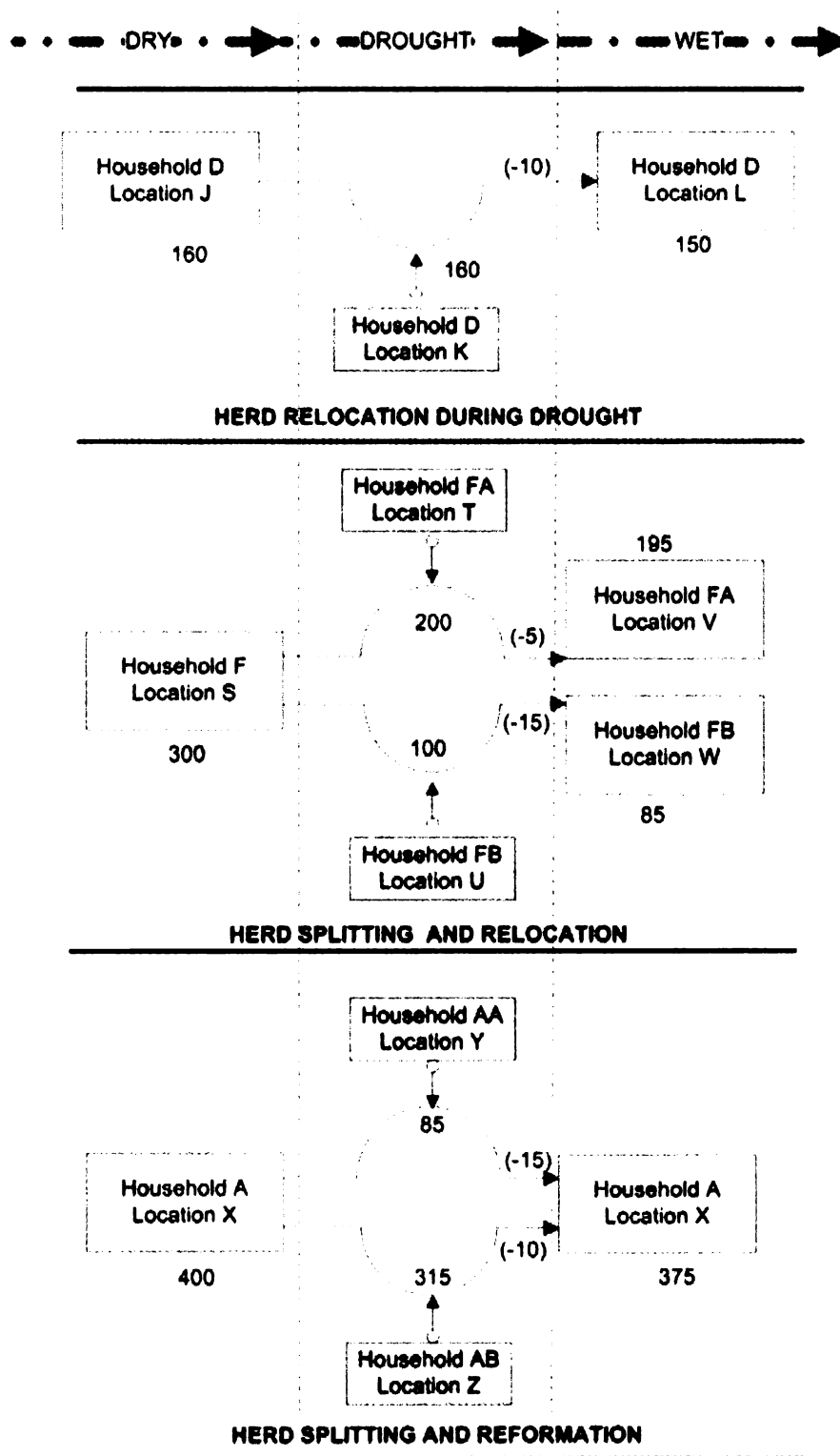


Figure 4.3: Total daily precipitation and maximum daily temperature and delineation of seasonality break points within the study area between August 1, 2005 and August 18, 2006. The wet season is associated with low daily maximum temperatures and high precipitation. Dry season is associated with high temperature and low precipitation. Drought is associated with maximum temperature and lowest precipitation.

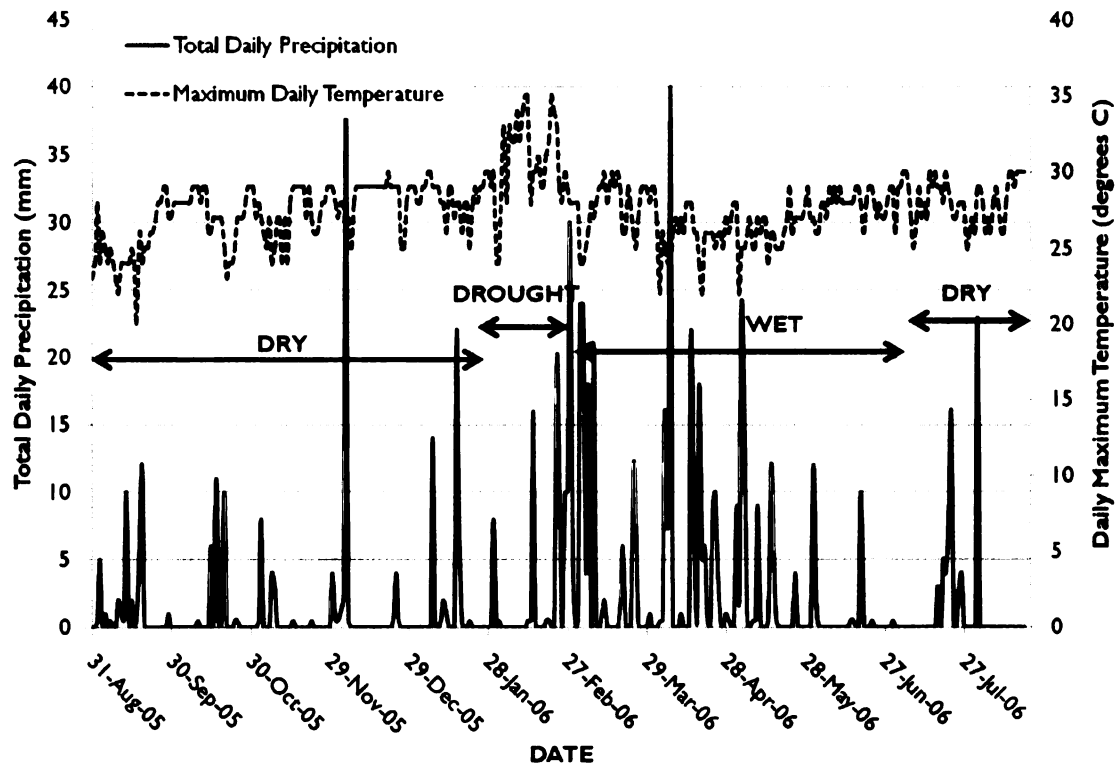


Figure 4.4: A sample grazing orbit tracked at 15-second intervals. The direction of movement is counterclockwise. Point 'P' is the furthest point from the enclosure in a straight line distance and it is the point from which the bearing measure is derived. Track points that are dispersed indicate walking segments, while points closer together indicate segments where cattle are near stationary and likely to be grazing.

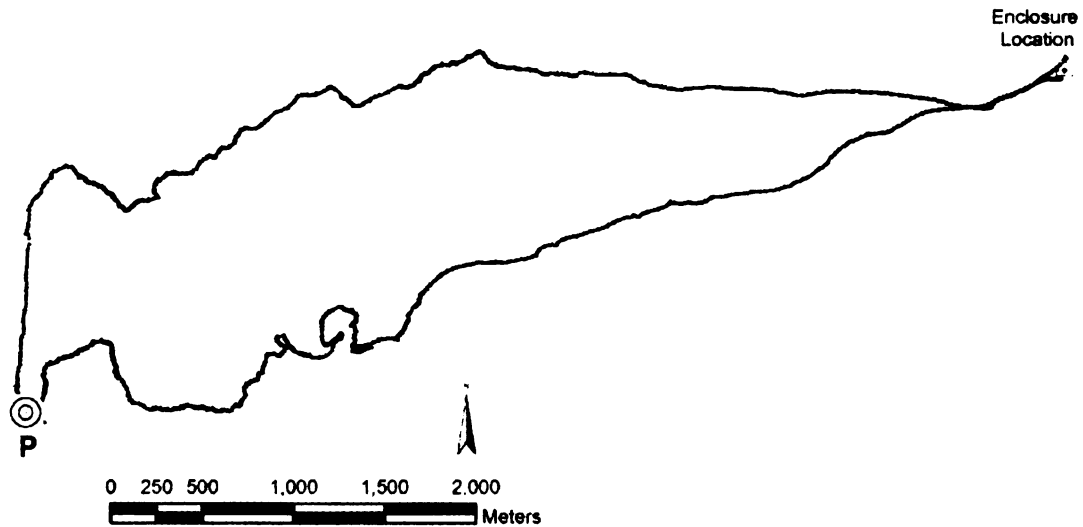


Figure 4.5: Stacked rose diagrams of orbit bearing by season for permanent households ($n = 411, 482$, and 47 for the wet, dry and drought seasons respectively). The length of the arc represents the variance. Mean bearing for the wet season is $187.49^\circ \pm 85.19^\circ$, with a variance of 0.67 , dry season mean bearing is $250.85^\circ \pm 90.23^\circ$ with a variance of 0.71 , while the mean bearing for the drought season is $248.96^\circ \pm 31.47^\circ$ with a variance of 0.14 .

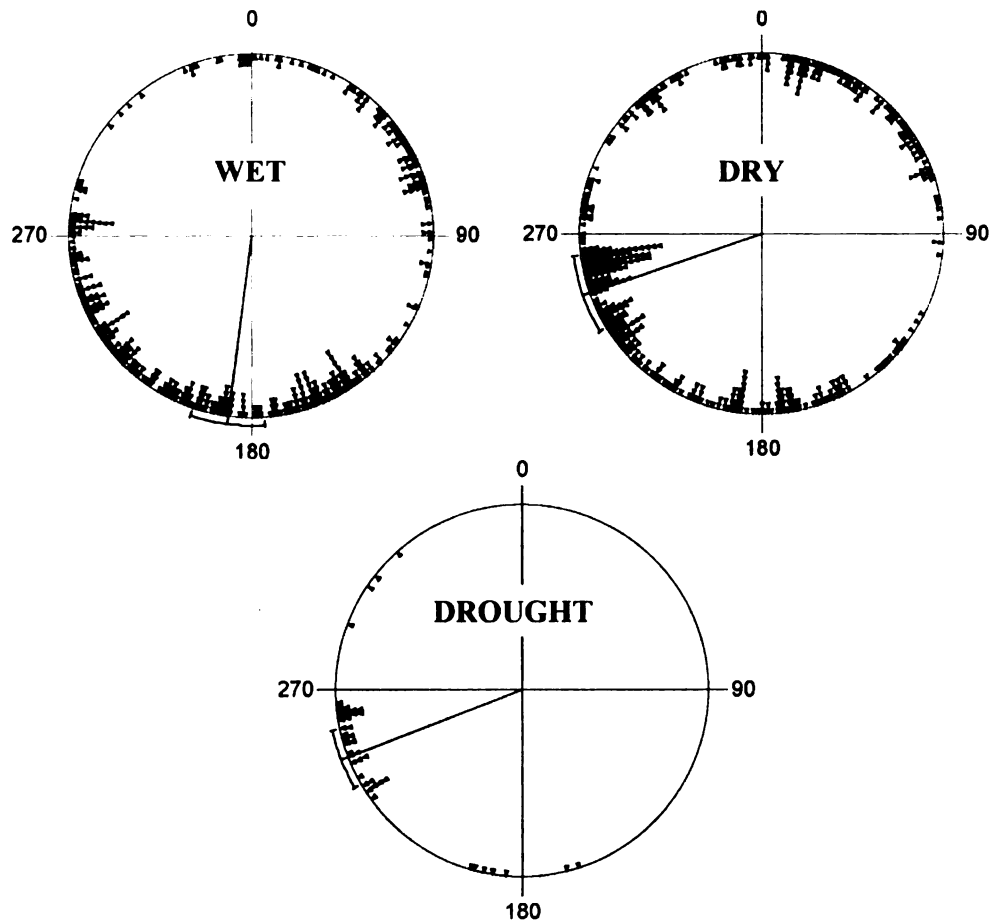


Table 4.1: Testing framework for research hypotheses (t is the average total duration of travel, d is the average total distance traveled, μ is the mean bearing and s^2 is the circular variance of the mean bearing direction of travel). Enclosure location is defined as the place of origin and departure of cattle and is divided into two types: permanent settlements and temporary camps. Seasonality is divided into three categories: wet, dry and drought, while herd size is divided into small herds (less than 60 head of cattle), medium sized herds (between 60 and 150) and large herd sizes (over 150 head of cattle).

Research Hypotheses	Tested Against	Test Type
$H_1 : t_{(WET)} < t_{(DRY)} < t_{(DROUGHT)}$	Enclosure location	ANOVA
$H_2 : d_{(WET)} < d_{(DRY)} < d_{(DROUGHT)}$	Enclosure location	ANOVA
$H_3 : s^2_{(DROUGHT)} < s^2_{(DRY)} < s^2_{(WET)}$ F-Test	Enclosure location	Watson-Williams
$H_4 : t_{(SMALL)} < t_{(MEDIUM)} < t_{(LARGE)}$	Enclosure location	ANOVA
$H_5 : d_{(SMALL)} < d_{(MEDIUM)} < d_{(LARGE)}$	Enclosure location	ANOVA
$H_6 : s^2_{(SMALL)} < s^2_{(MEDIUM)} < s^2_{(LARGE)}$ F-Test	Enclosure location	Watson-Williams
$H_7 : t_{(CAMPS)} < t_{(SETTLEMENTS)}$	Seasonality and Herd Size	T-Test
$H_8 : d_{(CAMPS)} < d_{(SETTLEMENTS)}$	Seasonality and Herd Size	T-Test
$H_9 : \mu_{(CAMPS)} \neq \mu_{(SETTLEMENTS)}$ F-Test	Seasonality and Herd Size	Watson-Williams

Table 4.2: Seasonality constraints tested against mobility parameters for permanent settlements. Distance (d) and Time (t) are tested using a one-tailed ANOVA, while bearing is tested using a one-tailed Watson-Williams F-test. * The mean difference is significant at the 0.05 level.† Degrees of freedom for the Watson-Williams F-Test between wet and dry are 1 and 891 (F = 93.44), degrees of freedom between wet and drought are 1 and 456 (F = 40.15), and degrees of freedom between dry and drought are 1 and 527 (F = 0.04).

Dependent Variable	(I) season	mean $\pm$ s.d.	var	(J) season	mean difference (I-J)	p
Time (hrs) F 27.992 p > F 0.0001 df 2, 937	1 (wet) n=411	11.09 $\pm$ 2.60	6.78	2	*-0.93	<0.001
				3	*-1.78	<0.001
	2 (dry) n=482	12.02 $\pm$ 1.70	2.89	1	*0.93	<0.001
				3	*-0.85	0.022
	3 (drought) n=47	12.87 $\pm$ 2.06	4.27	1	*1.78	<0.001
				2	*0.85	0.022
Distance (kms) F 25.335 p > F 0.0001 df 2, 937	1	12.90 $\pm$ 3.87	14.99	2	0.04	1.000
				3	*-3.67	<0.001
	2	12.85 $\pm$ 3.03	9.14	1	-0.04	1.000
				3	*-3.71	<0.001
	3	16.57 $\pm$ 3.88	13.48	1	*3.67	<0.001
				2	*3.71	<0.001
Bearing (deg)†	1	187.49° $\pm$ 85.19°	0.67	2	*-63.36°	<0.001
				3	*-61.47°	<0.001
	2	250.85° $\pm$ 90.23°	0.71	1	*63.36°	<0.001
				3	1.89°	0.841
	3	248.96° $\pm$ 31.47°	0.14	1	*61.47°	<0.001
				2	-1.89°	0.841

Table 4.3: Seasonality constraints against temporary camps. * The mean difference is significant at the 0.05 level.

† Degrees of freedom for the Watson-Williams F-Test between wet and dry are 1 and 91 (F = 26.01), degrees of freedom between wet and drought are 1 and 122 (F = 35.61), and degrees of freedom between dry and drought are 1 and 137 (F = 0.03)

Dependent Variable	(I) season	mean $\pm$ s.d.	var	(J) season	mean difference (I-J)	p
Time (hrs) F 5.397 p > F 0.005 df 2, 177	1 (wet) n=39	10.74 $\pm$ 1.87	3.49	2	-1.57	0.060
				3	0.17	1.000
	2 (dry) n=54	12.31 $\pm$ 1.14	1.30	1	1.57	0.060
				3	*1.74	<0.001
	3 (drought) n=85	10.57 $\pm$ 4.29	18.36	1	-0.17	1.000
				2	*-1.74	<0.001
Distance (kms) F 0.889 p > F 0.413 df 2, 177	1	12.78 $\pm$ 2.71	7.34	2	-1.06	0.745
				3	-0.26	1.000
	2	13.83 $\pm$ 2.23	4.93	1	1.06	0.745
				3	0.79	0.952
	3	13.04 $\pm$ 5.44	29.70	1	0.26	1.000
				2	-0.79	0.952
Bearing (deg) †	1	193.25° $\pm$ 59.32	0.41	2	*-53.92°	<0.001
				3	*-52.77	<0.001
	2	247.17° $\pm$ 37.69°	0.19	1	*53.92°	<0.001
				3	1.14°	0.852
	3	246.025° $\pm$ 31.36°	0.14	1	*52.77°	<0.001
				2	-1.14°	0.852

Table 4.4: Herd size constraints against permanent settlements. * The mean difference is significant at the 0.05 level.

† Degrees of freedom for the Watson-Williams F-Test between small and medium herd sizes are 1 and 493 (F = 32.22), degrees of freedom between small and large herd sizes are 1 and 657 (F = 109.40), and degrees of freedom between large and medium herd sizes are 1 and 724 (F = 272.08)

Dependent Variable	(I) season	mean $\pm$ s.d.	var	(J) season	mean difference (I-J)	p
Time (hrs) F 3.113 p > F 0.045 df 2, 937	1 (small) n=214	11.50 $\pm$ 1.82	3.31	2	-0.43	0.099
				3	-0.06	1.000
	2 (medium) n=281	11.93 $\pm$ 1.53	2.34	1	0.43	0.099
				3	0.38	0.083
	3 (large) n=445	11.56 $\pm$ 2.73	7.45	1	0.06	1.000
				2	-0.38	0.083
Distance (kms) F 10.883 p > F 0.0001 df 2, 937	1	12.14 $\pm$ 3.37	11.35	2	*-1.47	<0.001
				3	*-1.02	0.002
	2	13.60 $\pm$ 3.12	9.70	1	*1.47	<0.001
				3	0.45	0.285
	3	13.16 $\pm$ 3.81	14.55	1	*1.02	0.002
				2	-0.45	0.285
Bearing (deg) †	1	229.65° $\pm$ 66.94° 0.49		2	*-34.54°	<0.001
				3	*75.28°	<0.001
	2	264.19° $\pm$ 61.49° 0.44		1	*34.54°	<0.001
				3	*109.82°	<0.001
	3	154.37° $\pm$ 92.44° 0.73		1	*-75.28°	<0.001
				2	*-109.82°	<0.001

Table 4.5: Herd size constraints against temporary camps. * The mean difference is significant at the 0.05 level.

† Degrees of freedom for the Watson-Williams F-Test between small and medium herd sizes are 1 and 91 ($F = 147.63$), degrees of freedom between small and large herd sizes are 1 and 119 ($F = 67.74$), and degrees of freedom between large and medium herd sizes are 1 and 140 ($F = 3.22$)

Dependent Variable	(I) season	mean $\pm$ s.d.	var	(J) season	mean difference (I-J)	p
Time (hrs) F 10.591 p > F 0.0001 df 2, 177	1 (small) n=36	10.96 $\pm$ 2.02	4.07	2	*-1.66	0.036
				3	0.75	0.666
	2 (medium) n=57	12.63 $\pm$ 1.65	2.7	1	*1.66	0.036
				3	*2.41	< 0.001
	3 (large) n=85	10.21 $\pm$ 4.02	16.15	1	-0.75	0.666
				2	*-2.41	< 0.00
Distance (kms) F 14.592 p > F 0.0001 df 2, 177	1	12.16 $\pm$ 2.35	5.54	2	*-3.34	< 0.001
				3	0.03	1.000
	2	15.51 $\pm$ 3.46	11.94	1	*3.34	< 0.001
				3	*3.37	< 0.001
	3	12.14 $\pm$ 4.58	20.98	1	-0.03	1.000
				2	*-3.37	< 0.001
Bearing (deg) †	1	179.75° $\pm$ 38.86°0.20		2	*-76.12°	<0.001
				3	*-65.98°	<0.001
	2	255.87° $\pm$ 18.98°0.05		1	*76.12°	<0.001
				3	10.14°	0.067
	3	245.73° $\pm$ 41.00°0.23		1	*65.98°	<0.001
				2	-10.14°	0.067

Table 4.6: Comparisons of the three cattle mobility parameters by season for the two types of enclosure locations. Time and distance measures are tested using a difference of means test and bearing comparisons are made using a Watson – Williams F-test. All three parameters are tested at the 0.05 significance level*.

	SEASON	Settlements (I) mean	Camps (J) mean	(I-J) mean difference	t /F	p > t/F
Time (hrs)	WET	11.09	10.74	0.42	0.83	0.201
	DRY	12.02	12.31	0.25	-1.18	0.889
	DROUGHT	12.87	10.57	*0.67	3.44	< 0.001
Distance (kms)	WET	12.90	12.78	0.12	0.19	0.424
	DRY	12.85	13.83	-0.98	-2.30	0.992
	DROUGHT	16.57	13.04	*3.53	3.92	< 0.001
Bearing (deg)	WET	187.49°	193.25°	5.75°	0.23	0.631
	DRY	250.85°	247.17°	3.67°	0.16	0.694
	DROUGHT	248.96°	246.03°	2.93°	0.26	0.610

Table 4.7: Comparisons of cattle mobility parameters by herd size for permanent settlements and temporary camps. Time and distance measures are tested using a difference of means test and bearing comparisons are made using a Watson – Williams F-test. All three parameters are tested at the 0.05 significance level*.

	HERD SIZE	Settlements (I) mean	Camps (J) mean	(I-J) mean difference	t/F	p > t/F
Time (hrs)	SMALL	11.50	10.96	0.53	1.61	0.054
	MEDIUM	11.93	12.63	-0.69	-3.07	1.000
	LARGE	11.56	10.21	*1.34	3.82	< 0.001
Distance (kms)	SMALL	12.14	12.16	-0.02	-0.04	0.528
	MEDIUM	13.60	15.51	-1.90	-4.12	1.000
	LARGE	13.16	12.14	*1.02	2.18	< 0.001
Bearing (deg)	SMALL	229.65°	179.75°	*49.90°	23.39	< 0.001
	MEDIUM	264.19°	255.87°	8.32°	1.39	0.240
	LARGE	154.37°	245.73°	*-91.36°	116.27	< 0.001

Table 4.8: Outcome of hypotheses testing.

Hypotheses to Test Parameters by Seasonality	Enclosure Location	
	Permanent Settlements	Temporary Camps
$H_1 : t_{(WET)} < t_{(DRY)} < t_{(DROUGHT)}$	Accept	Reject
$H_2 : d_{(WET)} < d_{(DRY)} < d_{(DROUGHT)}$	Reject	Reject
$H_3 : s^2_{(DROUGHT)} < s^2_{(DRY)} < s^2_{(WET)}$	Reject	Reject

Hypotheses to Test Parameters by Herd Size	Enclosure Location	
	Permanent Settlements	Temporary Camps
$H_4 : t_{(SMALL)} < t_{(MEDIUM)} < t_{(LARGE)}$	Reject	Reject
$H_5 : d_{(SMALL)} < d_{(MEDIUM)} < d_{(LARGE)}$	Reject	Reject
$H_6 : s^2_{(SMALL)} < s^2_{(MEDIUM)} < s^2_{(LARGE)}$	Reject	Reject

Hypotheses to Test Parameters by Enclosure Location	Season		
	Wet	Dry	Drought
$H_7 : t_{(CAMPS)} < t_{(SETTLEMENTS)}$	Reject	Reject	Accept
$H_8 : d_{(CAMPS)} < d_{(SETTLEMENTS)}$	Reject	Reject	Accept
$H_9 : \mu_{(CAMPS)} \neq \mu_{(SETTLEMENTS)}$	Reject	Reject	Reject

Hypotheses to Test Parameters by Enclosure Location	Herd Size		
	Small	Medium	Large
$H_{10} : t_{(CAMPS)} < t_{(SETTLEMENTS)}$	Reject	Reject	Accept
$H_{11} : d_{(CAMPS)} < d_{(SETTLEMENTS)}$	Reject	Reject	Accept
$H_{12} : \mu_{(CAMPS)} \neq \mu_{(SETTLEMENTS)}$	Accept	Reject	Accept

CHAPTER 5

Vegetation dynamics and the spatio-temporal variability of pastoral cattle activities around the Maasai Mara National Reserve, Kenya*.

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Abstract

The relationships between pastoralists, cattle and rangeland environments are largely dependent on seasonality and vegetation cover. The aim of this study is to test hypotheses of interactions between spatially and temporally explicit cattle mobility and land cover using remotely sensed vegetation indices (NDVI). Using distance from pastoral households as the dependent variable for grassland NDVI, this study finds that mean NDVI values for grassland are significantly higher furthest away from pastoral households during the wet, dry and drought seasons with the highest differences recorded for the wet season. As grazing intensity increases, mean grassland NDVI decreases during the wet season, remains stable in the dry season, and increases during the drought season. The spatial location of high intensity areas differ by season and demonstrate that cattle intensively utilize different parts of the landscape at different time periods. High intensity areas during the wet season are found closer to the household; while during the dry season high intensity areas are located further away from the household. During the drought high intensity areas are located furthest away from the household. Areas within 500 meters from the household contain high intensity cells throughout the year.

Key words: savanna vegetation, grazing patterns, Maasai, NDVI, MODIS, drought, parks, cattle mobility, grazing impact.

5.0 Introduction

My objective in this chapter is to demonstrate the use of remotely sensed vegetation index data to delineate trends in the intra-annual variability of savanna vegetation around Maasai pastoral settlements that lie along the northern border of the Maasai Mara National Reserve (MMNR) in Southern Kenya. I consider how vegetation indices vary within and outside a protected area, distance from pastoral settlements, and land-cover type. A second aim of this chapter is to use these data and subsequent trends to quantify how vegetation productivity changes with the intensity of disturbance by pastoral cattle.

Savanna vegetation dominates many arid and semi-arid regions of the world (Middleton and Thomas 1997; Bourliere 1983). Long term ecological research shows that the productivity of savanna ecosystems is highly variable across space and time, and is the product of multiple disturbance regimes, precipitation and edaphic conditions (Oindo, Skidmore, and De Salvo 2003; Swemmer, Knapp, and Snyman 2007; Young et al. 1998; Said 2003; Augustine 2003a, 2003b; Augustine, McNaughton, and Frank 2003; Boutton, Tieszen, and Imbamba 1988a; Vanacker et al. 2005).

Across East Africa, savanna vegetation comprises between 40 and 90% of the total land area³³ (Bourn and Blench 1999; Pratt, Gwynne, and Blackie 1977; Heady 1960). Modification of savannas has been occurring for centuries (Robertshaw and Brown 1990). Savannas are thought to exist and persist because of herbivory from domestic livestock (Young et al. 1998), wild herbivores, especially ungulates (Sinclair 1979; Frank, McNaughton, and Tracy 1998; Sinclair 1995), elephants (Dublin 1995;

³³ In Kenya, savanna regions contribute to 40-50% of the total land area, 80-90% in Tanzania, and 30-40% in Uganda (Bourn and Blench 1999: 7).

Dublin, Sinclair, and Mcglade 1990) and fire (Roques, O'Connor, and Watkinson 2001; Belsky 1992). Many savanna ecosystems in East Africa are currently found within and around large protected areas that support some of the highest densities and distributions of ungulates in the world (Waithaka 2004; Broten and Said 1995).

There has historically been a great deal of controversy surrounding the impacts of domestic livestock on savanna vegetation (Brockington and Homewood 1996, 2001; Turner 2003a). During the colonial era and early independence period (pre-1970's), the commonly held belief by scientists and colonial administrators in many sub-Saharan African countries was that pastoralists' livestock were responsible for 'overgrazing' and 'degradation' due to high stocking rates (livestock density) and poor management techniques (Lamprey 1983; Niamir-Fuller 1999b). These assertions, made using western range science paradigms, were based on coupling stocking rates with predetermined measures of ecological or economic carrying capacity (Turner 1993; de Leeuw and Tothill 1993). These assessments are inaccurate for three reasons. First, they ignore the complex social relations of production and exchange of pastoralist herding strategies (Homewood and Rodgers 1991; Bassett 1986). Second, these perspectives do not account for the spatial and temporal heterogeneity associated with grazing resources in non-equilibrium environments (Turner 1998a). Lastly, where protected areas border pastoral areas, they overlook the varied social and ecological impacts of protected areas on pastoral livelihood systems (Anderson and Grove 1987). Today many conservation managers and development practitioners still accept the dominant perspective of 'overgrazing' and 'degradation,' despite these critiques (de Leeuw and Tothill 1993; Ellis

and Swift 1988; Illius and O'Connor 1999; Fairhead and Leach 1996; Leach and Mearns 1996).

Where attempts have been made to understand the effects of domestic cattle on the productivity of savanna vegetation, researchers have run into difficulties in quantifying the magnitude because of several factors. These are: (1) the large spatial extent of savanna ecosystems; (2) the high spatial and temporal variability of precipitation as the main driving variable of savanna productivity; (3) the complexity of isolating grazing effects of domestic versus wild herbivores; (4) the interconnectedness of different disturbance regimes; and, (5) the lack of flexible techniques to detect and link changes in vegetation to disturbance regimes.

Information on vegetation variability is important in order to better understand the effects of livestock activities on the physical environment on protected areas and pastoral settlements that border these protected areas (Niamir-Fuller 1999b; Fox et al. 2003). This information is critical because pastoralism and conservation are believed by a variety of researchers to be highly compatible land use systems (Prins, Grootenhuis, and Dolan 2000; Lamprey and Reid 2004; Bourn and Blench 1999; Reid et al. 2003).

This paper provides contributions to evaluating intra-annual variability of vegetation greenness at relatively fine spatial and temporal resolutions across multiple land-cover types. Second, the paper describes how researchers may be able to effectively link remotely sensed data with empirical observations of cattle mobility.

5.1 Evaluating Patterns of Variability in Savanna Vegetation

Savannas are defined as, “tropical or near tropical seasonal ecosystems with a continuous herbaceous layer... dominated by grasses or sedges, and a discontinuous layer of trees and/or shrubs” (Skarpe 1992: 293). The general model of variability that savanna ecosystems are thought to follow is the multiple stable state system, where vegetation fluctuates around one or more steady states or points of equilibrium, to which they return to after disturbance (Behnke, Scoones, and Kerven 1993; Bestelmeyer 2006; Walker 1993; Westoby, Walker, and Noymeir 1989b, 1989a). Net Primary Productivity (NPP) is the most common measure of vegetation productivity and is defined as the total vegetative production of an ecosystem minus the losses due to respiration, or alternatively, “the rate at which plants fix carbon through photosynthesis” (Schoen 1997: 477). NPP is highly variable within and between savanna ecosystems, across time and space, and under different precipitation and disturbance regimes (McNaughton, Milchunas, and Frank 1996; Chamaillé-Jammes, Fritz, and Murindagomo 2006; Paruelo and Lauenroth 1998; Melillo et al. 1993).

5.1.1 Soil Moisture, Precipitation and Cover Type

Field, analytical and simulation models of savanna vegetation suggest that soil moisture is among the most important factors determining savanna vegetation productivity (Mistry and Berardi 2006; Cole 1986; Skarpe 1991a, 1992; McNaughton 1985, 1979b). Reviewing this literature, Skarpe (1992) suggests that soil moisture models consider two vegetation components (grasses and trees/shrubs) and two soil components (upper and lower surface soils). Roots from grasses utilize the upper surface

soil layer while roots from trees and shrubs utilize both soil layers. The consensus has been that grasses almost always outcompete woody plants at the surface soil layer (Belsky 1990; Ludwig et al. 2004; Skarpe 1992).

Additional research has demonstrated that heavy grazing (e.g. in areas immediately around pastoral settlements) decreases the amount of grasses, increases soil compaction, and reduces infiltration and water holding capacity (Du Toit and Cumming 1999; Skarpe 1991b). As the amount of grassland decreases, more water becomes available to trees and shrubs, which leads to bush encroachment (Walker et al. 1981). As a result of the lower soil moisture levels, the impacts of herbivory on grasses are believed to be higher than on trees or shrubs during the dry and drought seasons (Hayashi 1992, 1996; Skarpe 1991b).

There is a large body of empirical data to suggest that above-ground NPP is positively correlated with rainfall in savanna ecosystems that receive between 700 and 900 mm of rainfall annually (Sen Roy and Yuan 2007; Ellis, Coughenour, and Swift 1993; Martiny et al. 2006; Scanlon et al. 2002; Wang, Rich, and Price 2003; Paruelo and Lauenroth 1998; Srivastava et al. 1997). NPP of savanna grasses follows a temporal pattern, where NPP is highest in the long rains period, lower in short rains and lowest in the dry season (Deshmukh 1986; McNaughton 1983, 1985). NPP is also found to vary within a season, whereby rates of production are higher for later in the rainy season than at the beginning (Deshmukh 1986; McNaughton 1985, 1983; Pandey and Singh 1992; Augustine, McNaughton, and Frank 2003).

Within savanna ecosystems, the differing spatial arrangement and density of trees and shrubs has led to problems ascertaining: (1) how much NPP is derived from woody

vegetation, herbaceous vegetation, and woody plus herbaceous vegetation, and; (2) how this varies by different tree-grass ratios (McNaughton 1985, 1979a, 1979b). One possible explanation for this interaction lies in how different types of species access different resources; for example House (2003) suggests that:

“...a mixture of C₃ woody plants and C₄ grasses may be able to exploit the seasonal cycle more effectively, with more water use efficient C₄ grasses being able to respond to small rainfall events in the dry season, and C₃ trees able to use more of the available water in the wet season” (House et al. 2003: 1769).

Additionally, C₄ grasses such as *Themeda triandra* have the highest NPP in comparison to their biomass, while the production to biomass ratio for other common grasses such as *Setaria spp.* and *Digitaria spp.* are significantly lower (Deshmukh 1986).

On a global scale, savanna ecosystems contribute the second highest amount of NPP, after tropical rainforests (Augustine 2003a, 2003b). Information on the degree of NPP of individual land-cover types within savanna vegetation is lacking within the literature as this is dependent on the individual site and the ratio of trees, shrubs and grasses. Generally, the assumption has been that on average NPP is highest for dense woody vegetation, while bushland, mixed bushland/grassland and grassland complete the continuum, where grassland has the lowest NPP (Wessels, Prince, and Small 2003; Martiny et al. 2006). However, within these classes, differentiating between the total amount of biomass and the biomass available for herbivory is also difficult to estimate because forage selection is different between domestic versus wild herbivores and among different wild herbivore species (Coppock, Ellis, and Swift 1986; Fryxell, Wilmshurst, and Sinclair 2004; Fryxell et al. 2005; Wilmshurst et al. 1999).

5.1.2 Grazing Intensity, Flexibility, and Exclusion

The intensity of grazing disturbance by wild and domestic herbivores also affects above-ground NPP. Under adequate soil moisture conditions, areas with intermediate levels of grazing intensity stimulate higher NPP than areas devoid of any grazing (Walker et al. 1981; Sankaran and Augustine 2004). The effects of grazing intensity on NPP are also scale dependent; for example, Milchunas and Lauenroth (1993) found that NPP and grazing intensity are affected by the evolutionary history of the grazing site. They suggest, through statistical models, that grazing can increase NPP in areas where there has been a long evolutionary history of grazing, and grazing intensity is low (335-337). Alternatively Skarpe (1992) suggests that, “the differences in vegetation behavior depends more on the differences in flexibility of the herbivore than on the proportion of primary production removed” (295).

In addition to the some of the major drivers and constraints on NPP, the effects of excluding grazing by domestic herbivores endogenous to the system has had a profound effect on the productivity and variability of savanna vegetation (Dublin 1995). In many areas of East Africa, the imposition of protected areas has succeeded in removing indigenous pastoralists and their livestock from historical grazing sites, and enforcing coercive-protective forms of conservation (Brockington 2002; Neumann 1998). Many conservation models implemented in East Africa follow the fences and fines approach in which any grazing by domestic herbivores is prohibited, despite the long co-evolutionary history of numerous savanna species that has occurred within present day protected areas (Neumann 1997). Strategies aimed at the conservation of biological diversity have

traditionally sought to limit disturbance regimes that were endogenous to the system, such as fire and grazing or trampling (Botkin 1990; Dublin 1995; Dublin, Sinclair, and Mcglade 1990; Waller 1990). As a result, changes in species composition have taken place with consequent changes to NPP (Allen, Wilson, and Mason 1995; McNaughton 1993; Milchunas, Sala, and Lauenroth 1988; Young et al. 1998; Belsky 1992; Courtois, Perryman, and Hussein 2004). Specifically, McNaughton (1993) drawing on research from (McNaughton 1979a, 1979b, 1983; Belsky 1986) in the Serengeti-Mara ecosystem suggests unequivocally that, “grazing benefits many grasses and other plants in grassland ecosystems..(and) moderate grazing promotes the productivity of many grasslands above the levels that prevail in the absence of grazing” (McNaughton 1993: 19-20).

5.2 Use of Remotely Sensed Imagery to Understand Vegetation Variability

In the absence of laborious and expensive estimates of NPP collected in the field (clipping, drying and weighing dry biomass), remotely sensed estimates provide the best and most reliable alternative. A number of remote sensing based products have been derived over the last 30 years to help understand vegetation variability on a global scale. The most common remote sensing products are: the Normalized Difference Vegetation Index (NDVI); Enhanced Vegetation Indices (EVI); Leaf Area Index (LAI); and Fraction of Photosynthetically Active Radiation ($fPAR$).

Of these measures, NDVI has long been regarded as the most accurate indicator of vegetation productivity and variability in many different ecosystems around the world (Tucker and Sellers 1986; Prince and Goward 1995; Field, Randerson, and Malmstrom 1995; Anyamba and Tucker 2005). Derived through various satellite platforms and

sensors, NDVI data are produced from red and near-infra red spectral reflectance measurements (DeFries and Townshend 1994), that determine the amount of absorbed and reflected photosynthetically active radiation from the density of chlorophyll within leaf structures and the density of the green leaves (Chamaille-Jammes, Fritz, and Murindagomo 2006). NDVI data are calculated as:

$$NDVI = \frac{\rho_{NIR} - \rho_R}{\rho_{NIR} + \rho_R}$$

where ρ_{NIR} is the reflectance from the near infra-red band and ρ_R is the reflectance from the red band.

NDVI values range from -1 to 1, with positive values associated with vegetative cover and negative values associated with bare surfaces such as rocks, ice, and bare ground. The normal range of vegetative cover is between 0.1 and 0.8. Lower positive values (between 0.2 and 0.3) are associated with low vegetation cover, while values between 0.4 and 0.8 demonstrate greener and denser vegetative cover.

Studies from different ecosystems have found that NDVI data are highly correlated with precipitation (Eklundh 1998; Richard and Pocard 1998; Anyamba and Eastman 1996; Fang et al. 2001; Wang, Price, and Rich 2001; Martiny et al. 2006) and primary productivity (Scanlon et al. 2002; Prince 1991; Tsolmon, Tateishi, and Tetuko 2002; Verbesselt et al. 2006). NDVI is also the most reliable indicator of brown biomass that typifies savanna ecosystems (Cihlar, St.-Laurent, and Dyer 1991; Paruelo and Lauenroth 1995; DeFries, Hansen, and Townshend 1995)

Most research using NDVI data has focused on pixel resolutions (between 1 and 8 kms) that cover continental or regional biomes, coupled with high temporal scales

(usually at bi-monthly, inter-annual and decadal intervals) (Serneels and Lambin 2001a; Sen Roy and Yuan 2007; Martiny et al. 2006; Funk and Brown 2006). The research questions at these scales have sought to identify and quantify different land-cover types and temporal land-cover change (Serneels and Lambin 2001a; Nemani and Running 1997; Boone et al. 2007; DeFries and Townshend 1994), their effects of climate-land surface interfaces (Bounoua et al. 2000), carbon flux (Box, Holben, and Kalb 1989), and species richness (Rasmussen, Wittemyer, and Douglas-Hamilton 2006).

The recent launch and operation of the Moderate Resolution Imaging Spectroradiometer (MODIS) sensor on-board the Terra Earth Observation System (EOS) spacecraft has provided an alternative to these coarse resolution remote sensing tools by providing relatively fine spatial (250-meter) and temporal resolutions (16-day) (Justice et al. 1998). As a result, MODIS data have provided greater insight into savanna vegetation dynamics in Africa across both space and time through a number of studies that have examined fire frequency (Chongo et al. 2007), land-cover change (Linderman et al. 2005), and vegetation variability in response to precipitation (Vanacker et al. 2005), and wildlife movements (Boone, Thirgood, and Hopcraft 2006).

5.3 Hypothesizing Patterns of Vegetation Variability

Based on these literatures, I developed five hypotheses to test patterns of vegetation productivity and variability in order to better understand the relationships between pastoralism, livestock and savanna environments. The first two hypotheses identify how different cover types respond to seasonality and how a protected area border influences vegetation variability. The latter three hypotheses consider the spatial

dimensions of grassland variability with different degrees of cattle intensity. Specifically, I hypothesize that:

- (1) *Densely wooded areas will demonstrate the highest values of NDVI, followed by bushland, mixed bushland/grassland, and finally grasslands demonstrating the lowest level of NDVI. This trend is hypothesized to be true for all seasons (wet, dry and drought).*
- (2) *NDVI values for the four different land-cover types listed above will be higher inside a protected area than outside. I also expect this to be true throughout the seasons.*
- (3) Assuming that the presence of cattle is highest close to all pastoral settlements in the study area and the effects of grazing are greater at these locations, I hypothesize, that *as distance from all pastoral settlements increases, NDVI values for grasslands will increase.* I expect this to hold true controlling for seasonality.
- (4) Given the same assumptions as (3), *as distance travelled by cattle increases, NDVI values for grasslands will concomitantly increase,* as cattle seek out greener pastures as they circumnavigate the grazing orbit. This hypothesis is similar to 3, but uses daily-scale cattle grazing from the selected ten bomas data merged with NDVI to understand how vegetation varies in relationship to observed cattle mobility.
- (5) *As cattle intensity increases, mean grassland NDVI values will decrease.* I expect this to hold true in the wet, dry and drought seasons.

A summary of the formal and verbal research hypotheses are shown in Tab. 5.1.

5.4 Study Area

Detailed descriptions of the study area have been provided in chapter 2. Briefly, vegetation within the study area can be divided into four broad land-cover classes that cover approximately 723 square kilometers: (1) a dense woodland zone around the banks of the Talek and Ntiakitiak Rivers dominated by fig trees (*Ficus sycomorus*); (2) an upland bushland cover that is heavily tsetse (*Glossina sp.*) infested and dominated by *Acacia gerardii*, *A. drepanolobium*, and *A. xanthopholea* species; (3) a lowland grassland zone to the south dominated by red oats grasses (*Themeda triandra*), thatch grasses (*Hyparrhenia spp.*), sweet pitted grasses (*Bothriochloa insculpta*) and *Pennisetum spp.*, and; (4) a mixed grassland/bushland zone dominated by *Croton dichogamus*, *Grewia bicolor* and *Cordia monoica* shrubs that line the numerous seasonal streams, known locally as *luggas*³⁴ (Heady 1960; Pratt, Gwynne, and Blackie 1977). There is only one perennial river, the Talek River, which is also the delineating feature for the border of the MMNR across much of the study area (Fig. 4.1).

Nocturnal temperatures range from a minimum of 10 degrees Celsius in July to a maximum of 20 degrees Celsius in January, while maximum daytime temperatures range from 20 degrees Celsius in July to 35 degrees Celsius in February (Fig. 4.4). Precipitation is bimodal, corresponding to a single long dry season between May and August/September, short rains between November and January, and long rains between

³⁴ Botanical nomenclature follows Heady (1960) and Dharani (2002)

March and May (Pennycuick and Norton-Griffiths 1976; Lamprey and Reid 2004; Broten and Said 1995).

Along the northern border of the MMNR, Maasai pastoralists reside with their livestock (cattle, sheep, and goats). There are approximately 140 Maasai households with associated livestock enclosures (Maa: *bomas*) that lie within two kilometers of the park border.

5.5 Methods

A suite of methods of data collection were used that relied on both primary and secondary data collection. Secondary methods were supplemented by primary data collected through on-the-ground observations throughout the study duration (between August 2005 and August 2006), and situated within the context of indigenous knowledge of grasslands by the Maasai pastoralists (Kiptot 2007; Oba 2001; Oba and Kaitira 2006). A detailed narrative of each of the data collection methods is provided in chapter 3 and a summary of the three datasets used to test the hypotheses are described below.

5.5.1 Datasets

The first dataset contains MODIS NDVI data. These data, corresponding to NASA science dataset MOD13Q1, were downloaded from the Land Processes Distributed Active Archive Center (LP-DAAC) through the EOS Data Gateway. The specific tile is h21v09.004 which covers southern Kenya and northern Tanzania. Data were collected between Julian dates 2005.209 (July 28, 2005) and 2006.259 (September 16, 2006). Data were gridded at 250-meter cell resolution for 16-day composites. In

total, 26 tiles were acquired and manipulated into ARC/INFO grid files. Data were then clipped to cover the study site located around the northern border of the Maasai Mara National Reserve (MMNR) in south-western Kenya.

The second data set contains cattle mobility information from ten pastoral settlements north of the MMNR border. These measures were obtained from direct sampling of animal locations throughout their daily movement. Locations were recorded using a Garmin eTrex legend 12 channel GPS receiver, which was enclosed in a plastic bag and a canvas pouch to protect the equipment. This assembly was taped to the cow bell. The receiver was powered by two rechargeable AA 2500 mAh batteries that typically lasted between 15 and 18 hours. The GPS receiver was set to log the date, universal time, northing, easting, elevation, speed, distance, time increment³⁵ and bearing at 15 second intervals. Locations were registered to UTM Zone 36 South, Arc 1960 datum. One GPS unit was placed on a single bull from each of the Maasai households before the herd left the cattle enclosure in the morning (usually between 7 and 9 am) and removed when the herds returned after the grazing day (usually between 6 and 8 pm). Each resulting path of points collected over the grazing day, referred to as the grazing orbit, was then downloaded and stored as Unicode text files using the OziExplorer™ GPS software each evening. Data were collected daily between August 2005 and August 2006 for herds from the ten households comprising the study site; between two and six³⁶ grazing orbits per day were captured, constituting a total of 1118 grazing orbits.

³⁵ In this context time refers to the time, in seconds, from the previously captured point. Although the GPS was configured to collect one point every 15 seconds, in some instances, largely due to in-situ and atmospheric effects, the time interval varied.

³⁶ Only two and six orbits were collected each day as this was limited by the number of GPS units and the distance between households that the researchers could get to before the cattle left their enclosures.

The final data set contains temperature and precipitation measurements that were collected at the center of the study site. The instruments are based at the Hyena Research Camp inside the MMNR. Precipitation measurements in millimeters were collected from a cylindrical rain gauge each morning and evening. Maximum and minimum daily temperatures in degrees centigrade were obtained from wet and dry bulb thermometers and reset each morning.

5.5.2 Development of land-cover map

To help understand how NDVI data varied by land-cover type, I constructed a land-cover map from Landsat ETM+ images (path 169, row 61) at 30-meter resolution. A single image was merged for January 27, 2000 (dry season) and April 02, 2003 (wet season). Data were acquired from the Global Land Cover Facility (GLCF) at the University of Maryland. A supervised classification was conducted in Erdas Imagine version 9.1 TM using training signature selection and the maximum likelihood algorithm using infra-red and red bands (bands 3 and 4 respectively). Signatures were developed for four land-cover categories (dense woodland, bushland, mixed bushland/grassland, and grassland). Approximately 20 signature sets were developed for grassland, 15 for bushland, 9 for mixed bushland/grassland and 10 for woodland. The classified image was then converted to an ARC/INFO grid file format and manually checked for errors of omission and commission. The classified image was also examined by various researchers who have had a long history of active research in the natural sciences to verify the validity of the classification.

5.5.3 Delineation of seasonality

As described in chapters 2 and 4, the study period was divided into three time periods corresponding to seasons: wet, dry, and drought. The wet season occurred between Mid-February and mid June 2006, the first dry season between August 2005 and mid January 2006 and again between mid June 2006 and Late August 2006. The drought occurred between mid January and mid February 2006. The delineation of seasonal breaks has been described in detail as part of chapter 4.

5.5.4 Evaluating distance from boma

In order to better understand how grassland vegetation varies by distance from the nearest boma (hypothesis 3) across the study site, I collapsed the distance from boma into four distance bands. The first distance band is within 1 kilometer of all bomas, while the second distance band is between 1 and 5 kilometers. One kilometer is selected for the first interval as these areas are likely to have the greatest impact from livestock activities and human activities associated immediately around the boma. The other distance bands are spaced 5 kilometers apart (> 5 and ≤ 10 , > 10 and ≤ 15). To do this, I used data from a ground count of bomas that was conducted in 2004. The count contains the spatial location of each Maasai boma within the study site. There are 182 bomas in the study area. Distance from boma was calculated using the assign proximity tool in the spatial analyst extension of ArcView™ GIS (Fig. 5.1).

In order to understand how grassland NDVI varies as a function of the distance that cattle travel away from the boma (hypothesis 4), I determined distance from the boma using data from the GPS track log. Data from the GPS was collected every 15

seconds and recorded the northing and easting coordinates (Chapter 3 and 4). Distance from boma was calculated using the hypotenuse distance function that subtracted the recorded x and y coordinates from the coordinate of the boma of origin. This was done in order to ensure that distance from boma is always a function of where cattle depart from as cattle relocated from their permanent settlements to temporary camps during the drought (Fig. 5.2). For example bomas 5, 7, 8, 9 and 10 moved from their permanent settlements in the eastern half of the study site to the west in order to access forage and minimize the distance needed to access that forage.

5.5.5 Data Processing and Analysis

Using the grid to point feature in ArcGIS™, I converted the center point of each NDVI grid cell to a point file. The following additional geospatial data were then extracted to the point file: presence or absence of the MMNR; land-cover type; and distance from all Maasai settlements. The latter was derived by calculating the Euclidian distance from all Maasai bomas within the study site. Cumulatively, this produced an ARC/INFO™ point coverage with 12,200 points evenly spaced at 250 meter intervals.

Additionally, cattle track points - separated by 15 second intervals - were assigned an NDVI value that corresponds to the pixel value that the track point falls within. For example, cattle track points collected between January 1 and January 17, 2006 were assigned NDVI values that were obtained from the MODIS imagery corresponding to Julian Date 2006.017.

To evaluate how cattle intensity influences grassland NDVI (hypothesis 5), I created an evenly spaced fishnet grid in Arc/Info™ using the same spatial boundaries and

grid cell size that correspond to the NDVI MODIS grids. I then used the Hawth's Tools Extension™ as part of ArcGIS™ version 9.2 (Beyer 2004) to count the number of 15 second cattle track points that fell within the bounds of the 250-meter grid cells and within the grassland land-cover category.

All statistical analysis was conducted in SPSS version 14.0 (SPSS 2005) and Stata/SE Version 7.0™ (StataCorp 2005).

5.5.6 Limitations of the method

A limitation of the method chosen to understand the spatial utilization of cattle concerns spatial auto-correlation. The resolution of the MODIS NDVI data is a square 250 meter cell and because it is likely the grassland pixels are likely to be dependent upon each other and located closer to each other. Therefore, there is a spatial pattern to the correlation within land cover types that is positively spatially auto correlated. I acknowledge that this problem exists within the data, but nonetheless the patterns of space utilization discussed in the results section illustrate interesting trends. Related to this problems, is that there are a large number of cells corresponding to different land cover types (Tab. 5.4). This large 'n' is largely to influence the statistical testing of significance levels.

A second potential problem in the method chosen to evaluate how grassland NDVI varies as a function of distance away from the boma (hypothesis 3 and 4) lies in the endogeneity and circularity of explaining: (1) whether cattle travel toward areas that are greener and that these areas are by their nature, further away from the bomas, or alternatively are greener because of edaphic conditions and historical but frequent and

intermediate scale disturbances; or (2) the presence of cattle decreases grassland greenness (as a result of grazing and trampling effects) and therefore cattle move toward areas that are underutilized and less affected by grazing/trampling effects. However, without additional explicit indicators of grass height and color that account for seasonal variability, we acknowledge this problem, but examine the trends exhibited in the data. We speculate on the extent to which these problems influence cattle mobility in the discussion section.

The method employed to estimate cattle intensity by counting the number of cattle track points that fall within cells is also limited because we are unable to attribute the number of track points as a result of: (1) cattle walking and entering cells frequently, but spending a short amount of time, such as near and around the boma or; (2) cattle grazing for long periods of time in a particular grid cell (i.e. longer time spent within cells on an infrequent basis). Similarly we speculate on how this method may alter the results of this study.

5.6 Results

5.6.1 Meteorological variability

An understanding of vegetation variability needs to be situated within precipitation and temperature trends. Annual precipitation in the study site for the study period is approximately 741.5 mm. The average annual precipitation recorded within the MMNR from the same recording station is 768 mm between 1988 and 2006. Average daily precipitation ranged from 3.6 mm/day in the wet season, 1.3mm/day in the dry season and 0.8 mm/day in the drought (Tab. 5.2). There is a high degree of temporal

discontinuity in precipitation with 358 mm of rainfall falling in 20 days in the wet season (48% of the total, and 77% of wet season total). During the dry season, 218 mm of rainfall was measured in 20 days (29% of the total, and 86% of dry season total). The three most intense rainfall days accounted for 15% of the total rainfall over the entire year. The variance in rainfall was highest in the wet season (51.47), 18.68 in the dry season and lowest in the drought (9.67).

The mean daily maximum temperature was 27.25 °C in the wet season, 27.31 °C in the dry season, and 29.72 °C in the drought season. There is a significant difference between dry and drought season maximum temperatures of 2.47°C ($t = -6.00$, $p < 0.0001$). The mean daily minimum temperature was 14.44 °C in the wet season, 16.16 °C in the dry season, and 16.90 °C in the drought season. There were marginal, but significant differences in the minimum temperatures between all the seasons ($F_{2, 348} = 68.06$, $p < 0.0001$).

5.6.2 Land cover variability

Results of the land-cover generation illustrate the grassland constitutes the highest percentage of the study area, followed by bushland (72% and 21% respectively). Woodland and mixed bushland/grassland constitute the remainder (5% and 2% respectively) (Table 5.4). The temporal sequence of green-up and brown down cycles for different land-cover types is shown in Fig. 5.4.

Mean NDVI for each land-cover type was highly responsive to measured rainfall ($R^2 = 0.605$ for woodland, $R^2 = 0.604$ for grassland, $R^2 = 0.596$ for mixed bushland/grassland and $R^2 = 0.591$ for bushland). Table 5.4. illustrates the mean NDVI

value for each land-cover type with rainfall. Mean NDVI was also highly negatively correlated with mean maximum temperature ($r_p = -0.467$ for woodland, $r_p = -0.446$ for grassland, $r_p = -0.465$ for mixed bushland/grassland and $r_p = -0.447$ for bushland).

5.6.3 Cattle mobility

A detailed description of cattle mobility has been provided in Chapter 4, including the phenomena where cattle relocate to temporary camps in order to reduce the distance traveled and duration of travel. In addition, the analysis presented in Chapter 4 distinguishes between the type of household (temporary camps vs. permanent settlements), and herd size (small, medium and large herds). The analysis relied on three parameters of mobility (total distance, duration of travel and direction of travel). However, in this chapter, I rely on herd radius and not total distance as a dependent variable for measures of grassland NDVI change. As a result, it is important to portray the results of the analysis in Chapter 4 in terms of herd radius distance in order to better link these two chapters.

During the wet and dry seasons, the mean maximum herd radius traveled by cattle are similar (3.552 kms for the wet season and 3.932 kms for the dry season), but the variance is higher for the wet season (Tab. 5.3). During the drought, distance traveled is almost double that of the wet or the dry season (7.630 kms), although the variance is also high. This pattern is also true for the total distance traveled by cattle. The duration of travel is significantly higher in the dry season (12.097 hrs) than in the wet season (10.994 hrs), while the duration of travel is higher in the drought (11.42 hrs) compared to the wet season. These trends also reflect measures of total distance and total duration of travel by

cattle. These results, while broadly indicative of patterns of cattle mobility, are misleading because they do not reflect the high degree of variability between cattle from different herd sizes and types of households (Chapter 4). However, these results do suggest how general cattle mobility parameters vary by season. Herd radius distance is most strongly positively correlated with total distance during the dry season ($r_p = 0.762$, $n = 535$, $p = 0.0001$), followed by the wet season ($r_p = 0.459$, $n = 451$, $p = < 0.0001$), while there is no significant correlation during the drought ($r_p = 0.079$, $n = 132$, $p = 0.364$), while there is a weak correlation between NDVI and herd radius (Fig. 5.5).

5.6.4 Hypothesis 1: NDVI of Cover Type

Using a one-way ANOVA, I found that each land-cover type responded differently to seasonality (Tab. 5.4). During the wet season, mean NDVI values were similar between land-cover classes (0.617 ± 0.08 for woodland, 0.586 ± 0.06 for bushland, 0.570 ± 0.07 for mixed bushland/grassland and 0.598 ± 0.07 for grassland). These measures were significantly different between classes ($F_{3, 12196} = 58.09$, $p = < 0.0001$ at $\alpha = 0.05$).

During the dry season NDVI values began to decrease with the pronounced increase in temperature and decreased rainfall. Mean NDVI values were 0.41 ± 0.07 for woodland, 0.35 ± 0.04 for bushland, 0.33 ± 0.03 for mixed bushland/grassland and 0.35 ± 0.03 for grassland. Differences between these classes were also significant ($F_{3, 12196} = 404.16$, $p = < 0.0001$).

During the drought, mean values decreased further to 0.33 ± 0.08 for woodland, 0.28 ± 0.04 for bushland, 0.26 ± 0.04 for mixed bushland/grassland, and 0.28 ± 0.04 for

grassland. These differences were significant except between bushland and grassland ($F_{3,12196} = 164.147, p = < 0.001$).

Two key issues stand out in this analysis. First, mean NDVI values are high and significant for woodland compared to any other land-cover class. Second, the bushland/grassland, bushland and grassland land-cover categories exhibited similarities in their mean NDVI values across the wet, dry and drought seasons. These results suggest that there are similarities between bushland and grassland across all seasons, and differences are only observed for the woodland land-cover category.

5.6.5 Hypothesis 2: NDVI Inside vs. Outside the MMNR

Using a t-test, I found that during the wet season, the mean difference in NDVI values for woodland is -0.103 lower outside the MMNR than inside the MMNR, which is a significant difference ($t = 15.192, p < 0.0001$) (Fig. 5.6). During the dry and drought seasons, the same relationship is true, although the mean difference is smaller but significant (-0.072 in the dry, $t = -10.06, p = < 0.0001$ and -0.071 in drought, $t = -8.994, p = < 0.0001$).

Bushland areas exhibited the same trend. The mean difference within and outside of the MMNR is -0.079 in the wet season, +0.023 in the dry season and -0.022 in the drought. Mixed bushland/grassland areas display a different relationship where the mean difference between the two areas is highest in the wet season (-0.079) and lowest in the dry season (-0.007). There was a statistically insignificant relationship for mixed bushland/grassland during the drought, where the mean difference is -0.001 ($t = -0.227, p = 0.421$).

Grasslands, much like woodlands, demonstrated a strong and statistically significant relationship between the two zones and by season. The mean difference inside vs. outside the MMNR for grasslands during the wet season is -0.091, -0.019 in the dry season and, -0.027 in the drought. These results confirm that mean NDVI values are higher inside the protected area than outside for all land cover types, except for the differences for mixed bushland/grassland in the drought.

5.6.6 Hypothesis 3: Grassland NDVI as a Function of Distance from Boma

Using a one-way ANOVA test and Bonferroni post-hoc statistics (Tab. 5.5a), I found that during the wet season, grassland NDVI within a kilometer from all bomas are always significantly lower than at any other distance away from the nearest boma. The mean NDVI rises significantly from 0.522 to 0.596, 0.653, and 0.693 in the last distance band (over 10 and less than 15 kms away) ($F_{3, 8724} = 4506.007$, $p = < 0.0001$). The same trend is apparent and significant for the dry season (Tab. 5.5b) ($F_{3, 8724} = 453.761$, $p = < 0.0001$). However, the mean difference is not as high. During the drought, mean differences were also significant between all distance bands (Tab. 5.5c) ($F_{3, 8724} = 772.113$, $p = < 0.0001$) and followed the same general trend described above, except between the first (less than 1 kilometer) and second distance bands (between 1 and 5 kilometers). Here the mean difference of 0.0006 was insignificant ($p = 1.000$).

This pattern suggests that, as distance away from the boma increases, grassland NDVI concomitantly increases, and this appears to be true throughout all the seasons (with the caveat that mean grassland NDVI is similar between less than 1 km from the boma and between 5 and 10 kms away from the boma during the drought). However, this

hypothesis uses distance from all the bomas as the dependent variable. As is common with many studies on pastoralism, the number of cattle and their spatial distribution within an area is difficult to estimate given the large spatial area and the movement of cattle between permanent settlements and temporary camps in order to better cope with drought conditions (Chapter 4). Cattle very rarely travel more than 15 kilometers. Instead, the typical daily range is between 5 and 10 kilometers during the wet, dry and drought seasons (Tab. 5.3).

The gradient of grassland NDVI between less than 1 kilometer and between 5 and 10 kilometers, suggests that there are significant differences in grassland NDVI during the wet and dry seasons. When the wet and dry seasons are compared against each other, the gradient is higher during the wet season. This suggests that the impacts of cattle, from either walking or grazing, are more severe in the wet season than the dry season. The significant, but marginal differences during the drought season, suggest that these impacts may be less severe during this period, but the range of NDVI values during the drought is considerably smaller. The results of the correlation using continuous cattle track point data that fall within the grasslands also confirm this trend, although the correlation is not strong and is mostly likely attributed to the large number of data points.

5.6.7 Hypothesis 4: Grassland NDVI as a Function of Cattle Movement Away from Boma

In order to help elucidate the relationships between grassland vegetation index and cattle movement, I performed a Pearson correlation and a one-way ANOVA test. The ANOVA was conducted with distance from the boma delineated at one kilometer

intervals. The dependent variable is distance from the boma. The independent variable is the mean NDVI of grassland that cattle track points pass over in each distance band. The tests were repeated for each season. The Pearson correlation was tested using distance from the boma as a continuous variable with the NDVI value of each grazing point along the orbit. Along with hypothesis 3, these data help clarify how grazing affects vegetation variability.

During the wet season, mean grassland NDVI values are positively related to distance from the boma (Pearson correlation = 0.292, $p = < 0.0001$). More than 84% of the total track points are within the first four kilometers from the boma. Mean NDVI values from the ANOVA are significantly positively different between 1 (0.461 ± 0.120) and 6 kilometers (0.569 ± 0.066), and between 8 (0.556 ± 0.073) and 10 kilometers (0.592 ± 0.078) (Table 5.7a). Mean values were significantly negatively different between 6 and 8 kilometers, and between 10 and 11 kilometers. Overall, the mean grassland NDVI increases within each distance interval from the boma.

During the dry season mean grassland NDVI values showed little correlation with distance from boma ($r_p = -0.022$, $p < 0.0001$). More than 82% of the total track points lie within the first four kilometers from the boma (Table 5.7b). Mean NDVI values increase significantly between 1 (0.338 ± 0.052) and 2 kilometers (0.351 ± 0.049), and then significantly decline steadily until 6 kilometers away from the boma (0.316 ± 0.047). NDVI values increased to $0.367(\pm 0.0577)$ 7 kilometers away from the boma. Between 7 and 8 kilometers, mean differences were insignificant. Mean NDVI values increase to 0.468 ± 0.021 13 kilometers away, however there are insignificant differences between

10 and 11 kilometers, and between 11 and 12 kilometers. The general trend that follows the mean grassland NDVI by each distance band shows a strong positive relationship.

During the drought season, mean grassland NDVI is most strongly related to distance from the boma (Pearson correlation = 0.479, $p < 0.0001$). Only 36% of the total track points are found within the first four kilometers from the boma, with the majority of the track points being found in the 6, 8 and 9 kilometers bands away from the boma. Mean NDVI follows a humped distribution in the first 5 kilometers. The mean value increases significantly between 1 and 2 kilometers by $0.0113 (\pm 0.0003)$, while insignificant differences are recorded between 2 and 3 kilometers, before falling significantly to 0.277 ± 0.023 in the five kilometer band. Mean NDVI increases to $0.342 (\pm 0.042)$ at a distance of 10 kilometers away from the boma, and significant positive differences are observed at each kilometer interval. Between 10 and 11 kilometers, mean values decreased to 0.335 ± 0.010 . Insignificant differences are observed between the 2 and 6 kilometer distance bands. Overall, mean grassland NDVI values are strongly related to distance intervals from the boma.

These results confirm that cattle move away from the boma in order to visit greener areas. However, we note the individual variations between distance intervals. During the wet and dry season, as distance away from the boma increases, mean grassland NDVI increases. The number of track points that fall within grid cells decreases exponentially, with greater than one-third of the track points falling within a kilometer from the boma. The trend is different for the drought season, where the highest percentage of track points falls between four and seven kilometers away from the boma (Fig. 5.7b). This may be attributed to the time at which the GPS was placed on the cow

(at the boma before they left their enclosures and includes the time that cattle spent ruminating close to the boma before leaving for grazing). Even if points are eliminated from the first kilometer, the trend during the wet and dry season remains the same. During the drought, cattle spend a minimum amount of time near the boma, often leaving early and returning late, and spend the majority of their time at intermediate distances from the boma.

5.6.8 Hypothesis 5: Grassland NDVI as a Function of Cattle Intensity

In order to understand how different degrees of cattle intensity are related to grassland NDVI, I defined cattle intensity as the number of points that fall within each grid cell. Because the range of values varies from 0 to more than 16000, I relied on a natural log transformation. This reduced the range of values to between 1 and 10. The log transformation allowed for greater understanding of how grassland NDVI differs within this reduced range of values.

Mean grassland NDVI in the wet season follows a bi-modal distribution, whereby mean grassland NDVI is highest in areas that are devoid of cattle, before decreasing in areas that have a very small number of cattle track points in them (Tab. 5.6a). NDVI values then decrease further as cattle intensity increases (as indicated by areas that contain the highest number of cattle track points).

In order to ascertain whether grassland NDVI values differ significantly by the level of intensity for the wet season, I further divided cattle intensity into four groups in order to conduct an ANOVA test. These groups were constructed by examining the continuous distribution of log normal points and mean NDVI. The four groups are: (1)

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zero cattle intensity (0 PG (points per grid cell)); (2) low intensity (>0 and ≤ 500 PG); (3) medium intensity (> 500 and ≤ 1000 PG); and (4) high intensity areas (> 1000 PG).

The results of the ANOVA suggest that as cattle spend a greater amount of time in each grid cell, mean grassland NDVI decreases significantly ($F_{3, 12196} = 292.33$, $p = < 0.0001$) (Tab. 6b). Significant negative differences in NDVI were noted between each of the groups. The highest significant negative difference was recorded between medium (0.532 ± 0.050) and low intensity areas (0.570 ± 0.062) ($p = < 0.001$), while high intensity areas recorded the lowest mean grassland NDVI (0.510 ± 0.042). Areas devoid of cattle presence recorded the highest mean NDVI (0.602 ± 0.068).

The same process was repeated during the dry season. The distribution of log of the number of points in each cell is different from the wet season. Based on a range of 0 to 9.78 (15702 PG), mean grassland NDVI values are high in areas devoid of cattle before decreasing as the number of cattle within a cell increases marginally (Tab. 5.7a). Mean NDVI values then increase rapidly as the number of track points increases between 1100 and 2800 to record the highest grassland NDVI. As the number of track points increases beyond 2800, mean NDVI values decrease to their lowest level in areas that have the greatest number of track points within them.

To determine significant differences in mean grassland NDVI as cattle intensity increases, I used the same intensity categories as with the wet season. Significant negative mean differences were recorded only between low intensity and zero intensity (-0.006 , $p = < 0.0001$) and between high and low intensity areas (-0.011 , $p = < 0.001$) (Tab. 5.7b). Between the different intensity categories, mean differences, where significant, are very low.

Mean grassland NDVI by cattle intensity during the drought follows a different distribution than during either the wet or dry season. As cattle intensity increases, NDVI appears to increase, especially between areas that have a minimal number of cattle tracks to areas that have the highest number of track points. The range of values during this period is 0 to 8.04 (2088 points) (Tab. 5.8a).

Since the number of cattle track points is lower in this season as it is a substantially shorter period of time (32 days), I modified the break point categories. The modified groups are: (1) zero cattle intensity, or areas that cattle did not traverse through; (2) low intensity areas that cattle passed through between 1 and 150 times; (3) medium intensity areas that cattle passed through cells more than 150 and less than 300 times; and (4) high intensity areas that cattle passed through more than 300 times.

The results of the ANOVA test confirm that as cattle intensity increases, mean grassland NDVI increases ($F_{3, 12196} = 16.256, p < 0.0001$) (Tab. 5.8b). However, insignificant differences are recorded between zero intensity and low intensity, and between medium and high intensity. Significant differences are greatest between high and low intensity grazing areas (mean difference + 0.017, $p = < 0.0001$) and high and zero grazing areas (mean difference +0.018, $p < 0.0001$).

These results confirm that as cattle intensity increase, mean grassland NDVI decreases, but only for the wet season and conclude that variations between the dry and drought season are less severe than during the wet season. Of particular interest are the individual variations between different intensity zones during the dry season and the surprising result that grassland NDVI values increase with cattle intensity during the drought. Analysis of grazing intensity suggests that mean grassland NDVI decreases as

cattle intensity increases but only during the wet and dry season. However, decreased grassland NDVI is not a smooth function of grazing intensity. The results of the data suggest that at low and intermediate zones of grazing intensity, mean grassland NDVI does differ significantly, but the margin of difference is relatively small (Fig. 5.8).

During the wet season, NDVI values differ significantly between areas that have no recorded cattle movement within them (0.605 ± 0.069) and a small amount of cattle movement (approximately than 150 points) (0.582 ± 0.067), staying stable between 150 and 400 track points, before decreasing by 0.1 of an NDVI value (to 0.509 ± 0.003) in areas that have a high number of track points. It is interesting to note that mean grassland NDVI values were similar between grid cells that contained between 3000 and 8000 track points (0.501 ± 0.046), and between 8000 and 16000 track points (0.509 ± 0.003). Data grouped by intensity zones confirms the overall trend. Spatial plots of cattle intensity during the wet season demonstrate that high intensity areas are found either within close proximity to the bomas, or in isolated locations furthest away from the boma (Fig. 5.9a). Areas furthest away from the bomas are possible grazing locations where the cattle spend a large amount of time.

During the dry season, the mean NDVI values vary from $0.362 (\pm 0.034)$ in cells that contain between 1100 and 2800 points, to $0.326 (\pm 0.016)$ in cells that contain between 11000 and 16000 points. It is interesting to note that the highest mean NDVI value is higher in cells that have been utilized by cattle compared to cells that recorded no presence of cattle (0.348 ± 0.032). High intensity areas are found close to the boma and at intermediate distances away from the boma, while medium and low intensity areas are found furthest away from the bomas (Fig. 5.9b).

During the drought, mean grassland NDVI values are highest in areas that have the highest number of cattle track points within them (0.315 ± 0.037), whereas areas devoid of cattle recorded a mean NDVI of $0.279 (\pm 0.042)$. In general, the trend suggests that as cattle intensity increases, mean grassland NDVI also increases. Based on daily interviews with herders, this trend may be attributed to herders directing cattle towards specific patches of grassland that are relatively greener than the surrounding area. Additionally, although there are a large number of cells that cattle did not utilize during this period (9779), a relatively small percentage of these cells were likely to have been used by cattle in the preceding dry season and may help explain the lower NDVI value in these cells. High intensity areas are more numerous and are found in locations furthest away from the bomas, while medium intensity areas are found at intermediate distances. Low intensity areas are found closest to the bomas and are relatively fewer compared to high intensity areas (Fig.5.9c).

5.7 Discussion

This study has revealed several key characteristics of savanna ecosystems in areas where pastoral settlements exist along the border of a protected area. In this section I discuss the relevance and implications of these findings in two parts. The first examines the implications of vegetation variability by cover type and park presence. The second explores how the relationships between the spatial variability of cattle mobility and vegetation.

5.7.1 Vegetation, Cover and Parks

Mean NDVI values for woodlands stand out in comparison to bushland, mixed bushland/grassland and grassland across all seasons. During the wet season, mean NDVI values are significantly different between different cover types, but the margin of difference is relatively small. During the dry and drought season, differences in mean NDVI are more pronounced between woodland and the other land-cover categories. This is expected given the density of green leaf material in woodlands and reinforces existing evidence that NDVI can be accurately used to differentiate woodland from other land-cover types.

The similarity between bushland and grassland during these periods warrants further discussion. Many of the species that comprise bushland such as *Croton dichogamus*, and *Croton megalocarpus* shed their leaves in order to conserve water. The leaves of other bushland species such as *Grewia similis*, *Grewia bicolor* and *Euclea divinorum* do not shed their leaves and remain green even during the dry season and are regularly browsed on by goats. From this analysis it appears as though the land-cover classification does not differentiate between these different bushland species. Additionally, it is extremely difficult to classify within bushland land-cover through remote sensing and may only be possible by undertaking extensive ground surveys which are expensive both in terms of time and money.

Analysis of cover types inside and outside the MMNR (hypothesis 2) demonstrates that invisible boundaries mark well defined differences on the ground in pastoral areas. These same phenomena have been documented in pastoral systems in Indian and Mongolia (Fernandez-Gimenez 2002; Robbins 2001a, 2001b; Casimir and

Rao 1998, 1992). As shown in Fig. 5.6, differences in mean NDVI between the two areas are more pronounced for woodlands during the wet season than other cover types. To a lesser extent this difference is also apparent for grasslands and may be misleading because the analysis does not take into account differences in the mean NDVI as a function of Euclidian distance from the boma (which are explicitly addressed in hypotheses 3 and 4). In spite of these differences, it is clear that grassland NDVI is significantly different inside vs. outside the MMNR during the wet season than during either the dry or the drought season. One possible explanation for this is that the wet season was preceded by the drought and would not be considered a 'normal' year in which the wet season is followed by the drought. However, climate predictions for the next 50 years suggest that although the amount of rainfall within a year may remain the same, the Mara will experience a high degree of rainfall variability and that occurrence of drought will become more common (IPCC 2001; Little, Mahmoud, and Coppock 2001; Little, Barrett et al. 2001; Galvin et al. 2001).

Data and analyses from hypotheses 1 and 2 suggest that there are many significant differences between and among different cover types, although the margin of difference is relatively small. While some of these differences were expected and hypothesized, many significant differences were not expected, such as between bushland and grassland in the wet season, and between bushland and mixed bushland/grassland in the drought. The significance of these differences may be attributed to the relatively large number of data points (12200) which affects the variance. One possible way to overcome this problem is to construct a systematic stratified unaligned sampling scheme that reduces the number of points. The problem inherent in such an approach is that it is difficult to

construct a scheme that accommodates the complexity of the landscape; especially the patchiness associated with bushland and mixed bushland/grassland, and is simultaneously representative of the larger study area.

5.7.2 Implications of Spatial Vegetation Variability on Dynamics of Cattle

Mobility

This study empirically confirms existing trends within the literature on the spatial dynamics of grasslands and cattle mobility. Spatial plots of grassland NDVI illustrate that areas of high values are located towards the confluence of the Mara and Talek Rivers and between the seasonal streams of Ol-Keju Rongai and the Ol-Keju Gem. The grasslands in this region are dominated by tall *Themeda triandra* grasses and are burnt periodically by the park authorities in order to stimulate fresh greener grasses that attract migratory wildebeest during the peak tourist season. However, historical key informant interviews with herders and elders suggest that cattle do not move into these areas until the drought period, although they traditionally accessed the area regularly before it was designated as a national reserve in 1961 (Wilson 1987; Dublin 1995). This demonstrates the problem of identifying where cattle from the larger population of all bomas and livestock graze, when they graze at those locations, and for how long they graze.

In order to link explicit movement of cattle to grassland NDVI, mobility data were collected on a sample of cattle from ten Maasai bomas. From these results, the trends described from the analysis of hypotheses 3 and 4 also hold true, i.e. that using grassland NDVI as an indicator of greenness and biomass, reveals that the impacts of cattle are higher in the wet season, compared to either the dry or the drought season (Fig.

5.10). Impacts of cattle during the drought are negligible when compared against areas that have no cattle activity within them. Additionally, the differences in the range of mean grassland NDVI values as an indicator of the magnitude of impact of cattle suggest that wet season impacts are greater than the dry and drought season.

The spatial location of high intensity areas differ by season and demonstrate that cattle intensively utilize different parts of the landscape at different time periods. High intensity areas during the wet season are found closer to the boma; while during the dry season high intensity areas are located further away from the boma. During the drought high intensity areas are located furthest away from the boma. Areas within 500 meters from the boma contain high intensity cells throughout the year.

As shown by the trends in these data, there are two different processes at work. First, cattle might be negatively impacted areas because of high intensity use because of repetitive use. Second, cattle are likely to be directed to greener areas (often in patches that may be discontinuous). In order to separate out these two different factors, future research should be directed towards understand soil and vegetation conditions on the ground as well as experimental designs that rely on finer scale satellite imagery (such as 30 meter Landsat ETM+ imagery) and using aggregating mobility data at 7 day intervals instead of the 16 days intervals used in this analysis. This is described in greater detail in Chapter 8, section 8.2.

The patterns observed in this study are difficult to quantitatively compare against other nomadic systems in sub-Saharan as there are few studies that explicitly track pastoral cattle mobility. However parallels can be drawn to a study of pastoral mobility in Senegal by Adriansen and Nielsen (2002), where grazing of cattle by Fulani pastoralists

follows temporal patterns responding to seasonality. They find that cattle mobility alternated between small cyclical patterns around the home (similar to the herding radius) during the wet season, where herders take advantage of greener pastures closer to the household, and large scale movements to temporary camps during the dry seasons and intermediate movements in response to rainfall events that result in the germination of new pastures. Similar patterns have also been documented by Turner (1999d) in central Mali, and the Kajiado district of Kenya (Bekure et al. 1991; BurnSilver, Boone, and Galvin 2003).

The grazing patterns of cattle and the trends in grassland greenness away from the boma in this study suggest that grazing patterns are tied to the pre-existing spatial structure of grasslands in the Mara. Additional data on species composition in seasonal grazing areas would allow for the testing of hypotheses supporting the notion that increases in spatial heterogeneity follow grazing, as has been documented in many grazing ecosystems around the world (Adler, Raff, and Lauenroth 2001).

In addition, as Thomas and Twyman (2004), Turner (1999d) and Fernandez-Gimenez (2000) note, such data could be positively enhanced through the use of local indigenous knowledge and a thorough understanding of the local environmental history of the area in order to counter dominant perspectives of overgrazing and degradation attributed to pastoralists (Turner 2003a, 1993). These narratives have also been used by conservationists to argue continued exclusion of pastoral cattle inside protected areas even during periods of severe drought, despite evidence to suggest that pastoral activities also result in wildlife clustering around settlements and creating multiple species associations (Reid et al. 2001).

Drawing on research from different ecosystems around the world Coughenour (1991) argues that the spatial components of pastoral ecosystems have been disrupted by competing land uses. This has negative implications for ecosystem persistence. As population of Maasai communities and number of settlements increases, greater sedentarization is likely to result in decreasing ecological heterogeneity (Rutten 1992; Kimani and Pickard 1998; Lamprey and Reid 2004). Further research should therefore also consider the use of spatially explicit models that seek to address the extent to which greater sedentarization can alter plant-herbivore interactions and institute development programs that can minimize negative effects.

5.7.3 Limitations of the Method and Spatial Inference

While the results of these analyses suggest the presence of interesting and provocative patterns in the space utilization of cattle in different seasons, they are difficult to contextualize. In order to overcome this problem, explicit spatio-temporal tracking of cattle mobility would need to be merged with the application of a precipitation time lag model, such as the one proposed by Eklundh (1998) developed for NDVI and precipitation. This model could be modified and coupled with spatially and temporally explicit cattle mobility data.

A second problem lies in the efficacy of counting the number of cattle track points that fall within grid cells. While a total count of the number of cattle points falling within predetermined grid cells is a good ‘first-cut’ indicator of cattle intensity, it is biased because of two main shortcomings. One way in which this may be overcome is to isolate track segments based on the speed of individual points (based on the distance between

successive 15 second track points). This data coupled with itineraries of grazing behavior, whereby researchers walk with cattle during the grazing day and record the behavior of the cow with the GPS collar every 5 or 10 minutes, would allow for greater accuracy in determining grazing vs. walking segments. One potential problem that may arise from this approach (which was conducted as part of the dissertation research during the dry and wet season – Chapter 3), is that cattle frequently graze and walk at the same time. Similarly, a speed of zero meters per second may indicate that the cow is either grazing at a specific patch or simply standing still. A speed of 0.34 meters/second may also indicate that the cow is either grazing or walking, but it does not differentiate between how much the cow is either grazing or walking. A solution to this problem may lie in utilizing the bite rate count approach commonly used in grazing studies in the United States (Spalinger and Hobbs 1992; Ruckstuhl, Festa-Bianchet, and Jorgenson 2003; Moen, Pastor, and Cohen 1997).

A third problem concerns cells that are identified as zero intensity areas. Although our measure of zero intensity areas is the total absence of cattle that were tracked, this measure does not account for the effects of cattle from other pastoral households that might have been using these cells, other domestic animals such as sheep and goats, or resource utilization by wildlife and other anthropogenic activities that may alter the NDVI signatures. However, we speculate that the zero intensity areas are spatially distributed inside the MMNR as well as outside. A mean measure of NDVI would therefore account for these differences.

In this study, measures of the: (1) effects that cattle intensity on the physical environment, and; (2) the effect of climatic variability on cattle intensity, are limited by

the use of NDVI as the sole indicator of vegetation variability and change. The reliance on range of mean grassland NDVI values can be a biased estimator of vegetative change because it relies on the photosynthetically active radiation from the density of chlorophyll within leaf structures and the density of the green leaves. Consequently, during the drought for example, the amount of chlorophyll within the stem and leaf structures of grasses may be low and comparable to bare ground, but that does not necessarily mean that the grass has disappeared. Similarly, the density of green leaves for bushland may be lower as a result of defoliation leaving only the branches that would demonstrate low NDVI values that are also similar to bare ground.

As a result, future research should rely both on grassland NDVI in addition to the use of the near real time field measurements of ecological conditions of soils, such as soil bulk density or aggregate stability (Herrick et al. 2002; Herrick and Whitford 1995; Seybold and Herrick 2001) and grasses, such as grass height and grass color. Cumulatively, the remote sensing approach with ground monitoring will allow for greater clarity on the exact nature, frequency and magnitude of grazing disturbances. An exact protocol for future research is shown in appendix

5.8 Conclusions

This chapter has dealt with the dynamism of pastoral dominated savanna ecosystems at the border of a protected area. In particular, the major findings from each of the hypotheses address important aspects of the interplay between pastoralists, livestock and the physical environment. These are: (1) woodlands demonstrate the highest mean NDVI values across all seasons, and NDVI values differ significantly

between land-cover types throughout the seasons; (2) mean NDVI values between various land-cover types are significantly different inside vs. outside the MMNR, with the highest difference being recorded for woodlands and grassland in the wet season; (3) using distance from the nearest bomas, the dependent variable for grassland NDVI, mean values are significantly higher furthest away from the boma in all seasons, with the highest differences recorded for the wet season; (4) using a sample subset of cattle mobility from ten Maasai bomas, mean grassland NDVI values increase as the distance cattle travel away from the boma increases. The incremental gradient is highest during the wet season; and, (5) as grazing intensity increases, mean grassland NDVI decreases during the wet season, remains stable in the dry season, and increases in the dry season.

An important finding of this research is that locations on the landscape that have the highest intensity of cattle differ by season. This demonstrates the highly variable and adaptive nature of pastoralism (Salzman 2004), where decisions on where to graze and how long to graze at specific locations are governed by social, political and economic dimensions (cf. Bassett 1986, 1994; Turner 1999a; Turner 1999c), but also, as this research has shown, by ecological variability. The differential space utilization by season allows for areas that were heavily utilized during the dry and drought seasons to recover in the wet season. The research demonstrates that areas immediately surrounding the boma are prone to the intensive impacts from trampling and grazing effects at all times of the year. As pastoralists face greater social, political and economic marginalization, their ability to maintain high mobility has been reduced, resulting in greater sedentarization (Little 1985b; Little, Smith et al. 2001; Homewood 2006; Fratkin and Roth 2005). It is likely that further constraints on traditional pastoral livelihood systems and grazing

ecology will alter green-up and brown-down cycles of vegetation and may negatively affect savanna ecosystems. Given the current spatial dynamism of cattle movement and grasslands within the study area, the study has shown that pastoralism is highly dynamic and adaptive and its effects on the ecosystem during periods of high stress, such as the drought and dry season, are significantly less than during the wet season. Further research should therefore address the dynamism within the wet season in order to determine the degree to which cattle activities affect the physical environment.

Figure 5.1: Determining distance from all bomas in the study site to test how grassland NDVI differs as a function of distance away from the boma (hypothesis 3). Areas between 10 and 15 kilometers away from the boma are located inside the Maasai Mara National Reserve (MMNR).

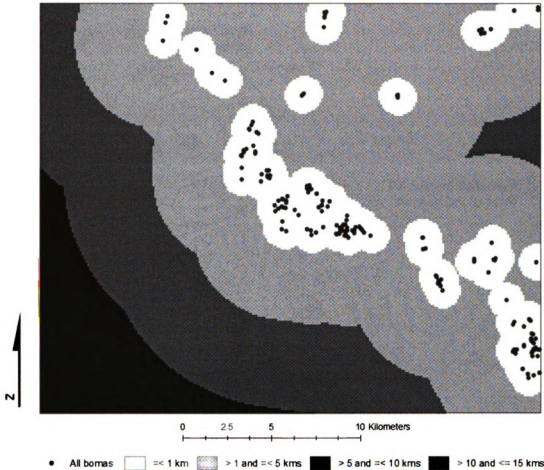


Figure 5.2: Determining distance from boma for sampled bomas. The square represents the location of the temporary camp from which cattle were based during the drought season. The triangle represents the location of the permanent settlement from which cattle departed and returned to during the wet and the dry season. The rings represent distance every 500 meters from the location of the temporary camp and permanent settlement.

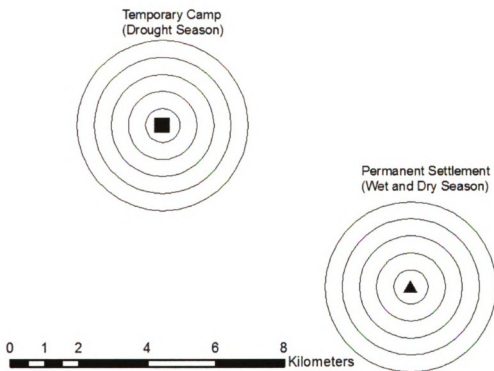


Figure 5.3: Land cover map derived from Landsat ETM+ satellite imagery for 2003. The classification method used a merged wet and dry season scene and employed the use of the maximum likelihood algorithm. The largest constitutive land area is grassland (519.68 km²), followed by bushland (149.80 km²), mixed bushland/grassland (36.66 km²) and woodland (19.96 km²). The thin band of woodland running through the center of the study site from east to west is the Talek River along which most households are located. The bushland area in the north central part of the study site is characterized by *Acacia sp.* and orange leaf crotons (*Croton dichogamus*). Grassland areas dominate much of the study site and are characterized by *Themeda triandra* and *Hyparrhenia sp.*

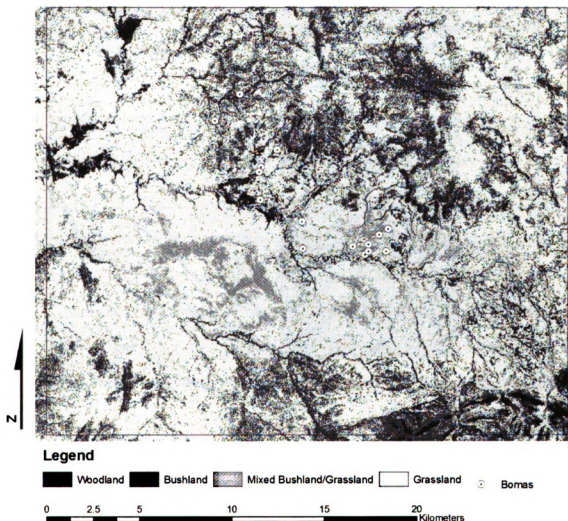


Figure 5.4: Green-up and brown down cycles for different land cover types during the study period. The temporal sequence of seasonality is: dry season begins from Aug 29, 2005 – January 14, 2006, drought season between January 15 and February 15, 2006, wet season between February 16 and June 31, 2006, and dry season between July 1 and August 19, 2006. There is a very rapid green-up and brown-down cycle for all types of cover during the wet season but woodland appears to remain greenest throughout the year. Differences between woodland and grassland appear to be highest during the late dry season and drought.

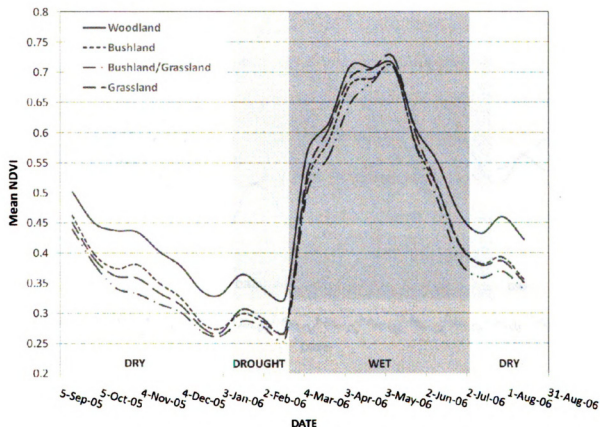


Figure 5.5: Mean herd radius (kms) for each 16-day time period plotted against and the mean grassland NDVI of those locations. The general trend suggests that herd radius increases when grassland NDVI is low and is best exhibited during the drought. During the late wet season, the inverse relationship is true.

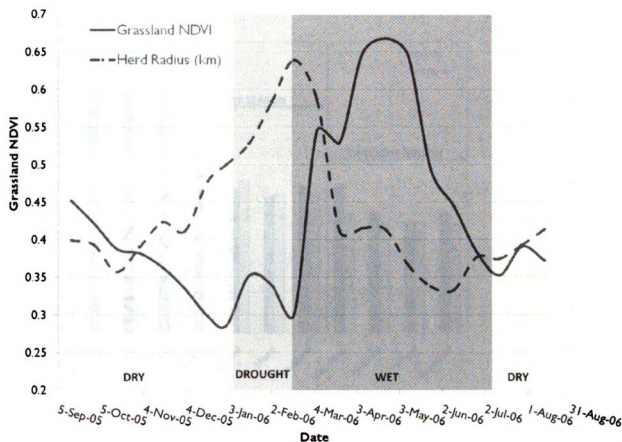
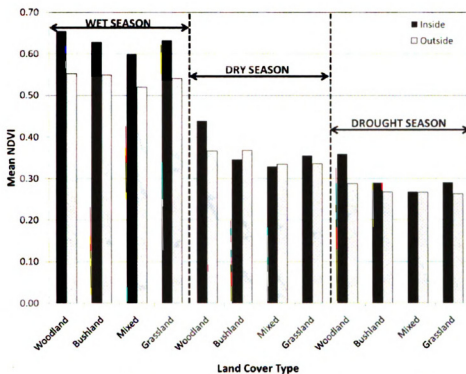


Figure 5.6: Mean NDVI for different land cover types (Woodland – W, Bushland – B, Mixed Bushland/Grassland – M, and Grassland – G) inside (I) vs. outside (O) the MMNR, during the wet, dry and drought seasons. T – t-value of t-test, * significant differences at the 0.05 level, ^a probability of insignificant differences (^a p = 0.421). Each cell is a 250 meters in length and width.



		Land Cover Type							t
		N (I)	M	SD	N (O)	M	SD	Diff ^a	
Wet	W	106	0.552	0.046	185	0.655	0.068	*-0.10	-15.19
	B	1332	0.549	0.037	1181	0.628	0.06	*-0.079	-39.3
	M	244	0.52	0.042	424	0.598	0.062	*-0.079	-9.422
	G	3266	0.541	0.04	5462	0.632	0.062	*-0.091	-2.736
Dry	W	106	0.366	0.039	185	0.439	0.083	*-0.07	-10.06
	B	133	0.369	0.045	1181	0.346	0.026	*0.023	-5.543
	M	244	0.335	0.032	424	0.329	0.025	*0.007	-2.989
	G	3266	0.336	0.025	5462	0.355	0.034	*-0.019	-1.102
Drght	W	106	0.288	0.038	106	0.359	0.096	*-0.07	-8.945
	B	1332	0.268	0.025	1332	0.289	0.054	*-0.022	-2.624
	M	244	0.267	0.025	244	0.267	0.043	-0.001	-0.227 ^a
	G	3266	0.263	0.024	3266	0.29	0.047	-0.027	-6.316

Figure 5.7a: Percentage of total track point by distance from boma. During the wet and dry seasons, there are a high percentage of total track points within the first four kilometers from the boma, while during the drought, tracks points are more evenly spaced further away from the boma.

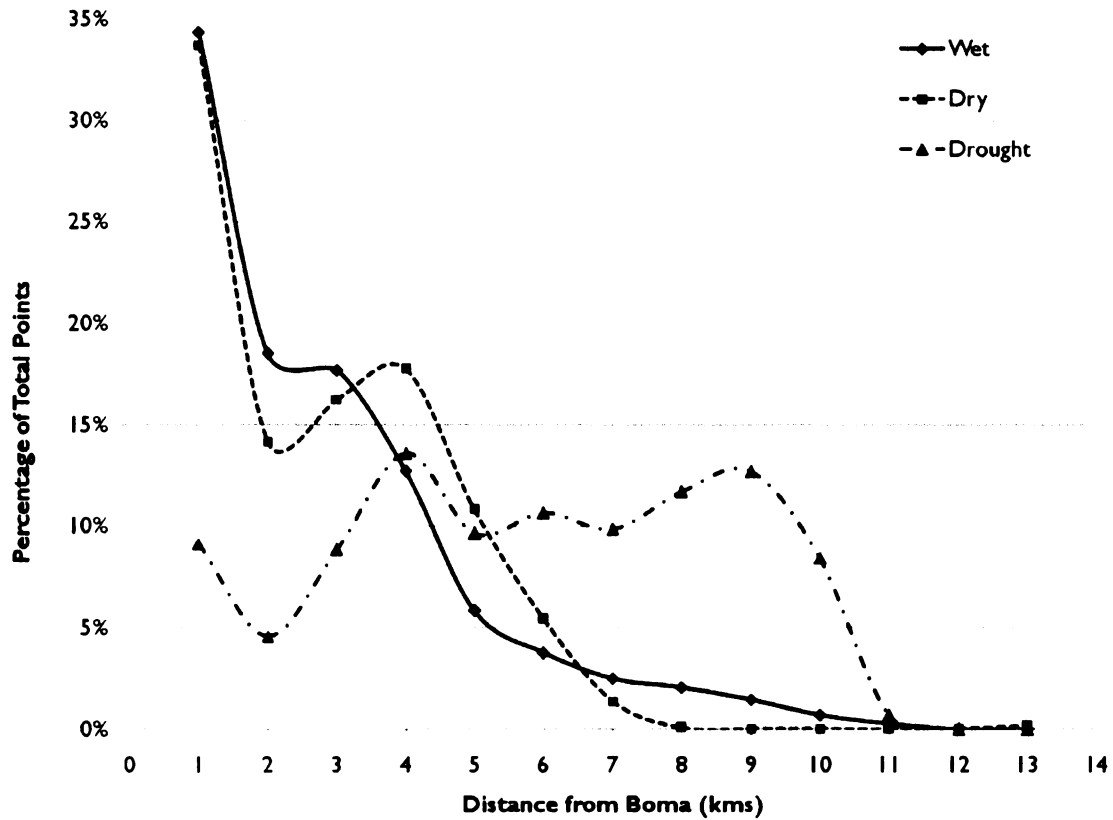


Figure 5.7b: Mean grassland NDVI as a function of distance from sampled bomas for the wet ($y = 0.008x + 0.483$, $R^2 = 0.535$), dry ($y = 0.010x + 0.303$, $R^2 = 0.746$), and drought seasons ($y = 0.006x + 0.259$, $R^2 = 0.774$). NDVI Data are collected from 16-day averages off MODIS and distance from the boma is measured through direct tracking of cattle as a function of Euclidian distance. Mean grassland NDVI values are always lowest closer to the boma and highest furthest away.

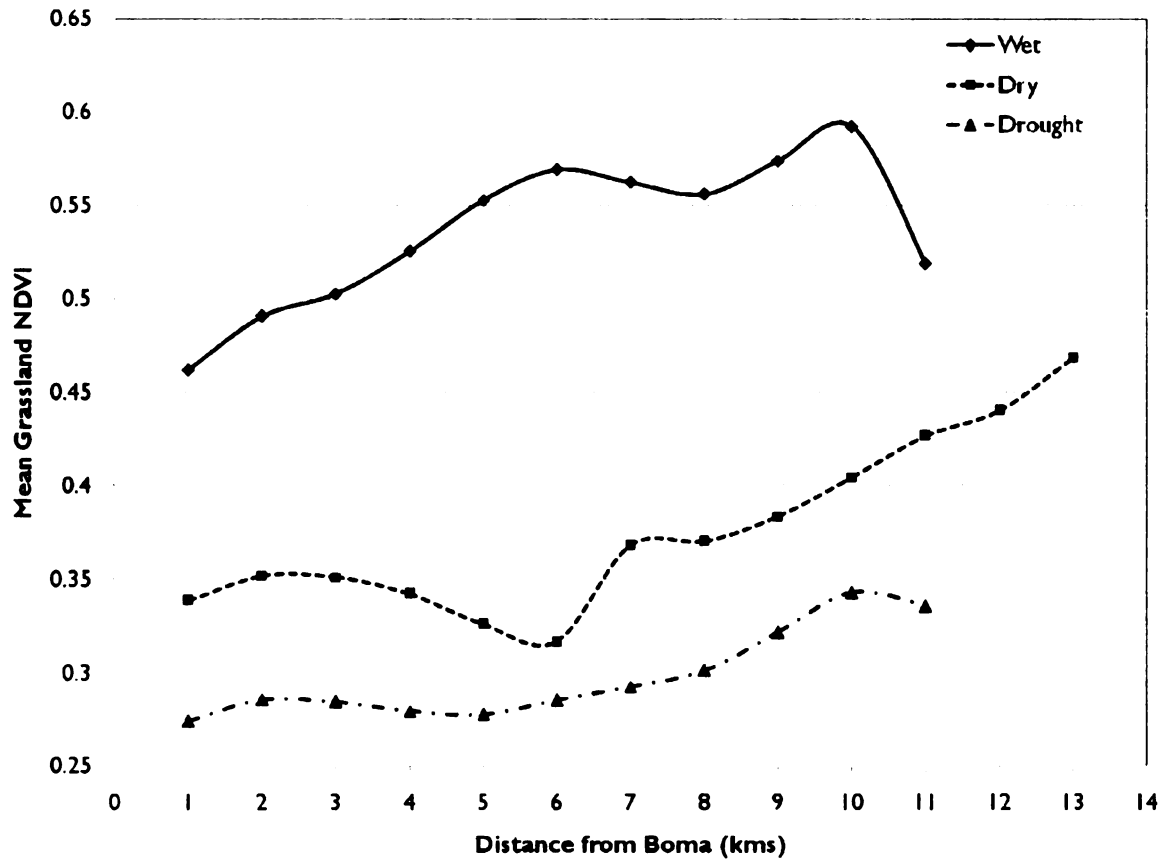


Figure 5.8: Mean grassland NDVI as a function of cattle intensity for the wet, dry and drought seasons. Intensity was calculated by counting the number of 15-second track points from GPS units on cattle that fall within 250 meter grid cells. Zero intensity areas are those with no cattle movement tracked within cells. Low intensity cells for the wet and dry season have been 1 and 500 points, medium intensity have been 500 and 1000 points, and high intensity zones have over 1000 points per cell. Intensity is calculated differently during the drought as the duration of drought is shorter. Low intensity areas are those with between 1 and 150 point per cell, medium intensity area have been 150 and 300 points per cell and high intensity areas are those with over 300 points per cell.

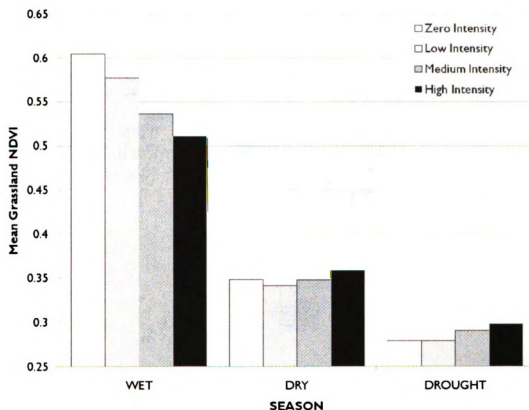


Figure 5.9a: Wet season cattle intensity. Zero intensity (0 point per grid cell), low intensity (1-500 points per grid cell), medium intensity (500-1000 point per grid cell), and high intensity (over 1000 points per grid cell). Medium and high intensity areas are located close to the bomas.

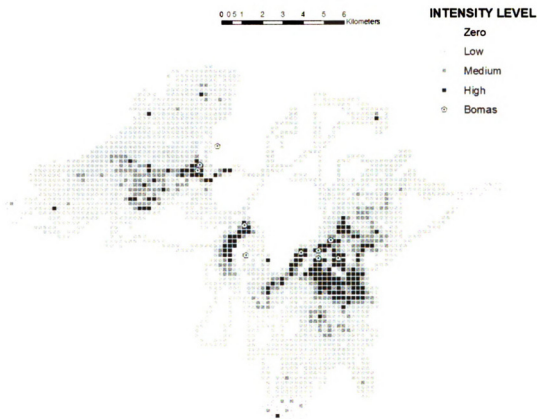


Figure 5.9b: Dry season cattle intensity. Zero intensity (0 point per grid cell), low intensity (1-500 points per grid cell), medium intensity (500-1000 point per grid cell), and high intensity (over 1000 points per grid cell). High and medium intensity areas are located further away from the boma.

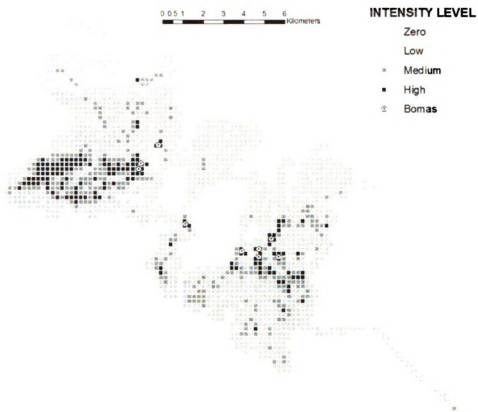


Figure 5.9c: Drought season cattle intensity. Zero intensity (0 point per grid cell), low intensity (1-150 points per grid cell), medium intensity (150-300 point per grid cell), and high intensity (over 300 points per grid cell). High and medium intensity areas are located furthest away from the boma.

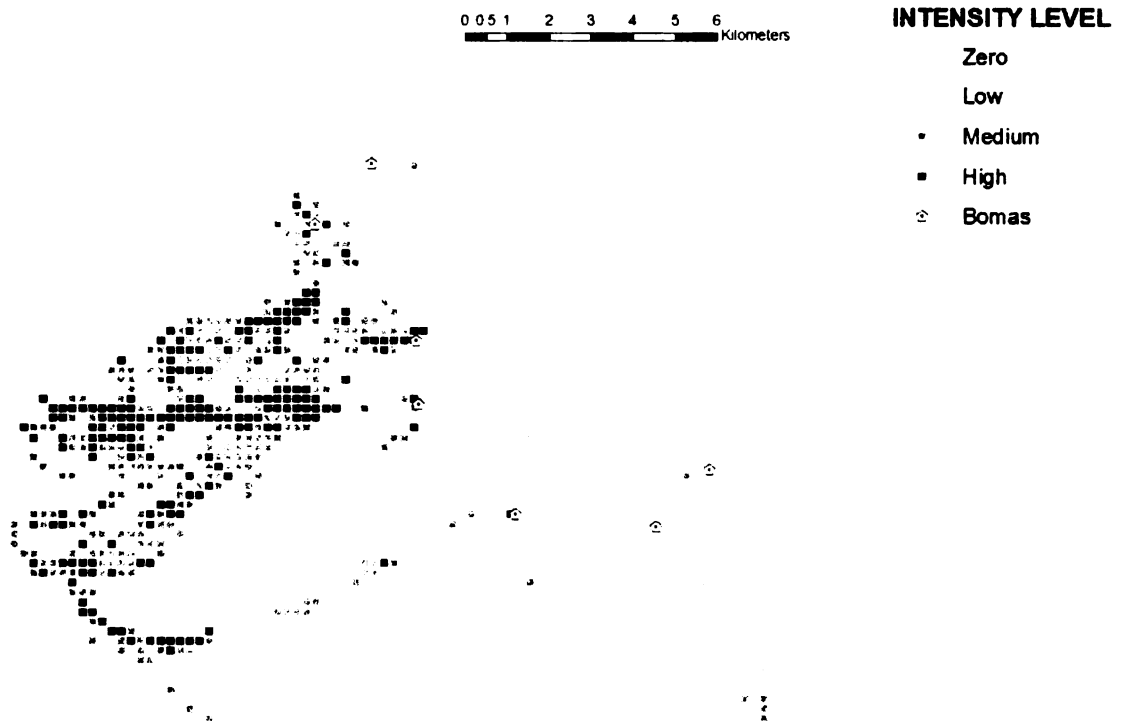


Figure 5.10: Comparative maps of high cattle intensity areas for the wet, dry and drought season. There are 173 high intensity cells (250 m cell size) during the wet season. Of these 173 high intensity cells, 56 also occur in the dry season and 16 in the drought. During the dry season, there are 151 high intensity cells, of which 56 also occur in the wet season and 37 in the drought. During the drought season, there are 198 high intensity cells of which 16 also occur in the wet season and 37 occur in the drought.

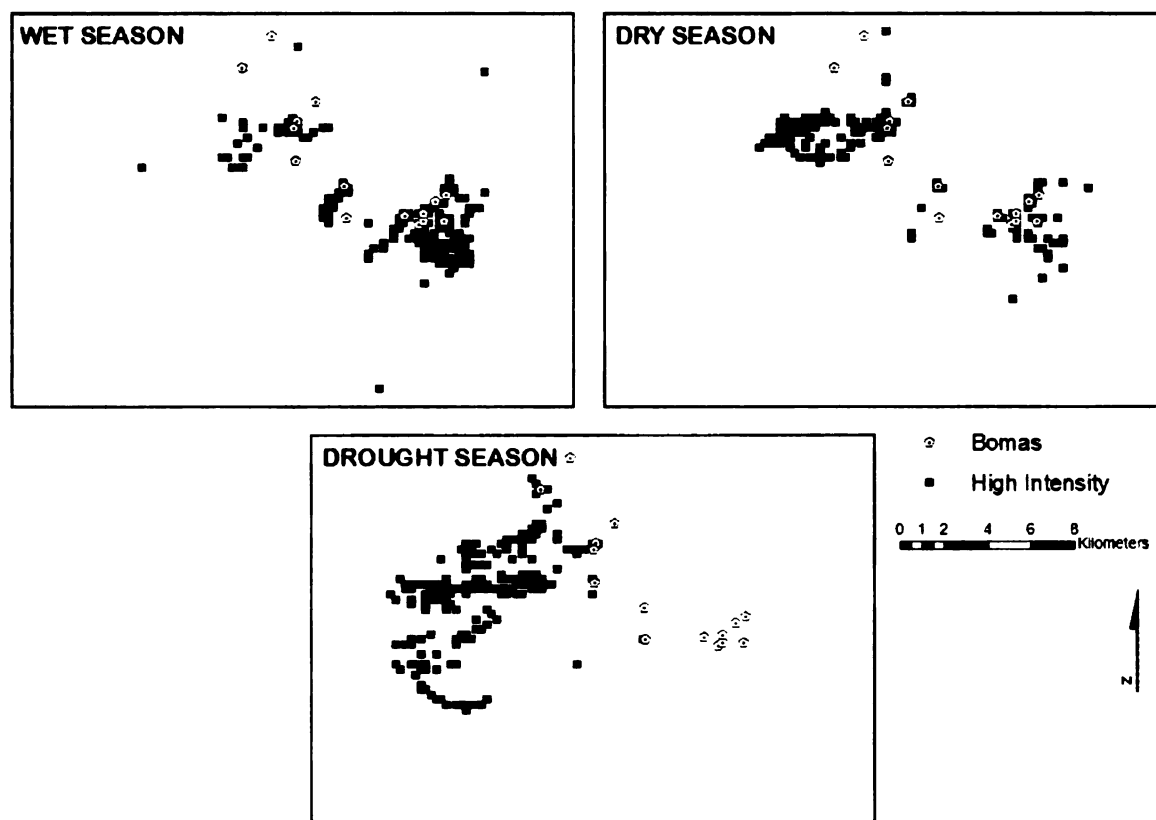


Table 5.1: Testing Framework and Research Hypotheses. NDVI denotes Normalized Differential Vegetation Index * ^GNDVI denotes Grassland NDVI

Research Hypothesis

$$H_1: NDVI_{(Grassland)} < NDVI_{(Mixed\ Bush/Grassland)} < NDVI_{(Bushland)} < NDVI_{(Woodland)}$$

During all three seasons, NDVI and NPP is lowest for grasslands and highest for woodlands

Tested Against: *Season*

Test Type: *ANOVA*

$$H_2: NDVI_{(Outside)} < NDVI_{(Inside)}$$

Mean NDVI for each land cover is lower outside the protected area than inside, suggesting that anthropogenic activities lower productivity

Tested Against: *Land Cover, Season*

Test Type: *T-Test*

$$H_3: {}^GNDVI_{(<1\ km)} < {}^GNDVI_{(>1\ \&\ <5\ km)} < {}^GNDVI_{(>5\ \&\ <10\ km)} < {}^GNDVI_{(>10\ \&\ <15\ km)}$$

As distance away from pastoral settlements increases grassland greenness concomitantly increases, suggesting that a gradient exists away from settlements

Tested Against: *Season*

Test Type: *ANOVA*

$$H_4: {}^GNDVI_{(1\ km)} < {}^GNDVI_{(2\ km)} \dots < {}^GNDVI_{(n\ km)} \dots < {}^GNDVI_{(Max\ n\ km)}$$

Cattle move towards greener areas regardless of seasonality in an effort to access greener pastures located further away from the household

Tested Against: *Season*

Test Type: *ANOVA & Correlation*

$$H_5: {}^GNDVI_{(High\ Intensity)} < {}^GNDVI_{(Medium\ Intensity)} < {}^GNDVI_{(Low\ Intensity)} < {}^GNDVI_{(Zero\ Intensity)}$$

As the time spend by cattle in a patch of land increase, grassland greenness decreases suggesting that cattle negatively influence productivity

Tested Against: *Season*

Test Type: *ANOVA*

Table 5.2: Average daily seasonal precipitation (mm/day), maximum and minimum temperature (deg C) between August 2005 and August 2006. N is the number of days encompassed in each season, M is the mean value, SD is the standard deviation and V is the variance

Temp Season	Days	Precipitation (mm)			Maximum Temp			Minimum		
	N	M ¹	SD	V	M ²	SD	V	M ²	SD	V
WET	128	3.61	7.17	51.47	27.25	2.05	4.23	14.43	1.35	1.83
DRY	191	1.32	4.32	18.68	27.30	1.94	3.79	16.16	1.51	2.30
DROUGHT	32	0.81	3.11	9.673	29.71	2.86	8.20	16.90	1.44	2.08
TOTAL	351	2.11	5.56	30.99	27.50	2.19	4.81	15.60	1.71	2.92

Table 5.3: Mobility parameters of cattle by season. Three parameters of mobility are calculated. HD denotes herd distance (total distance traveled by cattle in kilometers), HR is the herd radius (the maximum Euclidian distance traveled by cattle away from the boma in kilometers), and H.DUR is the herding duration (total time of travel from when cattle depart their enclosures, until they arrive back, in hours). N is the number of grazing orbits, M is the mean value, SD is the standard deviation and V is the variance

Season	N	Herd Distance (kms).			Herd Radius (kms).			Herd Duration (hrs.)		
		M	SD	V	M	SD	V	M	SD	V
WET	451	12.88	3.78	14.31	3.55	1.84	3.40	10.99	2.54	6.49
DRY	535	12.92	2.96	8.78	3.93	1.54	2.40	12.09	1.65	2.73
DROUGHT	132	14.39	5.19	27.03	7.63	1.99	3.96	11.42	3.81	14.59
TOTAL	1118	13.08	3.65	13.37	4.21	2.13	4.57	11.57	2.42	5.90

Table 5.4: ANOVA results and Bonferroni post-hoc statistics for mean NDVI by land cover type and season. N is the number of 250 meter cells that comprise each land cover type; W – woodland, B – bushland, M – mixed bushland/grassland, and G – grassland. Wet season $F_{3, 12196} = 58.098$, $p = < 0.0001$, dry season $F_{3, 12196} = 404.167$, $p = < 0.0001$, drought season $F_{3, 12196} = 164.147$, $p = < 0.0001$.

(I) landcover	N	mean	sd	(J) landcover	Mean Difference (I-J)	P
WET SEASON						
Woodland	291	0.617	0.079	B	*0.031	< 0.0001
				M	*0.048	< 0.0001
				G	*0.020	< 0.0001
Bushland	2513	0.586	0.063	W	*-0.031	< 0.0001
				M	*0.017	< 0.0001
				G	*-0.011	< 0.0001
Mixed	668	0.570	0.067	W	*-0.048	< 0.0001
				B	*-0.017	< 0.0001
				G	*-0.028	< 0.0001
Grassland	8728	0.598	0.070	W	*-0.020	< 0.0001
				B	*0.011	< 0.0001
				M	*0.028	< 0.0001
DRY SEASON						
Woodland	291	0.412	0.078	B	*0.031	< 0.0001
				M	*0.048	< 0.0001
				G	*0.020	< 0.0001
Bushland	2513	0.356	0.038	W	*-0.031	< 0.0001
				M	*0.017	< 0.0001
				G	*-0.011	< 0.0001
Mixed	668	0.333	0.030	W	*-0.048	< 0.0001
				B	*-0.017	< 0.0001
				G	*-0.028	< 0.0001
Grassland	8728	0.348	0.032	W	*-0.020	< 0.0001
				B	*0.011	< 0.0001
				M	*0.028	< 0.0001
DROUGHT SEASON						
Woodland	291	0.333	0.086	B	*0.055	< 0.0001
				M	*0.065	< 0.0001
				G	*0.053	< 0.0001
Bushland	2513	0.278	0.043	W	*-0.055	< 0.0001
				M	*0.011	< 0.0001
				G	-0.002	0.135
Mixed	668	0.267	0.037	W	*-0.065	< 0.0001
				B	*-0.011	< 0.0001
				G	*-0.013	< 0.0001
Grassland	8728	0.280	0.042	W	*-0.053	< 0.0001
				B	0.002	0.135
				M	*0.013	< 0.0001

* The mean difference is significant at the 0.05 level

Table 5.5a: ANOVA and Bonferroni post-hoc statistics for wet season grassland NDVI by distance band. ($F_{3, 8724} = 4506.007$, $p = < 0.0001$). Distance band 1 ≤ 1 km away from the boma, band 2 $> 1 \text{ \& } \leq 5$ kms away from the boma, band 3 $> 5 \text{ \& } \leq 10$ kms away from the boma, and band 4 $> 10 \text{ \& } \leq 15$ kms away from the boma

(I) DBAND	N	mean	sd	(J) DBAND	Mean Difference (I-J)	P
1 (≤ 1 km)	1280	0.522	0.044	2	*-0.047	< 0.001
				3	*-0.131	< 0.001
				4	*-0.171	< 0.001
2 ($> 1 \text{ \& } \leq 5$ kms)	4280	0.596	0.046	1	*0.047	< 0.001
				3	*-0.084	< 0.001
				4	*-0.123	< 0.001
3 ($> 5 \text{ \& } \leq 10$ kms)	2199	0.653	0.043	1	*0.131	< 0.001
				2	*0.084	< 0.001
				4	*-0.039	< 0.001
4 ($> 10 \text{ \& } \leq 15$ kms)	969	0.693	0.024	1	*0.171	< 0.001
				2	*0.123	< 0.001
				3	*0.039	< 0.001

* The mean difference is significant at the 0.05 level

Table 5.5b: ANOVA and Bonferroni post-hoc statistics for dry season grassland NDVI by distance band. ($F_{3, 8724} = 453.761$, $p = < 0.0001$). Distance band 1 ≤ 1 km away from the boma, band 2 $> 1 \text{ \& } \leq 5$ kms away from the boma, band 3 $> 5 \text{ \& } \leq 10$ kms away from the boma, and band 4 $> 10 \text{ \& } \leq 15$ kms away from the boma.

(I) DBAND	N	mean	sd	(J) DBAND	Mean Difference (I-J)	P
1 (≤ 1 km)	1280	0.333	0.028	2	*-0.007	< 0.001
				3	*-0.024	< 0.001
				4	*-0.037	< 0.001
2 ($> 1 \text{ \& } \leq 5$ kms)	4280	0.341	0.029	1	*0.007	< 0.001
				3	*-0.016	< 0.001
				4	*-0.029	< 0.001
3 ($> 5 \text{ \& } \leq 10$ kms)	2199	0.358	0.034	1	*0.024	< 0.001
				2	*0.016	< 0.001
				4	*-0.013	< 0.001
4 ($> 10 \text{ \& } \leq 15$ kms)	969	0.371	0.020	1	*0.037	< 0.001
				2	*0.029	< 0.001
				3	*0.013	< 0.001

* The mean difference is significant at the 0.05 level

Table 5.5c: ANOVA and Bonferroni post-hoc statistics for drought season grassland NDVI by distance band. ($F_{3, 8724} = 772.113$, $p = < 0.0001$). Distance band 1 ≤ 1 km away from the boma, band 2 > 1 & ≤ 5 kms away from the boma, band 3 > 5 & ≤ 10 kms away from the boma, and band 4 > 10 & ≤ 15 kms away from the boma.

(I) DBAND	N	mean	sd	(J) DBAND	Mean Difference (I-J)	P
1(≤ 1 km)	1280	0.268	0.028	2	0.0006	1.000
				3	*-0.022	< 0.001
				4	*-0.058	< 0.001
2(> 1 & ≤ 5 kms)	4280	0.267	0.030	1	-0.0006	1.000
				3	*-0.023	< 0.001
				4	*-0.059	< 0.001
3(> 5 & ≤ 10 kms)	2199	0.290	0.052	1	*0.022	< 0.001
				2	*0.023	< 0.001
				4	*-0.035	< 0.001
4 (> 10 & ≤ 15 kms)	8728	0.326	0.030	1	*0.058	< 0.001
				2	*0.059	< 0.001
				3	*0.035	< 0.001

* The mean difference is significant at the 0.05 level

Table 5.6a: Mean grassland NDVI Values by Intensity Level, for the wet season. IL is the Intensity Level based on the number of track points in each 250 meter cell. Min and Max are the minimum and maximum number of points contained within each grid cell, N is the number of cell, mean is the mean grassland NDVI value for grid cells, SD is the standard deviation of the mean and VAR is the variance of the mean.

IL	min	max	N	Mean	SD	VAR
0	0	0	7011	0.605	0.069	0.004
1	1	2	20	0.565	0.054	0.002
2	3	7	35	0.582	0.065	0.004
3	8	20	134	0.565	0.065	0.004
4	21	54	279	0.568	0.067	0.004
5	55	148	400	0.582	0.067	0.004
6	149	403	463	0.583	0.059	0.003
7	404	1096	273	0.541	0.056	0.003
8	1098	2976	99	0.513	0.042	0.001
9	3067	7998	10	0.501	0.046	0.002
10	8266	16397	4	0.509	0.003	
	0.0000109					
Total	0	16397	8728	0.597	0.070341	0.0049

Table 5.6b: ANOVA and Bonferroni post-hoc statistics for mean grassland NDVI and cattle intensity during the wet season ($F_{3, 12196} = 292.339$, $p = < 0.00001$). Cattle intensity is derived as: CI 1 (Zero Intensity) – 0 points per cell, CI 2 (Low Intensity): $> 0 \text{ \& } \leq 500$ points per cell, CI 3 (Medium Intensity) : $> 500 \text{ \& } \leq 1000$, CI 4 (High Intensity): > 1000 points per cell

(I) CI	N (cells)	mean	sd	(J) Intensity	Mean Difference (I-J)	P
1	9779	0.602	0.068	2	*0.032	< 0.0001
				3	*0.070	< 0.0001
				4	*0.092	< 0.0001
2	2008	0.570	0.062	1	*-0.032	< 0.0001
				3	*0.038	< 0.0001
				4	*0.060	< 0.0001
3	240	0.532	0.050	1	*-0.070	< 0.0001
				2	*-0.038	< 0.0001
				4	*0.021	0.006
4	173	0.510	0.042	1	*-0.092	< 0.0001
				2	*-0.060	< 0.0001
				3	*-0.021	0.006

* The mean difference is significant at the .05 level.

Table 5.7a: Mean grassland NDVI Values by Intensity Level, for the dry season. IL is the Intensity Level based on the number of track points in each 250 meter cell. Min and Max are the minimum and maximum number of points contained within each grid cell, N is the number of cell, mean is the mean grassland NDVI value for grid cells, SD is the standard deviation of the mean and VAR is the variance of the mean.

IL	min	max	N	Mean	SD	VAR
0	0	0	7342	0.348	0.032	0.001
1	1	2	14	0.343	0.026	0.0007
2	3	7	47	0.335	0.024	0.0006
3	8	20	95	0.341	0.023	0.0005
4	21	54	164	0.343	0.026	0.0006
5	55	148	298	0.343	0.027	0.0007
6	149	403	377	0.339	0.028	0.0008
7	405	1094	290	0.346	0.030	0.0009
8	1102	2795	87	0.362	0.034	0.0012
9	3070	7157	11	0.338	0.030	0.0009
10	11283	15702	3	0.326	0.016	0.0002
Total	0	15702	8728	0.347	0.031	0.0010

Table 5.7b: ANOVA and Bonferroni post-hoc statistics for mean grassland NDVI and cattle intensity during the dry season ($F_{3, 12196} = 18.406$, $p = < 0.00001$). Cattle intensity is derived as: CI 1 (Zero Intensity) – 0 points per cell, CI 2 (Low Intensity): $> 0 \leq 500$ points per cell, CI 3 (Medium Intensity) : $> 500 \leq 1000$, CI 4 (High Intensity): > 1000 points per cell

(I) Intensity	N (cells)	mean	sd	(J) Intensity	Mean Difference (I-J)	P
1	10111	0.351	0.037	2	*0.006	< 0.0001
				3	0.003	0.542
				4	-0.005	0.505
2	1660	0.344	0.028	1	*-0.006	< 0.0001
				3	-0.003	1.000
				4	*-0.011	0.0007
3	278	0.347	0.030	1	-0.003	0.542
				2	0.003	1.000
				4	-0.008	0.093
4	151	0.356	0.035	1	0.005	0.505
				2	*0.011	0.0007
				3	0.0085	0.093

* The mean difference is significant at the .05 level.

Table 5.8a: Mean grassland NDVI Values by Intensity Level, for the drought season. IL is the Intensity Level based on the number of track points in each 250 meter cell. Min and Max are the minimum and maximum number of points contained within each grid cell, N is the number of cell, mean is the mean grassland NDVI value for grid cells, SD is the standard deviation of the mean and VAR is the variance of the mean.

IL	min	max	N	Mean	SD	VAR
0	0	0	7597	0.279	0.042	0.0018
1	1	2	18	0.265	0.025	0.00063
2	3	7	36	0.265	0.030	0.00090
3	8	20	109	0.272	0.034	0.00116
4	21	54	233	0.278	0.033	0.00114
5	55	148	308	0.284	0.033	0.00114
6	149	398	333	0.290	0.032	0.00107
7	404	1089	85	0.302	0.030	0.00092
8	1175	2088	9	0.315	0.037	0.00139
Total	0	2088	8728	0.280	0.0417853	0.00174

Table 5.8b: ANOVA and Bonferroni post-hoc statistics for mean grassland NDVI and cattle intensity during the drought season ($F_{3, 12196} = 16.255$, $p = < 0.00001$). Cattle intensity is derived as: CI 1 (Zero Intensity) – 0 points per cell, CI 2 (Low Intensity): > 0 & ≤ 150 points per cell, CI 3 (Medium Intensity) : > 150 & ≤ 300 , CI 4 (High Intensity): > 300 points per cell

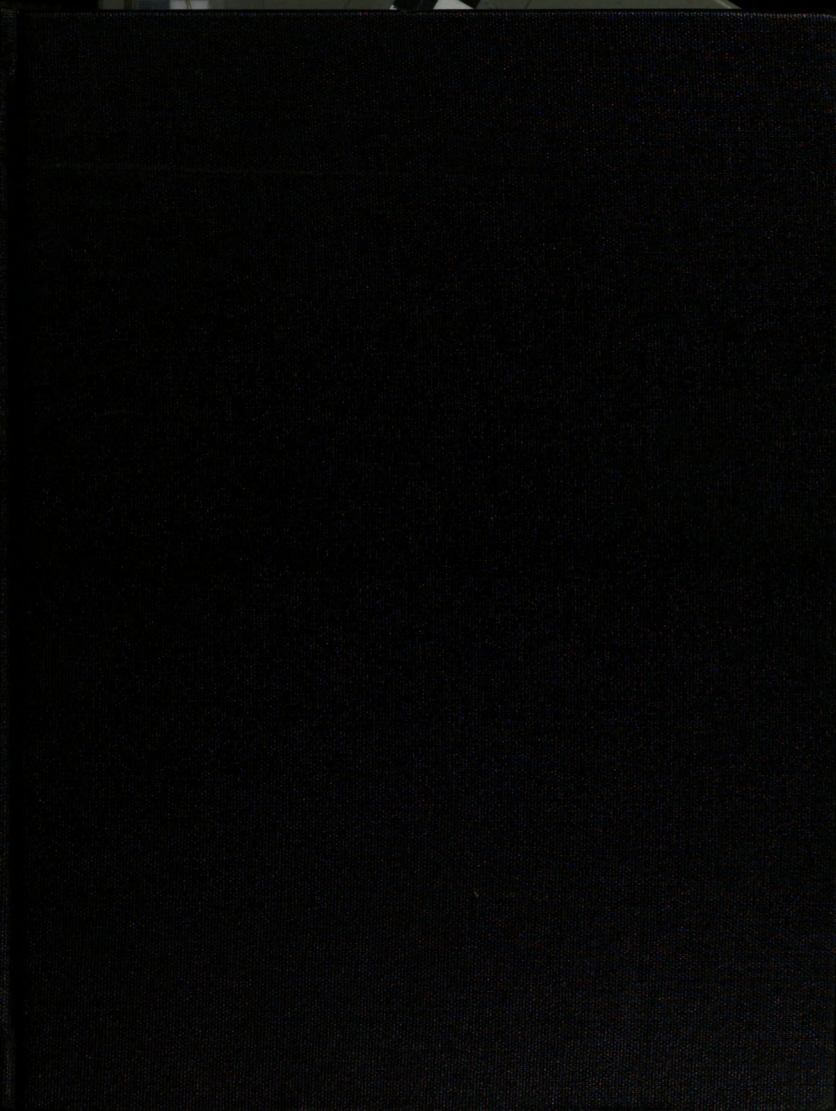
(I) Intensity	N (cells)	mean	sd	(J) Intensity	Mean Difference (I-J)	P
1	10756	0.279	0.045	2	-0.0003	1.000
				3	*-0.010	0.0001
				4	*-0.018	< 0.0001
2	950	0.279	0.035	1	0.0003	1.000
				3	*-0.010	0.002
				4	*-0.017	< 0.0001
3	296	0.290	0.0337	1	*0.010	0.0001
				2	*0.010	0.0022
				4	-0.007	0.4560
4	198	0.297	0.0311	1	*0.018	< 0.0001
				2	*0.017	< 0.0001
				3	0.007	0.4560

* The mean difference is significant at the .05 level.

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**GRAZING ON THE EDGE: CATTLE MOBILITY, ECOLOGY AND MAASAI
HERDING IN SOUTHERN KENYA.**

VOLUME II

By

Bilal Butt

A DISSERTATION

**Submitted to
Michigan State University
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Department of Geography

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CHAPTER 6

Herding strategies of Maasai pastoralists: Does wealth matter?

6.0 Introduction

Pastoralism is the most efficient livelihood system in dry land regions of the world (Salzman 2004; Ellis and Galvin 1994). Despite this, pastoralists in East Africa have been marginalized by the national government and witnessed a reduction in their access to historical grazing lands through the creation of national parks and reserves, and the dilution of traditional coping strategies through local and national policies that privilege commercial and subsistence agriculture as well as nature conservation over nomadic pastoralism (Rutten 1992, 2002). These constraints have reduced the flexibility inherent within a traditional pastoral livelihood system (Sørbo 2003; Fernandez-Gimenez and Le Febre 2006). Cattle mobility forms the basis of many traditional coping strategies of pastoralists (Niamir-Fuller 1999b). These include taking advantage of ecological gradients and heterogeneity across the landscape, and movement to informal market centers and trade among several other strategies (Chapter 2, 4) (Behnke, Scoones, and Kerven 1993; Scoones 1994a). Daily and seasonal decisions driving cattle mobility are thought to be the product of cross-scalar socio-cultural, political, economic and ecological conditions. These decisions are both highly dynamic and adaptive across both space and time as they are sensitive to seasonality and climatic constraints (Turner 1998a; Ellis and Galvin 1994; Ellis, Coughenour, and Swift 1993; Galvin et al. 2001).

There is a large body of literature that describes the herding strategies of pastoralists as it relates to cattle mobility and herd management practices among different pastoral groups in East Africa (Sieff 1997; Bekure et al. 1991; Dyson-Hudson and

McCabe 1983; Little, Barrett et al. 2001; McCabe 2004; Coppolillo 2000). However there are few attempts that identify the herding strategies of pastoralists who reside at the periphery of large protected areas (PAs), and who utilize as PAs as frequent grazing areas (Turner 1999b). Where attempts have been made, they do not consider: (1) household wealth; (2) seasonal variability, and; (3) combined social and ecological factors influencing herding. The purpose of this chapter is to understand the herding strategies of Maasai pastoralists around the Maasai Mara National Reserve in Kenya by explicitly considering these three factors. Using daily interviews with herders and elders, structured household surveys, and spatially explicit tracking of cattle, this chapter identifies household and non-household conditions influencing herding strategies before cattle depart their enclosures, while herding, and once they return. This study finds that the herding strategies of wealthier households are better suited to coping with drought conditions than less wealthy households.

6.1 Herding strategies of pastoralists

Herding strategies are the synergistic product of a number of different social, cultural, political, economic and ecological factors that are sensitive to space and time (Baker and Hoffman 2006; Ruttan and Mulder 1999; Butt 2002; Sieff 1997; Turner 1998a; Turner 1999a; Bassett 1994, 1986). In order to effectively understand the variability of herding strategies and their relationships to the decision making process, I divide herding strategies into two 'place-based' categories: household and non-household factors. Household factors such as the amount of labor dedicated to herding, the size of the pastoral household, its relative wealth, and livestock health practices are directly

controlled by pastoralists. Conversely, non-household factors such as forage, water, hazardous wildlife, diseases, and park/ranger patrols are beyond the direct control of pastoralists, but accrued knowledge of these factors helps inform decision making at the household level. The selection of these factors is informed by the literature and my experience with Maasai pastoralists in Kenya.

6.1.1 Household-level factors

Labor: Pastoralism is a labor intensive process that transcends age, gender and class. Previous studies of pastoral herding have sought to understand labor and herding by evaluating the percentage of time spent on herding activities (Bekure et al. 1991; Fratkin 1989). The most laborious livestock related activities include, but are not limited to: (1) watering; (2) herding; (3) milking; and (4) dipping/spraying cattle. These activities take place daily scale except for dipping/spraying which occurs on a bi-monthly or monthly basis (de Leeuw and ole Pasha 1987). Non-livestock related activities that contribute indirectly to the herding process are: (1) the construction of housing and enclosures to fence in cattle at night; (2) cooking and cleaning; (3) engaging in part-time or full time employment; (4) school attendance; (5) social activities such as circumcisions and weddings; and (6) household relocation during times of additional stress such as drought and flood (Chapter 4).

The amount of labor devoted to herding also depends on the type of livestock. Adult and immature cattle are often herded as one group, while young calves, sheep and goats are divided into a second group (Homewood and Rodgers 1991). Some pastoral households combine older suckling cattle with resting bulls and sick or weak cattle

(Bekure et al. 1991). In most cases labor is recruited from within the household and may include both family and non-family members who are not paid, but may receive compensation, such as food, lodging or the payment of school fees for the herder's siblings (Grandin, de Leeuw, and de Souza 1991). In other instances herders are hired from outside the family and even outside the region to assist in herding (Bassett 1994; Little 1985a, 1985b).

In the Kajiado district of Kenya, Grandin, de Leeuw and de Souza (1991) found that Maasai herders split cattle herds during the dry season with a 'wet' herd that involves lactating cattle left in the home to provide milk for women and children, and a 'dry' herd where cattle, mature and immature steers are moved to distant grazing in order to access forage located further away. The gendered division of herding labor varies from site to site. Adult married men are the primary managers and supervisors of the herding process and,

“...make the initial decision on residence location, decide on herd movement and splitting, on the watering location, the daily orbit of grazing and who will do the herding. They tell the herder where to go and often accompany the herd to make sure that it follows the intended orbit. Men usually oversee watering to ensure that animals are watered in an orderly fashion and are not pushed away by someone else's animals” (Grandin, de Leeuw, and de Souza 1991: 71).

Adult women control the milking of cows and attend to the feeding of young calves and also retain the right to milk cows from their own households. Women also perform other 'invisible' activities that maintain the herd, such as caring for sick animals and feeding herders before they leave and when they return from grazing (Chieni and Spencer 1993; Spencer 2003; Hodgson 2001, 2000). Herding is also done by women and

in some cases the amount of time dedicated to herding is no different from that of adult men. For example, in a study of Maasai herding in the Kajiado district of Kenya, Grandin, de Leeuw, and de Souza (1991: 75) found that the average time spent on herding activities for adult men and women was approximately 0.4 hours per day, while male and female children spent 5.0 and 4.5 hours/day respectively. Children between the ages of 6 and 15 are responsible for the bulk of herding. Children as young as 3 or 4 years old become engaged in the herding of calves, sheep and goats, before they become apprentices to older herders at around the age of 11 (Grandin, de Leeuw, and de Souza 1991; Sieff 1997; Spencer 2003).

In West Africa, Turner (1999a) suggests that not only is the age of the herder important, but also the relationship of the herder to the herd owner and herd patriarch, also known as the “the eldest male member of the herding family” (Turner 1999a: 269), as this affects the quality of the herding process. He argues that:

“...the quality of herding, although affected by the individual personality, knowledge, and maturity of herders, is also strongly shaped by a broader set of social factors. Labor availability within the production unit will help determine the demands placed on the herder. Low labor availability is associated with a greater reliance on younger, more inexperienced herding labor as well as with longer herding hours, which lead ultimately to a drop in herding diligence” (Turner 1999a: 271).

There are numerous ethnographic accounts of herders which suggest that this is also the case for the Maasai (Jacobs 1975; Spencer 2003; Saitoti and Beckwith 1980; Sankan 1971; Spencer 1988; Spear and Waller 1993; Ole Saibull and Carr 1981).



Sieff (1997) summarizes some of the most recent debates concerning labor as a limiting factor in the herding process. She suggests that given the unique set of constraints that each pastoral household faces, herding labor is dependent upon: (1) the number of herds that can be managed; (2) the number of animals within the herd; (3) herd growth over time; (4) labor; (5) condition of grazing resources; (6) cooperation with other households.

Scoones (1992) argues that there are minimum labor requirements for the herding process which vary from place to place. Once these requirements have been met, livestock productivity is not sensitive to additional inputs. He found that, during the 1986-1988 droughts in Zimbabwe, cattle survival was not affected by who undertook the herding (individuals within the household, cooperating households, or hired help). These findings have been reinforced by Sieff (1997) where the 'minimum requirements' thesis has also been observed by Datoga pastoralists in Tanzania.

Household size and wealth: The size of a pastoral household is among the most important factors in the herding process (Coppolillo 2000; Turner 2000; Sutter 1987; Johnson 1983). Household size refers to the number of individuals, both resident and non-resident, that contributes financially, socially, culturally, or otherwise towards the general well-being and sustainability of the pastoral household. The concept of a pastoral household is problematic as it implies a static place in time (Carr 2005) and as Turner (2000) describes, many researchers have had problems with dealing with the household as a single, undifferentiated social unit. Pastoral households, especially the Maasai transcend scales of space and time and have various socio-spatial scales of organization (Chapter 3) (Grandin 1991), and, "members of the household have different external



relations and are differently positioned with respect to capital..” (Turner 2000: 1010). In addition the number of individuals within the household varies as occupants may stay within the household from time to time shifting between permanent households and temporary camps, or use the household as a base to stay when they visit while engaging in permanent employment elsewhere. The number of adults and children within the household is also difficult to estimate because children may be sent to boarding schools. Overcoming these problems is difficult as it requires length intensive field periods to evaluate the different ‘situatedness’ of households and researchers have therefore turned to analogous measures of household size. These are: (1) the ratio of livestock to people, and; (2) the number of tropical livestock units (TLU)³⁷ managed by the household.

Within Maasai dominated parts of southern Kenya, researchers have delineated poor households as those with < 5 TLU (approximately 3.5 cattle), medium wealth ≥ 5 and ≤ 13 TLU (3.5 - 9.1 cattle) and, rich households > 13 TLU (> 9.1 cattle) (Grandin, de Leeuw, and de Souza 1991). Measures of the ratio of people to livestock can be traced to western paradigms of carrying capacity and stocking density (Heady 1960), although it is still used today³⁸. Generally, researchers have assumed that larger households are those

³⁷ TLU (Tropical Livestock Unit) is a convenient method for quantifying a wide range of different livestock types and sizes in a standardized manner. It is defined as, “a common unit to describe livestock numbers of various species as a single figure that expresses the total amount of livestock present – irrespective of the specific composition”. In order to do this, the concept of an ‘exchange ratio’ has been developed, whereby different species of different average size can be compared and described in relation to a common unit (e.g. 1 TLU = Camels 1.0; Cattle 0.7; Sheep/Goats: 0.1) (LEAD 2007).

³⁸ For example, within Narok district of Kenya, Lamprey and Reid (2004) compare stocking densities and equivalency units of the number of livestock needed to sustain pastoral households. Among the measures they employed are the standard stock units (SSU) and livestock units (LU) or 250kg per reference adult (RA) which may be approximated to the active adult male equivalent (AAME). These standardized measures, while good for broad scale analyses across time and space, do not consider small variations in livestock numbers within a single year or between multiple households or split herds. As a result, some researchers have simply relied on the total number of livestock within a household to estimate wealth status (BurnSilver, Boone, and Galvin 2003; Coppolillo 2000) or TLU per household (Sieff 1997).

that have a high number of TLU and a high number of adult males, dependents, and children resident within the household (Sieff 1997; Thornton et al. 2007; McCabe 2004).

There is recent evidence to suggest that pastoral households in East Africa are supplementing livestock-derived wealth with monetary income from tourism and agricultural activities (Thornton et al. 2007). Households with greater monetary wealth are able to hire herders from outside the household to conduct the bulk of herding activities. Fratkin (1991a) suggests that there are tradeoffs between hiring non-household related family members and individuals from within the households. On the one hand hired herders may be less concerned about cattle and their welfare, while on the other having hired herders reduces the strain on households that have fewer herders within the labor pool to begin with (Little 1985a, 1985b; Fratkin 1991a). Households that have less monetary wealth may be inclined to utilize existing labor from within the household and who have a greater vested interest in ensuring that cattle are better managed (Bassett 1994; Turner 1999a).

The advantages of wealth on livestock production practices of pastoralists have been the subject of debate amongst many researchers. Differences in wealth among pastoral households are served and facilitated by both narrow self-interest that sustain the herd and household, and high interdependence between households that are not necessarily equal in wealth (Sieff 1999; Sellen 2003; Ruttan and Mulder 1999; Mulder 1991, 1999).

There are numerous ways by which wealth influences pastoralism and pastoral herding strategies. Wealth generally translates to power, and as a result, the wealthy may find it 'advantageous to coerce others' into practices that suit the wealthy (such as

cooperative herding, or engaging in community conservation schemes that offer payouts to large herd owners, though not exclusively) (Ruttan and Mulder 1999; Anderson 2002; Anderson and Broch-Due 1999; Waller 1999). In addition, although wealth is not a prerequisite for elder status, influential and respected elders are usually rich in livestock. As a result elders are in a good position to enforce grazing rules and to sanction and punish violators of these rules primarily because they are the owners of the majority of the livestock within a given neighborhood/locality” (Maa: *elatia/enkutoto*) (Ruttan and Mulder 1999: 631; Fratkin 1991a; Waller 1999). Wealthier households have more people living in their homesteads (Grandin, de Leeuw, and de Souza 1991: 75). Therefore, there are, “few opportunity costs for wealthy old men (Swahili: *Wazee*) in spending time on committees and councils, attending trials, and adjudicating moots”, rather than spend time supervising cattle on a regular basis (Ruttan and Mulder 1999: 632). Similarly wealthier households are likely to benefit from the labor provided by poorer households, by being able to hire more herders, more cheaply (Fratkin and Smith 1994; Ruttan and Mulder 1999). Mutual cooperation (between wealthy and poor households) is most likely when, “wealth inequalities are mild and costs are low, that is, when the payoffs to any given strategy are somewhat similar for wealthy and poor herders” (Ruttan and Mulder 1999: 628). In contrast, poorer households value the presence of wealthier families in their neighborhood, “since the latter not only commonly provide community defense (of land and livestock), but also offer quasi-patronage to households with insufficient livestock for subsistence” (Ruttan and Mulder 1999: 635). Numerous mechanisms exist whereby a household (poor or otherwise) undergoing crisis receives gifts or loans of

livestock from wealthier households, especially where family ties are strong between these households (Ruttan and Mulder 1999: 635; Waller 1999; Spear and Waller 1993).

Livestock health: Livestock inputs such as salt licks, dips, spraying and injecting cattle with prophylaxis or antibiotics are directed towards minimizing diseases risks and maximizing livestock health. Livestock health is related to: (1) the prevalence, intensity and spatial distribution of diseases, and; (2) the ability of the household to purchase veterinary inputs. Vaccination is the most common type of livestock health and is usually administered within the home or at designated (often government-run) vaccination or veterinary centers. There are two main means by which veterinary inputs are administered and the timing of inputs varies by seasonality and the prevalence of diseases. The first and most common is to inject cattle with prophylaxis/trypanocides to guard against and cure trypanosomiasis. This takes place on a daily basis. Second, herders will either take livestock to dips to prevent ticks and tick-borne diseases and takes place weekly or bi-monthly. This strategy is dependent upon how many dips are located with a suitable range of the household, the number of herders available to take the herd to the dip, and the financial cost associated with dipping cattle. If the household is unable to meet these requirements, they may collaborate with other households to purchase a hand pump and manually spray acaracides on individual cattle or the entire herd. de Leeuw and Ole Pasha (1987) note that although spraying is less effective than dipping, “it is cheaper and easier to organize, since each producer can decide on his own schedule, acaracide type and strength” (de Leeuw and ole Pasha 1987: 179).



6.1.2 Non-Household-level factors

There are five non-household based factors that contribute to the herding process. These are: (1) forage; (2) water; (3) wildlife; (4) diseases, and; (5) park/ranger patrols. The latter three factors may be considered specific to pastoral areas bordering large protected areas, although diseases such as trypanosomiasis are common in bushland dominated savanna ecosystems (Waller 1990). There also is high density and distribution of wildlife outside protected areas (Ottichilo, Said et al. 2000; Broten and Said 1995; Said 2003; Peden 1984; Reid et al. 2003). Each of these factors – along with household factors – contributes to the selection of a grazing location and the path that herders chose to direct their cattle along (the grazing orbit).

Forage: Forage quality and quantity is among the most important non-household considerations influencing herding strategies (Coughenour 1991; Ndikumana et al. 2000; Turner 1999a). Forage quantity can be estimated through: (1) the amount of grazeable biomass as measured by dry matter (DM) weight (usually in kilograms) per hectare per millimeter of rainfall (Deshmukh 1984; Sinclair 1979; Bekure et al. 1991), or the herbage mass (HM) in kilograms of dry matter per hectare (Turner, Pierre, and Eva 2005); (2) the growth rate during the growing season expressed as DM weight per hectare per day (Fryxell, Wilmshurst, and Sinclair 2004; Wilmshurst, Fryxell, and Colucci 1999). However, these measures are difficult to obtain as they require lengthy field study periods, and the logistics associated with the measurement method (clipping and drying biomass) are time consuming and expensive (Boutton, Tieszen, and Imbamba 1988a; Coe, Cumming, and Phillipson 1976). Forage dry matter is highest in areas and time

periods of higher rainfall during the growing season (wet season) than during the dry season (Kinyamario and Macharia 1992).

Forage quality is measured by the amount of crude protein content, and percentage digestibility (de Leeuw 1991). Crude protein content is linked to the amount of standing biomass, and is higher for leaves than stems or leaf sheaths (which make up a larger percentage of the diet for cattle). Greater amounts of crude protein are positively associated with higher rainfall (Ottichilo, De Leeuw et al. 2000).

Where quantitative measures are unavailable, researchers have relied on grass height as a representative indicator of forage quantity. This indicator is also used by herders to assess forage quantity. For example, Reid et al. (2003) in a ground count of the Maasai Mara region relied on grass height divisions of ≤ 3 cm, > 3 and ≤ 5 cm, > 5 and ≤ 10 cm, > 10 and ≤ 20 cm, and > 20 and ≤ 200 cm to extrapolate forage quantity. Grass height provides the quickest measure of forage quantity and assumes that taller grasses are indicative of higher forage quantity. Similarly, forage quality has been related to grass color. This may either be done visually or using Munsell TM plant tissue charts (Wilmschurst et al. 1999), or by qualitative visual estimates of grass color. Reid et al. (2003) divided grass color into five equal increments of percentage greenness. Generally a lower percentage of greenness is associated with poorer forage quality (Augustine, McNaughton, and Frank 2003).

Water: The strategies that pastoralists rely on to provide water for their cattle vary from region to region and is dependent on the amount, availability, spatial distribution of water (de Leeuw 1991) as well as the size and composition of the herd. Additionally, pastoralists consider the time since the herd was last watered. For example, BurnSilver,

Boone, and (2003) found that Maasai herders in the Amboseli basin of Kenya alternate their herding strategies whereby cattle are taken for grazing 5 days a week and are taken to water holes twice a week.

Water is generally not a limiting factor during the wet season as there are numerous seasonal streams that fill quickly with surface runoff (Talbot 1986). However, during the dry season, water quantity quickly decreases in seasonal streams (known as luggas), leaving stagnating pools of muddy water. Along the perennial rivers, water quality is also affected by the increased amount and concentration of phosphorus and nitrogen from the excrement of hippos and other wild animals. Kavana, Kizima and Msanga (2005) have found that Maasai pastoralists in Tanzania rank water quality on the following preferential criteria: (1) clear color; (2) somewhat salty; (3) less turbidity (muddy water is considered not suitable for livestock and blamed as source of diseases); (4) no odor (muddy smell water is not acceptable), and (5) lack of visible parasites and algae.

Wildlife: Pastoralists generally choose to avoid areas that are heavily populated by wild animals such as elephants and lions, which have been known to attack cattle while being herded, often injuring or killing herders and their cattle (Kolowski and Holekamp 2006; Frank, Woodroffe, and Ogada 2005; Woodroffe, Thirgood, and Rabinowitz 2005). Kolowski and Holekamp (2006) studied the spatial and temporal variability of livestock depredation and their effects by wild animals on livestock in and around the Maasai Mara National Reserve. They found that attacks by hyenas (*Crocuta crocuta*) on grazing herds during the day were as common as attacks at night when cattle are corralled within their enclosures. Hyenas were, “responsible for more than 80% of attacks both on cattle within



the boma, and on grazing herds of sheep and goats.” Additionally, “lions (*Panthera leo*) attacked corralled livestock less than they attacked grazing herds and were involved in 74% of attacks on grazing cattle herds. Conversely, leopards (*Panthera pardus*) attacked grazing herds less than livestock in bomas and were responsible for 56% of all attacks on sheep and goats in bomas. All attacks at the boma took place during the night whereas 71% of attacks on grazing herds took place between 11:00 and 16:00 hours” (Kolowski and Holekamp 2006: 533).

Wildlife-livestock conflicts follow a temporal relationship where the frequency of attacks is highest during the wet season and strongly correlated with rainfall (Kolowski and Holekamp 2006). Within the same area Ogutu, Bhola and Reid (2005) found that the density and distribution of carnivores and their prey is different between pastoral areas and border protected areas. In addition wild prey biomass density is higher outside the protected area during the wet season, but the density of lions is eight times lower outside the protected area. Lion, hyena and wild prey biomass densities during the dry season did not appear to be different over a twelve year period (Ogutu, Bhola, and Reid 2005).

Ogada et al. (2003) examined the effects of livestock husbandry activities on depredation by wildlife in Northern Kenya. They found that the, “effects of husbandry on depredation away from the boma concerned only sheep and goats because no field attacks on cattle involved the loss of more than one animal. A small number of sheep or goats was lost to predators on each attack where the ratio of herders to livestock was high” (Ogada et al. 2003: 1528).

Diseases: The two most prevalent diseases that influence the herding process around protected areas in east Africa are animal trypanosomiasis, and malignant catarrhal

fever (MCF) (Bourn and Blench 1999). Tsetse fly (*Glossina sp.*) transmitted trypanosomiasis has hindered human and livestock development in many parts of Africa (Sindiga 1987b, 1984; Ford 1971; Waller 1990, 2004b). Tsetse flies are found in dense bushland areas and do not affect wild African bovidae (Bourn and Blench 1999). In a study around the MMNR, Butt (2002) found that Maasai herders face a dilemma of grazing cattle on understory forage in dense upland bushland zones at the cost of more frequently injecting cattle with trypanocides. This trade-off is dependent upon seasonality where the incidence of trypanosomiasis is higher in the dry season than the wet season. In one of the few studies that examines how cattle management practices influence susceptibility to trypanosomiasis, Torr et al. (2000) found that tsetse flies are attracted to larger herds, especially mature oxen, indicating that treating only mature oxen with trypanocides may reduce the effects of trypanosomiasis. In Tanzania, Coppolillo (2000) finds that the effects of trypanosomiasis on cattle are higher during the early wet season and that, “larger herds may encounter a more substantial challenge from parasites” (Coppolillo 2000: 551).

Malignant Catarrhal Fever (MCF) is spread by inhalation or ingestion of the ovine herpesvirus, that is passed onto cattle from the excreta of young wildebeest (*Connochaetes taurinus*) or afterbirth of newborn wildebeest calves (Grootenhuis 2000a). Around the MMNR there are two main wildebeest populations: (1) the migratory population that originates in the neighboring Serengeti National Park and comes into the MMNR between August and October, and; (2) the resident or ‘Loita’ populations which remains within and around the pastoral areas year round and calve between January and



March (Serneels and Lambin 2001a; Ottichilo, De Leeuw, and Prins 2001). The mortality associated with MCF can be as high as 10% for cattle (Grootenhuis 2000a).

Park Patrols: The influence that park or ranger patrols have on the herding process of pastoralists has received little attention from researchers. This is partly because of the controversy of researching illegal activities and the difficulties of collecting field data in arduous environments (Nordstrom and Robben 1995). However, Turner (1999b) has found that Fulbe pastoralists around National Park 'W' in Niger move into the protected area not because of "stubborn cultural pride" (as is the dominant view among park stakeholders and conservationists'), but because the alternatives available to them are "even less attractive" (Turner 1999b: 358). He adds that the effects of ranger patrols did not "greatly curtail" Fulbe livestock movements into the park, but did result in increased movement through the park at night to avoid rangers and to lessen the disturbance to wild animals. Herding of livestock at night is a strategy employed by pastoralists during dry and drought periods to reduce heat stress and increase forage intake and is well documented across West Africa (Adriansen and Nielsen 2002; Ayantunde et al. 2002; Ayantunde et al. 2000).

6.1.3 Synergies between herding factors

On any given day, a different set of household factors combine with non-household factors to produce the herding orbit, or the path that cattle traverse from when they leave their enclosures until they return (chapter 4). The way in which these two factors synergize is dependent upon the strength of the factors and the degree of

interaction. Therefore a discussion on the synergies is therefore necessary to demonstrate the complexity of the decision-making strategies of pastoralists.

To do this, I use labor as a starting point. The amount and type of labor dedicated to the herding process is tied to the availability, or lack thereof, of the number of herders, the age of the herders, the availability of the herder to conduct herding, the human composition of the household, its relative wealth status, the season and time period within the season (for example early wet or late wet season), as well as forage and water conditions (Butt 2002; Turner 1999a; Turner, Pierre, and Eva 2005). A less wealthy household is often unable to afford to employ a hired herder must rely on the labor recruited from within the household (Fernandez-Gimenez 1999; Fratkin 1989; Fratkin and Smith 1994; Turner 1999a). Depending upon the age and gender composition of the household, where a young male herder of approximately 12 years old may be asked to undertake the herding upon instruction from the herd patriarch. During the dry and drought periods, such a young herder may not have the necessary experience to lead a herd of cattle into areas that are unfamiliar to him. If the size of the herd is small (which is likely to be the case with a less wealthy household), the herder may spend a lot more time walking and grazing the herd, resulting in an elliptical orbit. In contrast, a wealthier household with an older and more experienced herder may direct cattle towards areas that he has come to be familiar with – areas where green flushes of vegetation are prevalent, even in the late dry season. Because of this knowledge, the herder will direct cattle to these areas and spend a maximum amount of time at green patches for a sustained amount of time, before returning straight back to the household resulting in a more linear and elongated herding orbit.

Pastoralists who reside around protected areas (PAs) also face the added dimension of act of aggression by park rangers for grazing their cattle inside the PA. Seasonality is a large determinant of movement in to PAs (as PAs often contain the last reserves of forage during the late dry and drought season) (Turner 1999b). Herder age and experience also becomes more important during this period as younger and inexperienced herders from less wealthy families may be forced to graze their cattle inside the PAs despite their reluctance to do so, and upon the insistence of the herd patriarch. Wealthy households may be more inclined to take these risks as they are more able to pay for fines levied upon them by rangers, while less wealthy households are unable to pay them

In some cases, labor and its constituent elements may not be as important if seasonal constraints are not severe, such as during the wet season. Forage and water are in abundance and located close to households during this season, and household factors such as wealth or herd size are relatively unimportant to the selection of a particular herding strategy. Instead other factors such as diseases, particularly foot and mouth disease (Bourn and Blench 1999) and the potential for attacks by wildlife (Kolowski and Holekamp 2006) become more important.

6.2 Methods

6.2.1 Data Collection

Data was collected from ten Maasai households between August 2005 and August 2006 across the wet, dry and drought seasons. Detailed descriptions of the data collection process have been described in chapter 3, 4 and 5.

6.2.2 Data Sets

Three datasets were used to analyze the decision making strategies of Maasai pastoralists. The first dataset contains a point file of the spatial location of the furthest Euclidian distance point that cattle travel from the household (hereafter known as the herd radius), along with the total duration of herding (hrs), total distance (km), average speed (km/h), season, herd size, and an identifier code for each household.

These spatial data were integrated with the second dataset which involved twice daily key-informant interviews with herders. Interviews were conducted with the herder responsible for herding cattle before cattle left their enclosures in the morning (the pre-herding orbit report). A second interview was conducted when cattle returned in the evening (post-herding orbit report). A copy of the original pre and post-herding orbits report forms used in the study is shown in Appendix 1. The protocol for administering the interviews is described in chapter 3.

The dataset resulting from these interviews provides the list of variables to infer herding strategies and understand the relationships between herding strategies, wealth and decision making. These variables are shown in Tab. 6.1. Pre-herding orbit questions focused on the age, gender and number of herders, who were responsible for selecting the grazing location, as well as the environmental considerations driving the choice of the grazing location (grass height, color, water quality and quantity). Grass height was categorized as: short, medium and tall. Grass color was categorized as: fresh-green, green-brown, and dry-brown. Water quality and quantity was categorized as: clean and flowing, clean and stagnant, muddy and stagnant, and muddy and flowing. While these

categories may be considered subjective, Maasai herders used distinct words in the Maa to describe these environmental variables. For example, the Maa word for fresh green grass usually found after intense rainfall events or along the banks of rivers and streams is *empilili*, *orkisirati* is used to describe grass that is drying but the stem remaining green, and *erashe* or *orpalakai* is used to describe dry grass or the literal translation of dry grass as *nkujit natoito*. Similarly water quality and quantity were inferred from the following combination of Maa words: *ngare* (water); *nasingila* (clean); *enaruko* (flowing); *engiyo* (dirty), *olomonira* (stagnant). Post-herding orbit question focused on whether all herders returned with the herd, and the reasons that they not all return, whether the herd traveled to the location that was selected earlier, and the reasons associated with a change. Additional questions sought to determine the number of herds and cattle encountered along the orbit, whether joint herding took place, how many cattle were diagnosed with any diseases, and whether any animal health inputs were administered to the cattle.

The third dataset incorporates information on household size and wealth status. These data are derived from structured household surveys. Specific components of the survey used in this analysis include: the number of adult males living within the household; sources of, and amount of formal and informal income; and cattle herd size. A copy of the actual survey used in the study is shown in Appendix 5 and the protocol used to administer the survey is described in chapter 3.

6.2.3 Processing and Analysis

The processing steps for determining herd radius and associated spatial data are described in Chapters 4 and 5. Data from the orbit report forms were entered manually into MS Access TM. Responses to interview questions were assigned a numeric code and merged with the spatial data for the grazing orbit. In total 1108 grazing orbits and associated interview data were compiled. The units of analysis for this study are: (1) the grazing orbit (defined spatially and temporally as the path of track points that cattle circumnavigate beginning from when cattle leave their enclosures until when they return), and; (2) the household from which the grazing orbits correspond to.

Herd size has been used as a surrogate for wealth in many studies of the pastoral Maasai in East Africa (BurnSilver, Boone, and Galvin 2003; Sutter 1987). In this study, wealth is determined by combining herd size with operating income and the number of adult males within the household. Herd size was divided into three categories: small (< 60 head of cattle); medium (60 -150 head of cattle); and large (> 150 head of cattle). These categories are chosen to best encompass the variability observed in herd sizes documented during preparatory fieldwork and verified during the yearlong study period. Mean herd size from all households studied is approximately 201 head of cattle, with a standard deviation of 106. Herd size classification changed dynamically during the study as households split and (re)merged in response to the drought. The number of cattle deaths during the study period was not large enough to change herd size classifications (Chapter 4). The herd size classifications are significantly different than the categories used by Grandin, de Leeuw and de Souza (1991) because of two main reasons: These are: (1) Grandin, de Leeuw and de Souza (1991) study was in a much drier part of the

neighboring Kajiado district and contain different section of the Maasai as well as different social and economic dimensions as well as different development histories; (2) the data were from the late 1980's. The herd size category of poor that I utilize (≤ 60 head of cattle) is also different from the criteria used by Grandin, de Leeuw and de Souza (1991) (approx 3.5 cattle) because a criteria for the selection of the households was a minimum of 20 head of cattle. The categories are also different because the poor in the study are categorized relative to the sample population.

Operating income was derived by subtracting average total income from the average total expenditure incurred each month for the adult males in each of the ten households. Three groups of low, medium and high wealth status were then derived (Tab. 6.2).

Wealth categories of poor, medium and rich were chosen in order to maintain consistency with similar studies on pastoral wealth (Fratkin and Roth 1990; Grandin 1988; Grandin, de Leeuw, and de Souza 1991; Little 1985b; Thornton et al. 2007). The number of households that correspond to these characteristics does not equal the number of total number of households used in this study, because several households did not conform to these exact categories. For example, household 'P' had a high net income, but the herd size was small as was the number of adult males within the family. Households that did not conform to these characteristics, and the associated interviews, were excluded from the wealth analysis. A minimum of two households were encompassed in each wealth category. Chi-square contingency tables and summary case analysis was conducted in Stata 7/SE TM.

6.3 Results

The results of this study are divided into two sections. The first summarizes the responses given by *all herders, regardless of wealth*, on the factors influencing the herding strategies before cattle depart their enclosures, as well as the subsequent outcomes and events of the grazing day. These responses are categorized and analyzed by season. The second section is a subset of data that is dissected by *wealth status* in order to better understand how wealth influences the herding strategies of Maasai pastoralists. Of the 1108 interviews addressed, approximately 446 interviews were conducted during the wet season, 553 in the dry season and 129 in the drought season (Tab. 6.3). All the results of the chi-square analysis in this section, unless otherwise noted, are significant at the 0.05 level.

In addition to herding strategies documented in sections 6.3.1 and 6.3.2 that take place on a daily scale, a common drought coping strategy that is discussed in greater detail in Chapter 4 is household relocation. This is when households physically move the base of herding operations from permanent settlements to temporary camps for the duration of a stress period, such as drought. Of the ten households that were tracked, only seven households conformed to the wealth categories delineated earlier (Tab. 6.2). Of the three households that conform to the rich wealth categories, all three households physically relocated to temporary camps for the duration of the drought period. Only one of the two households classified as medium wealth households relocated. None of the poor households relocated.

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6.3.1 Part I: Seasonal variability of herding strategies

Who does the herding? During the wet and the dry season, herder age and gender were similar. Males between the ages of 6 and 22, undertook the bulk of the herding. Females undertook a small percentage of the herding. During the drought, women played no role in herding and older men between the ages of 23 and 40 took the responsibility of herding cattle, along with older children between 16 and 22. Children under 6 did not take part in the herding process at any time. The number of herders did not change substantially during the wet and dry season, where a single herder is responsible for herding (87% in the wet and dry season). This proportion changed during the drought where 44.19% of the herding was undertaken by two herders.

When is the decision made on where to herd, and who makes the decision?

Decisions on where to graze cattle were made just before the cattle depart their enclosures during the wet and dry season. However, during the drought, the decisions were made either on the day before herding, just before herding, or the night before herding. During all three seasons the majority of herding decisions were made by the herder(s), although the herding was done by older herders between the ages of 23 and 40 during the drought. The herd patriarch in consultation with other herders and elder relatives did not significantly contribute to making herding decisions during the drought.

Factors contributing to selecting the intended grazing location: Unsurprisingly forage and water are the two most important factors contributing to the selection of a grazing location. During the wet season, avoiding tsetse-infested areas and rangers contributed to the third and fourth most common factors influencing grazing location (11.43% and 8.52% respectively). During the dry season, these relative positions reverse

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(22.14% attributed to avoiding rangers and 6.94% attributed to the lack of tsetse), while during the drought ranger avoidance was the third most important factor (9.3%). During the wet season, herders suggested that water resources are clean and flowing (84.3%). During the dry season this percentage decreased to 57.60%. Clean and stagnant (38.76%), muddy and stagnant (31.01%) and clean and clean and flowing (26.36%) were the three most common responses given by herders during the drought season. During the wet season, herders perceived grass to be of medium height (51.35%) and mainly green-brown in color (73.09%), whereas during the dry season grass was also medium height (59.85%) but corresponded to a dry brown color (63.23%). During the drought grass was mainly short and medium height (48.84% and 47.29%, respectively) and was mainly green brown (48.06%) and dry brown (44.96%).

Did all herders return to the boma and if not, why? During all three seasons, over 95% of herders interviewed returned with their respective herds to their enclosures. The herder suddenly falling sick, or being captured by rangers were the most common reasons that the original herder did not return.

Did herders go to where they intended and if not, why? Herders largely grazed at locations that they had planned and intended to graze during all three seasons. The reasons given by herders for not grazing at their intended locations were: (1) avoidance of wildlife; (2) avoidance of rangers; (3) avoidance of other cattle; and (4) insufficient grass or water.

Did you encounter additional herds during the grazing orbit? During the wet season, 21.3% of herders stated that they did not encounter any additional herds. During the dry season, this percentage dropped to 17.07% and decreased further to 6.20% during

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the drought season. Where herds were encountered during each of these seasons, 72.65% encountered two herds in the wet season, 56.56% during the dry season, and 29.75% during the drought. Approximately 68.6% of the herders encountered 3 or more herds during the dry season. The vast majority of these encounters resulted in joint herding for over half of the grazing orbit.

Diseased cattle, type and livestock health inputs: The numbers of cattle that were diagnosed with a disease by Maasai when they returned to their enclosures at the end of the grazing orbit is high during all three seasons. Between one and two diseased cattle accounted for the highest percentage of diseased cattle. Approximately 90% of diseased cattle are diagnosed with Trypanosomiasis during all three seasons. Diseases such as East Coast Fever, Heart water disease, Foot and Mouth Disease and Malignant Catarrhal Fever did not significantly affect cattle within the study area. Injecting cattle was the most common type of livestock health input and was most frequent during the drought and least frequent during the wet season.

Wildlife encounters, attacks, outcome and ranger encounters: Herders and their cattle encountered wild carnivores frequently but encounters were not dominant. However encounters were most frequent during the drought. Attacks by wild animals on the cattle herd were uncommon with very small percentages during the dry and drought season and no attacks were recorded during the wet season. Where attacks on the herd did occur, the most common outcome was to split and disrupt the herd. There was only one recorded incident of cattle injury, and two events where attacks resulted in the death of cattle during the drought ($\chi^2 = 4.6061$, $p = 0.466$). Encounters with rangers were highest

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during the drought (21.70%) and lowest during the wet and dry season (9.64% and 9.94%, respectively).

Movement into the Maasai Mara National Reserve (MMNR): Maasai pastoralists frequently moved their cattle into MMNR, with 74.22%, 75.42% and, 97.67% of grazing orbits recording their furthest location inside the MMNR during the wet, dry and drought seasons respectively (Fig. 6.1). Contact with the rangers the previous day did not influence the herder's decision to graze cattle inside the MMNR (85.71%, 79.07%, and 90.63%, $\chi^2(2) = 1.850$, $p = 0.396$).

6.3.2 Part II: Variability of herding strategies by wealth status

The results of the study thus far provide a detailed description of the factors influencing the herding process at three separate time periods: before cattle depart, during the grazing orbit, and after they return. However, these results do not consider how herding strategies differ by wealth status across the seasons. In this section, four components of the herding process along with the distance and duration that cattle travel are compared against three categories of wealth (poor, medium, and rich).

Herding responsibility: During the wet season, the number of herders responsible for the herding process did not change with wealth (Fig. 6.2), where 89.83% of poor, 87.80% of medium and 84.30% of rich households utilized one herder. The same trend is true during the dry season, (86.15%, 91.84% and 86.87% for poor, medium and rich households respectively, $\chi^2(4) = 4.69$, $p = 0.320$). During the drought, the number of herders did not change from previous seasons for poor and medium wealth households,

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but did change significantly for rich households, where 67.92% of these households utilized two herders.

The dominant age of herders from poor households was between 6 and 15 years of age and accounted for 55.93% of the grazing orbits during the wet season (Fig. 6.3). This was similar to the proportion of herders of the same ages used by medium wealth households (53.66%). Rich households had 28.10% of the herding being conducted by herders between the ages of 6 and 15.

During the dry season, poor and medium wealth households had the highest percentage of herding being conducted by herders between the ages of 6 and 15. Rich households had the highest percentage of herders between the ages of 16 and 22. During the drought, most of the herding in poor and rich households was conducted by herders between the ages of 23 and 40, whereas medium wealth households had 60.00% of grazing orbits managed by herders between the ages between 6 and 22.

As stated above, most of the herding was undertaken by males. However, females from poor households accounted for 10.77% of the herding during the dry season (Tab. 6.4) and just 1.69% of the time during the wet season. Medium wealth households had almost no herding conducted by females ($n = 2$ during the dry season). Herding by females also took place in rich households and accounted for 7.44% of the herding during the wet season, 3.03% during the dry and none during the drought.

Decision making: During the wet and dry season, decisions on where to graze for poor, medium and rich households were made by herders, and made just before herding. During the drought, the trend was similar with herders making the decision most frequently irrespective of wealth. However, the timing of the decision during the drought



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changed with wealth. Poor and rich households made the herding decision between 12 and 24 hours before herding, while the majority of the decisions from medium wealth households were made right before herding (46.67%) (Fig. 6.4).

Selection of grazing location: Grazing needs (44.07%) and grazing/water needs (33.90%) were the two most prevalent reasons given by herders from poor households in the selection of a grazing location during the wet season (Fig. 6.5). During the dry season, these reasons were also considered, but ranger avoidance also became more important. During the drought, grazing and grazing/water needs were the most common followed by ranger avoidance.

The responses provided by herders from medium wealth households suggested that avoiding tsetse zones are most important during the wet season, followed by ranger avoidance. During the dry season, grazing and grazing/water needs encompassed 63.27% of the responses, followed by ranger avoidance (17.35%). During the drought, ranger avoidance accounted for 13.33% of the responses, with grazing and grazing/water needs most common (86.67%).

Herders from rich households suggested that grazing and grazing/water needs were most common during the wet season (88.43%), and primarily grazing needs in both the dry season (40.40%) and drought season (56.60%). Ranger avoidance or tsetse flies were not considered important during the drought.

Joint herding and herd/cattle encounters: The practice of joint herding is common (over 80%), but not significant, irrespective of wealth ($\chi^2_{(8)}_{\text{WET}} = 1.05$, $p = 0.59$, $\chi^2_{(8)}_{\text{DRY}} = 15.89$, $p = 0.044$, $\chi^2_{(8)}_{\text{DROUGHT}} = 4.45$, $p = 0.108$, Tab. 6.5). However there were notable differences in the number of herds encountered where joint herding



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takes place. During the wet season, the percentage of poor households undertaking joint herding with 3 or more herds was 55.93%, 43.90% for medium wealth households, and 66.12% for more wealthy households (Tab. 6.6). During the dry season, this percentage increased to 75.38%, 59.18%, and 77.78% for poor, medium and rich households respectively. During the drought these percentages increased to 76.92%, 60.00% and 94.34% respectively, suggesting that as the landscape becomes drier households join more herds and this likelihood is greater for wealthier households.

The number of herds encountered did not necessarily reflect the abundance of cattle. Therefore, similar analyses were conducted for the total number of cattle encountered (Tab. 6.7). During the wet season, poor households encountered herds with over 300 cattle 23.73% of the time. This percentage increased to 40.00% and 46.15% during the dry and drought season respectively, suggesting that as the landscape becomes drier, more cattle are encountered. The trend was different for medium wealth households that encountered herds with over 300 cattle 19.51% of the time during the wet season, 46.94% during the dry season, and 26.67% during the drought. Rich households encountered cattle herds of the same size 18.18% of the time during the wet season, 42.42% of the time during the dry season, and 92.45% of the time during the drought.

Does greater wealth translate to greater mobility? During the wet season, average herd radius was higher and significantly different between poor and medium households ($t = -3.382$, $p = 0.0005$, $df = 98$), in favor of medium households (+ 0.917 kms). The duration of travel by cattle did not significantly differ by wealth ($F_{2,218} = 1.822$, $p = 0.164$). During the dry season, there were no significant differences by wealth between either herd radius ($F_{2,259} = 1.197$, $p = 0.304$), or duration of travel ($F_{2,259} = 1.20$, $p =$

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0.303). During the drought there were no significant differences between poor and medium households ($t = -0.655$, $p = 0.2591$, $df = 26$) for herd radius, or duration of herding ($t = -0.2185$, $p = 0.414$, $df = 26$). However, significant differences were observed between medium and rich households for both average herd radius ($+1.725$ kms, $t = -3.457$, $p = 0.0005$, $df = 66$) in favor of rich households and duration of herding (-3.586 hrs, $t = 3.094$, $p = 0.0014$, $df = 66$) (Fig. 6.6).

6.4 Discussion

The herding strategies of Maasai pastoralists around the Maasai Mara National Reserve, much like other pastoralists across East Africa, vary seasonally. Unlike other studies, this research has found that herding strategies also vary considerably by wealth. These results provide one of the first quantitative and systematic analyses of wealth differentiation. The lack of data at similar scales does not allow for comparative analysis. However, the results of the data suggest that there is considerable variability among household and non-household related factors before cattle depart their enclosures, while herding, and once they return.

6.4.1 Strategies before cattle leave

The results of the data suggest that similar herding strategies are employed by poor, medium and rich households during the wet and dry seasons, where one younger herder is used (Fig. 6.2) and the involvement of women is minimal (Tab. 6.4). However during the drought wealthy households rely on a different strategy. This involves: (1) dedicating a greater number of male herders to manage cattle in comparison to poorer and



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medium wealth households (Fig. 6.3); and (2) utilizing more experienced herders. The latter is also true for poor households, as the proportion of herders between the ages of 23 and 40 is higher when compared to rich households. There are two possible explanations for this. First, poor households are smaller in size, have more children and a low operating income (Tab. 6.2). As a result, it is likely that the herd owner/patriarch is engaged in full or part-time salaried employment, children who do not attend school are the primary herders. The role of the patriarch is limited to a supervisory and support role, rather than an active participant in the herding. Conversely rich households are able to afford the services of two (or more) older hired herders between the ages of 16 and 40, while the herd patriarch maintains a supervisory role ensuring livestock health is maintained during the drought. Although there is little direct evidence of these phenomena in the literature, there is data to suggest that hired herding is becoming increasingly common: (1) in wealthier households (Scoones 1994a); (2) as a product of individualization of production (Bassett 1994; Turner 1999a); (3) as a response to drought (Scoones 1992), and; (4) decreased social cohesion (Grandin, de Leeuw, and de Souza 1991).

A second possible explanation may lie in the frequency with which individual herders are rotated during the drought. As the distance and duration that cattle travel increases significantly compared to the dry season (Figs. 6.2 and 6.3), so does the frequency of movement in the MMNR (Fig. 6.1). Rich households choose to minimize the risks to individual herders by rotating herders every other day. As a result, herders are given sufficient time to rest for an entire day before resuming the responsibility. Poor households, because they do not have sufficient herders, may choose to rest their herders

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every 4th, 5th or even 6th day. The strain felt by poor households is therefore greater than rich households. Grandin, de Leeuw, and de Souza (1991) suggest that this strategy may adversely affect the proportion of children already attending primary school and provide less incentives for poor households to send their children to school.

Another common strategy that pastoralists utilize to better cope with drought is to make decisions on where to graze cattle earlier. This enables rich households to better weigh advantages and disadvantages of grazing at a specific location, and allows for herders and herd managers to share information with other herds in advance (Niamir-Fuller and Turner 1999). As a result, the decision on where to graze cattle during the drought is likely to be made earlier (Fig. 6.4). Rich households employ this strategy more often compared to medium wealth households, although poorer households also have a large proportion of the decision made the night before herding. These results suggest that the timing of grazing decisions at shorter (daily) scales of time may be as important to the herding process and drought coping strategies as the timing decisions at longer (weekly or monthly) scales, where decisions are timed to coincide with green flushes, wildlife densities in certain areas, or intense rainfall (Coppolillo 2000; Walker 1993; Westoby, Walker, and Noymeir 1989a).

Across the wet, dry and drought season herders indicate that forage and water are the most common primary factors influencing their grazing decisions. However, assuming that these are necessary conditions needed to sustain the livelihood system and are removed from the analysis, avoidance of both rangers and tsetse fly become important factors (Fig. 6.5). During the drought, ranger avoidance is less of a factor for rich households, while it is more important for poor households. Poorer households still



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consider the forage and water needs as critical to their survival during the drought, but do not completely disregard the risk of being caught by rangers, as they may less able to afford the fines.

Ranger patrols the previous day did not significantly deter herders from directing their cattle grazing inside the MMNR during any season. These findings build on existing research implying that the choices available to herders on where to graze during the drought are narrow for all types of households (Horowitz and Little 1987; Turner 1999b; Fratkin and Roth 1990). Unlike these studies, this research provides new data showing that poor households face a greater opportunity cost for selecting these choices than rich households, and I speculate that this is because wealthier households are more able to pay for transgressions into protected areas.

Herders' perceptions of environmental conditions (characterized by grass height, color, water quality, and quantity) match seasonal constraints. While water quality and quantity decreases during the dry and drought seasons, there still remains a proportion of water this is both clean and flowing. This indicates that herders are knowledgeable of specific areas where this might be the case, especially along the rivers and near natural springs. The findings are similar to those of Coast (2002: 91) who found that 66.5% of Maasai residents in the Talek areas draw their water from the rivers and 30.2% from springs in the wet season. During the dry season this percentage drops to 37.9% drawing water from rivers 40.1% from springs and 16.5% from ponds in the dry season. The implications of these findings are that water, while important to sustain a pastoral livelihood system, is not a significant factor in the herding practices of the Maasai in the Talek area. These findings should not negate the importance of water in drier pastoral

savannas, such as in the Kajiado district (Grandin, de Leeuw, and Ole Pasha 1991; BurnSilver, Boone, and Galvin 2003), northern Kenya (Dyson-Hudson and McCabe 1983; Leslie et al. 1988; McCabe 2004; McCabe et al. 1988; Coppock, Ellis, and Swift 1988) and northern Tanzania (Homewood and Rodgers 1991; Rodgers and Homewood 1986) where researchers have found water availability extensively influenced herding practices (Witsenburg and Roba 2007).

6.4.2 Strategies while herding

An important component of the herding process is joint (or cooperative) herding, where herds from different families are joined together during the grazing day. Joint herding among Maasai in the study area is common throughout the year and most common during the drought (Tab. 6.5). All types of households are likely to join three or more herds. However, the total number of cattle encountered is higher for rich households. These data suggest that there is cooperation across different wealth categories during the drought, but rich households are more likely to encounter herds of similar size (Box 1). These findings reinforce existing studies on herding cooperation across wealth categories (Galaty and Johnson 1990) and is steeped in the spiritual and cultural appreciation of cattle in Maasai societies (Spear and Waller 1993; Saitoti and Beckwith 1980; Sankan 1971; Galaty 1981b, 1983, 1989). However, these findings also suggest that there is a trend towards increasing cooperation between rich households and may be attributed to the increasing intensification of cattle production and maintenance practices (Ruttan and Mulder 1999; Grandin 1988; Grandin 1993; Sieff 1999).

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Box 1*: Example of the herding strategies employed by a wealthier household during the drought

At the onset of the drought (*Swahili: Kiangazi*) in early January 2006, the Mzee Karkarr had decided, along with his brother that the time had come to move their herds towards the western part of the study area. The grasses were still tall but dry like everywhere else, they explained to me. They pooled their herders together and moved the estimated 600 cattle to a temporary camp. Two days before the move, Mzee Karkarr asked his nephew who owns a small pick-up truck to ferry water from the Talek River near their home to the temporary camp in 60 gallon containers. A day before the move, the women of the households, along with the young children walked to the temporary camps carrying only essential items such as clothing and cooking utensils, as well as a few young calves that were still being weaned. Older calves and sheep were left behind at their permanent settlements. They would be managed by school going children and the elderly. On the day the move took place, cattle were taken down to the river and watered for longer than usual. The two herds then split for the days herding and merged just before they arrived at the temporary camp.

The herding was conducted by two hired herders that Mzee Karkarr employs at a wage of 2,000 Kenya Shillings (30\$) a month. In order to ensure that the herders have a vested interest in the well-being of the cattle, they are each given a bull and three calves after a year of employment.

On arrival at the temporary camps later that evening, the cows were hurriedly milked to prepare tea for the herders. They have only a few hours of rest before they were to herd again. The move resulted in decreasing the distance to the Posse plains and cleaner water along the Ol-Keju Ronkai River located deep inside the Maasai Mara National Reserve. At 3:00am the next morning, the silence of the night was broken by the bells of cattle rustling as they were milked again and set off for the days grazing. The reason for the early departure, Mzee Karkarr explained to me as I carried a cup of steaming tea to him while he maneuvered between the cattle, was so that they could reach the plains before the tourists arrived on their game drives and complained about the cattle.

This pattern continued for the next 3 weeks and the herding was rotated between the hired herders and by the elder sons of the Karkarr brother. They are men of the *Iseuri* age set (between the ages of 25 and 40), who had temporarily given up their usual task of purely 'supervising' the hired herders and drinking *muratina* (the local brew). Armed with two spears and a short *simi* sword, they departed the temporary boma with eagerness and strength, and returned covered in dust, but brimming with the satisfaction that the cattle had eaten well and the cattle were surviving (for now).



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Box 2: Example of the herding strategies employed by a poorer household during the drought

Mzee Ole Kasoe, wizened by years of hardship and disaster, sensed that the drought was about to come. The short rains had failed and being a former ranger for the Narok County Council, knew that the rangers were going to start cracking down as the numbers of tourists were increasing over the Christmas break. One of his four wives sells curios to tourists at one of the nearby lodges had told him of the increase in American and German tourists.

Two months ago his son Waiyaki was caught herding inside the park and was held at one of the park gates until he paid a fine of 10,000 Kenya Shillings. He could not afford this amount again. Mzee Kasoe asked his friend Mzee Kayiok, with whom he shared clan affiliation, if he could move his herd of 75 cattle to his *boma*, until the rains arrived. Mzee Kayiok and his family helped prepare a *manyatta* for the herders to stay at night and provide them with food and water.

For the first few weeks the herding was conducted by either Kenaiyo, or Munkasiyo, two of Mzee Kasoe's younger children. After a week he saw that the older cows and some steers were beginning to get weaker. He unilaterally decided to take responsibility for the herding for a week in order to ensure that the cattle would access the best grasses in a rapidly desiccating environment. After a short meal of *chai* (tea) and *uji* (ground maize and milk), he left the boma at 6:00am each morning and returned at 8:00pm - an amazing feat for a 70 year old man in 90°F temperatures. He was forced to do this to ensure that his sole means of survival would not perish like in the drought of 1962 and 1982, and because his older male children had left the Talek area in search of regular employment in Narok (the district city) or Nakuru (the provincial capital), and his younger children, while knowledgeable of grazing niches close their permanent boma, were in unfamiliar surroundings here.

One night during the drought Mzee Kasoe lost five sheep which had been trampled to death when a leopard attacked the poorly built temporary enclosure. The herders were tired and less vigilant and did not hear the commotion until it was too late. For the next few nights he made his eight year old son sleep in the sheep pen and alert him whenever he suspected attacks were about to occur.

* All names have been changed to protect the privacy of research subjects

Conflicts with wildlife are minimal while grazing, and where conflict does occur, cattle death or injury was extremely low. These findings contradict those by Kolowski and Holekamp (2006) and may be attributed to the data collection during a drier year.



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The low cattle depredation rate shows greater similarity to the findings of Ogada et al. (2003) and Frank, Woodroffe and Ogada (2005) in the Laikipia district of northern Kenya. However, while cattle mortality is low, this study does not examine the effects of livestock depredation on sheep and goats, which are common throughout the year (Kolowski and Holekamp 2006). Poor households have weakly constructed enclosures that are prone to attacks by wild carnivores at night (*Ibid.*). As a result poor households face additional stress by increasing vigilance at night watching over sheep and goats, as well as during the day when herding cattle (Box 2).

Much of the supporting literature on wildlife-livestock interactions suggests that as the landscape becomes drier, the probability of epizootics increases as both wildlife and livestock congregate around the few remaining water holes (Grootenhuis 2000a; Grootenhuis and Olubayo 1993; Prins 2000). However within the study site, there are neither significant cases of MCF, nor are the few cases higher during the drought. There are two possible explanations for this. First, as Goldman (2007) suggests, Maasai have a strong knowledge of the density and distribution of wildebeest at different times of the year. Consequently herders avoid areas that are frequented by wildebeest in order to reduce the risk of contracting the virus that causes MCF. Second, the timing and location of wildebeest calving (primarily during the wet season and outside the study site), does not coincide with herding patterns.

6.4.3 Strategies employed once cattle return

Surprisingly, the transmission of sleeping sickness remains high throughout the year and does not support the notion that the disease transmissions are highest during the

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drought (Butt 2002). Instead the frequency with which cattle are injected with trypanocides is higher during the drought. There are two possible reasons for this: (1) the effects of sleeping sickness on cattle already suffering from heat stress and low metabolic weight (from low forage quality) during the drought are likely to be greater than at other times (Connor 1991), and; (2) poor and rich households employ different strategies of administering trypanocides.

Key informant interviews with herders and participant observation at veterinary shops reveal that poor households use a single dose of Veriben (administered intravenously) for up to two cattle, instead of the recommended single dose per infected animal. Rich households use Samorin (a stronger and more effective trypanocide administered intramuscularly (Münstermann et al. 1992)) at the recommended dosage. Veriben is sold as a single dose packet that costs 50 shillings (69 US cents) each, while Samorin is sold as a single packet of 10 doses at a cost of 500 shillings (US\$ 6.90). Rich households purchase Samorin and utilize the entire packet (as they share the dosage among other rich households). These findings once more reinforce the advantageous strategies employed by rich households over poor ones because of their greater purchasing power. This translates to more effective livestock care and maintaining overall herd health.

6.5 Conclusions and Future Research

This chapter sought to identify the herding strategies of Maasai pastoralists at the periphery of the Maasai Mara National Reserve. Using daily interviews with herders and

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structured household surveys the study identified household and non-household based factors influencing herding strategies and elucidated how wealth impacts these strategies.

The study finds that similar strategies are employed during the wet and the dry season and these strategies do not significantly differ between wealth classes. However during the drought, rich households employ different strategies. Mobility parameters gathered from the tracking of cattle such as herd radius and duration of travel illustrates these strategies well.

Rich households cope better with drought by: (1) utilizing a greater number of herders that are more experienced; (2) making herding decisions earlier; and (3) encountering more herds with larger numbers of cattle resulting in shortening the grazing time and increasing the distance traveled. These strategies ensure that herders are able to better communicate knowledge on greener and more palatable patches of grass. The results of this study suggest that the poor continue to be disproportionately marginalized in their herding strategies during the drought. Poor households are unable to afford, or do not have sufficient labor, to match the qualities of herders from rich households. Although cattle from poorer households do not suffer proportionally higher numbers of infections from trypanosomiasis, their herd sizes are smaller and the cost of investing in trypanocides is higher. These findings echo existing studies on Maasai herding strategies in the neighboring Kajiado district (Grandin, de Leeuw, and de Souza 1991; Grandin 1988; Grandin 1993) and supports the notion that, “wealthier pastoralists... have more management options...and that...they would be likely to have more control over grazing ... than poorer producers” (Grandin 1993: 32).

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Factors unique to pastoralists around protected areas such as wild carnivore attacks on cattle and the prevalence of epizootic diseases such as Malignant Catarrhal Fever (MCF) were found to be unimportant to the herding process. The frequent movement of cattle into the MMNR reinforces quantitative data from chapter 4. Data from chapter 5 suggests that although, space utilization by cattle is seasonally different, normalized differential vegetation indices (NDVI) show the greatest degree of negative change as cattle intensity increases during the wet season. Further research should therefore investigate whether these changes occur in areas that cattle from rich households use. Such an investigation would aid research that seeks to understand how the environmental impacts of pastoralism, where negative, would clarify the influence of wealth in exacerbating or lessening these impacts.

This study has not evaluated the ecological impacts of grazing and how these impacts may differ by wealth. This is warranted by patterns in the data suggesting that during the drought season cattle from rich households are joined by additional herds that contain more cattle. As a result the environmental effects of more cattle on a given patch of land would be higher than fewer cattle. Given that the majority of the herding is done inside the MMNR, this research would be integral the long-term conservation of the MMNR. Research also indicates that the effects of cattle inside the MMNR have altered animal behavior patterns (Boydston et al. 2003). Future research should address these issues using rigorous testing frameworks that are able to isolate the impacts of cattle from the impacts of wildlife on soil and vegetation, as well as isolate the impacts of cattle from other anthropogenic activities (such as tourism) on animal behavior.



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This research has also found that the role of women in the herding process is low during the wet and dry season, and absent during the drought. I have speculated that during periods of additional stress women provide vital support roles to herders such as providing food for herders and taking care of the calves. Future research should address these roles and the extent to which women maintain the production system, particularly during the drought. Such research would complement the increasing body of knowledge challenging the perceived view of Maasai pastoralism as a dominantly patriarch system (Hodgson 2000, 2001).

Movement into the MMNR is frequent during all seasons. However in the course of my field observations, and after conducting several interviews with elders, the greatest factor limiting movement into the MMNR is the level of water flowing through the Talek River. Several cattle and a few herders have perished in the strong flow of the river during intense rainfall events such as during both the 1997/1998 El-Nino floods and again during late December 2006/early January 2007. These observations warrant further research into the impacts of floods on the herding process. Although there has been limited attention on this subject, Little, Mahmoud and Coppock (2001) suggest that floods, like droughts, result in, “some herders, with sufficient household labor and favorable access to unaffected pastures, (being) able to adjust to the unusual event (flooding), while others suffered terrible human and animal losses” (Little, Mahmoud, and Coppock 2001: 158). Research on flooding and pastoralism is difficult to conduct because flood events are less common than droughts. However, targeted participatory research could be adapted to help understand flood coping strategies and used to develop intervention strategies during these periods.

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Figure 6.1: Frequency of cattle movement into the Maasai Mara National Reserve (MMNR) during the wet season (74.22%), dry season (75.42%), and drought (97.67%). Movement within the MMNR occurs when the herd radius point lies within the bounds of the MMNR.

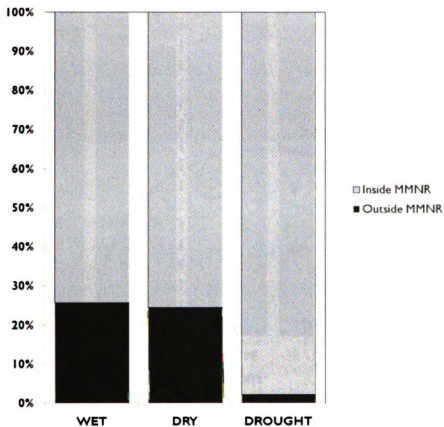


Figure 6.2: Number of herders utilized by poor, medium and rich households during all three seasons. $\chi^2_{(2)} = 1.17$, $p = 0.572$ for the wet season, $\chi^2_{(4)} = 4.69$, $p = 0.320$ for the dry season, and $\chi^2_{(4)} = 23.14$, $p = < 0.0001$ for the drought season.

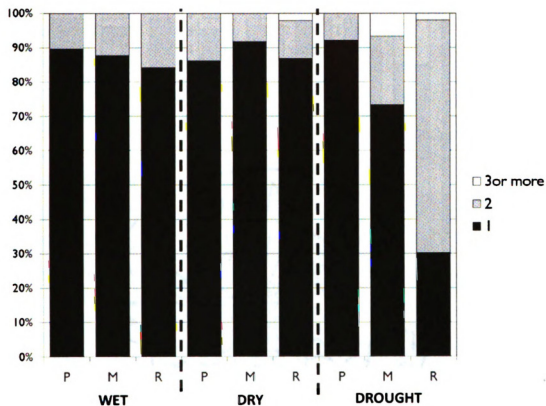
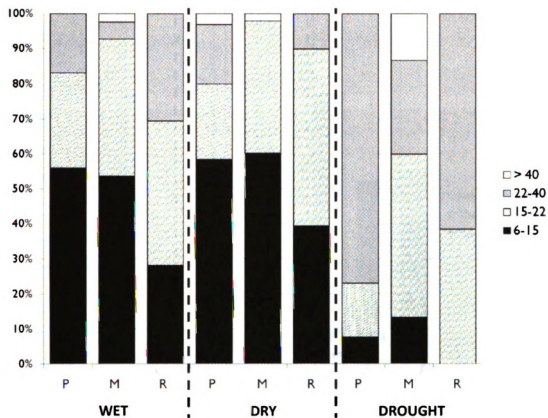


Figure 6.3: Seasonal variation in the age of the herder by wealth class (P = poor, M = medium, R = rich) $\chi^2_{(6)} = 26.57$, $p = < 0.001$ for the wet season, $\chi^2_{(6)} = 30.92$, $p = < 0.0001$ for the dry season, and $\chi^2_{(6)} = 21.11$, $p = < 0.0001$ for the drought season.





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Figure 6.4: Timing of herding decision by poor, medium and rich households during all three seasons. $\chi^2_{(4)} = 5.10$, $p = 0.276$ for the wet season, $\chi^2_{(4)} = 6.69$, $p = 0.349$ for the dry season, and $\chi^2 = 18.82$, $p = 0.004$ during the drought.

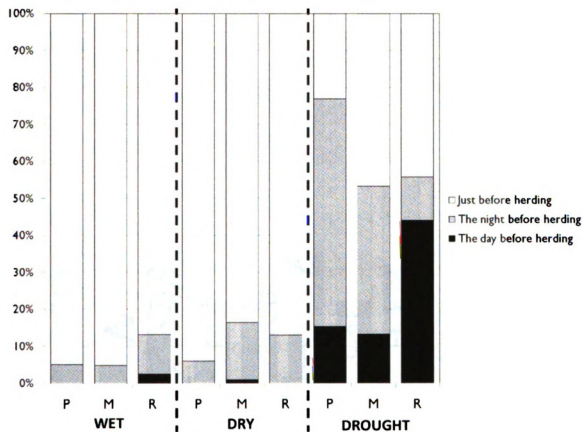




Figure 6.5: Primary factor influencing the selection of an intended grazing location for poor, medium and rich households during all three seasons. $\chi^2_{(8)} = 57.28$, $p = < 0.001$ for the wet season, $\chi^2_{(8)} = 15.89$, $p = 0.044$ for the dry season, and $\chi^2_{(8)} = 15.00$, $p = 0.020$ for the drought season.

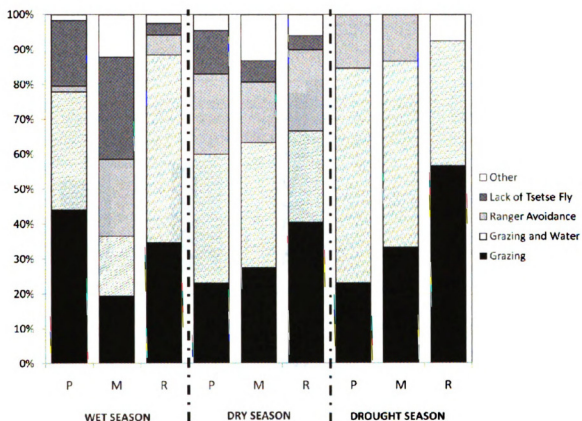
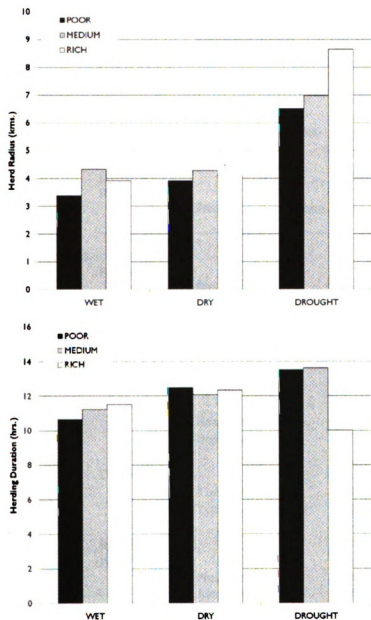


Figure 6.6: Mean herd radius (kms) and duration of travel by cattle from different wealth households. Herd radius is derived from the maximum Euclidian distance away from the boma. Herd radius is highest for rich households during the drought. Wet and dry season herd radii are similar for all wealth classes.





Box

Table 6.1: Factors influencing herding strategies of pastoralists

Factor	Component	Variables	Selected Reference
Household	Labor	Herder age Herder gender Number of herders	(Grandin, de Leeuw, and de Souza 1991) (Sieff 1997) (Homewood and Rodgers 1991)
	Household Size/Wealth	Number of herds Number of cattle Number of adult males Net income	(Grandin 1988; Grandin 1993) (Sutter 1987) (Fratkin and Smith 1994)
	Livestock Health	Frequency of healthcare	(de Leeuw and ole Pasha 1987)
Non-Household	Forage	Grass height Grass color	(Lamprey 1984; Lamprey and Reid 2004) (Reid et al. 2003)
	Water	Water quality Water quantity	(Kavana, Kizima, and Msanga 2005) (Coppolillo 2001)
	Wildlife	Hazardous wildlife Depredation	(Ogada et al. 2003) (Kolowski and Holekamp 2006)
	Diseases	# of diseased cattle Type of disease	(Grandin, de Leeuw, and de Souza 1991) (Torr et al. 2000; Homewood et al. 2006)
	Ranger/ Park Patrols	Presence of rangers Acts of aggression	(Turner 1999b) (Neumann 1998, 2001)
Both	Primary grazing factor		(Coppolillo 2000, 2001; Turner 1993)
	Joint herding		(Fratkin 1986; Sieff 1999)
	Timing of decisions		(Coppolillo 2000; Sieff 1997)
	Who makes the decision?		(Agrawal 1999; Grandin 1988)



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Table 6.2: Characteristics of households by wealth class

Household characteristics	Poor (n = 2)	Medium (n = 2)	Rich (n = 3)
Operating income/month (*shs)	≤ 2,000	> 2,000 & ≤ 5,000	> 5,000
Herd Size	≤ 60	> 60 & ≤ 150	> 150
Number of Adult Males	≤ 5	> 5 & ≤ 10	> 10

* The mean exchange rate (2005-2006): US\$ 1 = 73.23 shillings (shs) Source: Central Bank of Kenya

Table 6.3: Number of orbits and interviews by wealth class and season

Season	Poor	(% T*)	Medium (% T)	Rich	(% T)	Total	(% T)
Wet	59	13.22%	41	9.19%	121	27.13%	221
Dry	65	12.19%	98	18.38%	99	18.57%	262
Drought	13	10.07%	15	11.62%	53	41.08%	81
TOTAL	137	12.36%	154	13.89%	303	27.34%	564

* Percentage of total orbits (n = 1108)

Table 6.4: Gender of herders involved in herding

Gender of herders	Wet			Dry			Drought		
	Poor	Med	Rich	Poor	Med	Rich	Poor	Med	Rich
Male	58	41	112	58	96	96	13	15	53
Female	1	0	9	7	2	3	0	0	0
TOTAL	59	41	121	65	98	99	13	15	53

$\chi^2(2) = 5.41, p = 0.067$ $\chi^2(2) = 7.68, p = 0.021$

Table 6.5: Did you undertake joint herding ?

Joint herding?	Wet			Dry			Drought		
	Poor	Med	Rich	Poor	Med	Rich	Poor	Med	Rich
Yes	56	40	113	60	81	91	13	14	53
No	3	1	8	5	17	8	0	1	0
TOTAL	59	41	121	65	98	99	13	15	53

$\chi^2(2) = 1.05, p = 0.590$ $\chi^2(2) = 5.37, p = 0.068$ $\chi^2(2) = 4.45, p = 0.108$

Table 6.6: Number of herds encountered

Herds encountered	Wet			Dry			Drought		
	Poor	Med	Rich	Poor	Med	Rich	Poor	Med	Rich
Between 1 and 2 herds	26	23	41	16	40	22	3	6	3
Over 3 herds	33	18	80	49	58	77	10	9	50
TOTAL	59	41	121	65	98	99	13	15	53

$\chi^2(2) = 6.63, p = 0.036$ $\chi^2(2) = 9.24, p = 0.010$ $\chi^2(2) = 11.76, p = 0.003$

Table 6.7: Number of cattle encountered

Cattle encountered	Wet			Dry			Drought		
	Poor	Med	Rich	Poor	Med	Rich	Poor	Med	Rich
> 1 and ≤ 100	21	13	56	19	13	31	3	3	1
> 100 and ≤ 200	14	7	29	11	6	18	1	2	2
> 200 and ≤ 300	10	13	14	9	33	8	3	6	1
> 300	14	8	22	26	46	42	6	4	49
TOTAL	59	41	121	60	98	99	13	15	53
	$\chi^2_{(6)} = 10.84, p = 0.093$			$\chi^2_{(6)} = 32.44, p = < 0.001$			$\chi^2_{(6)} = 33.62, p = < 0.001$		

CHAPTER 7

Cattle, conservation, mobility and the etiology of grazing conflicts in southern Kenya.

7.0 Introduction

On December 12, 2005, the 42nd anniversary of Kenya's Independence from Britain, six Maasai children herding their families' cattle two kilometers inside the world famous Maasai Mara National Reserve, were caught by armed game rangers. At the onset of the worst drought in 25 years, the young herders were directing their cattle to the few remaining patches of preferential forage accessible to them inside the reserve. Most of the preferred grazing areas outside the park were too short and where good grazing areas could be found, they were infested with tsetse causing trypanosomiasis. The children were chased and hid crouched on the ground between clumps of thorn trees before they were pulled out by the scruffs of their necks. They were slapped, beaten and kicked repeatedly while pleading for mercy. Their elders were verbally abused. They were locked inside a room at one of the park entrance gates and held until their families paid a fine of 10,000 shillings (US\$ 150) for each child. They waited patiently with limited food and water until the fine was paid – almost six days later. These acts of violence and aggression have been taking place for the last 20 years yet have received little attention from researchers, human rights groups, government administrators, and non-governmental organizations.

Why did rangers inflict violence on the herders? Why did herders enter the protected area? And how did the rangers know that cattle were grazing there? These were the questions that I sought answers to as part of this research which examines the patterns



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and processes influencing the herding strategies of Maasai pastoralists at the periphery of protected areas.

Conservation conflicts between protected area managers and park adjacent dwellers are not uncommon in East Africa particularly where indigenous peoples have been forcefully removed from their ancestral lands (Brockington 2002; Neumann 1998). Additional exogenous factors such as the privileging of commercial agriculture over pastoral livestock development coupled with the individualization of communal land tenure have restricted access to historical dry and drought season grazing reserves, successfully reduced the resiliency of pastoral livelihood systems (Rutten 1992; Sørbo 2003; Niamir-Fuller 1999b) and weakened of traditional institutions that prescribed drought coping strategies (Oba 2001).

Conservation conflicts in and around protected areas have traditionally been characterized as: (1) human-wildlife conflicts (HWC's) typified by attacks on humans by wild animals and vice versa (Woodroffe, Thirgood, and Rabinowitz 2005); (2) conflicts between protected area managers and park adjacent dwellers (Neumann 2001); and (3) livestock-wildlife conflicts through epizootic disease transmissions and depredation events (Prins 2000; Kolowski and Holekamp 2006).

In this chapter, I focus on the second of these types of conflicts through a case study of Maasai pastoralism around the Maasai Mara National Reserve in southern Kenya. Specifically, I demonstrate how conservation conflicts and acts of violence are the synergistic product of local socio-economic and ecological factors and that incidence of conflict do not involve the central state. This approach moves beyond perspectives on the increasing governmentality of state rule over protected areas as being a top-down and



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centralized approach (Neumann 1997; Peluso 1992, 1993). This chapter takes advantage of new conceptual frameworks in the understanding of the networks and relational webs of local socio-economic and ecological factors in changing landscapes (Rocheleau and Roth 2007; Robbins 2004), theories of violence (Schmidt and Schroeder 2001; Sen 2006) and the genesis of environmental conflict between local herders and protected area institutions.

7.1 People, Protected Areas and Coercive Conservation

Conflict between people and protected areas are varied and complex, partly because protected areas act as both *political institutions of the state* and *reservoirs of biological diversity* (Butt 2002). This plurality of competing roles defines how park-adjacent dwellers form the means to secure access to grazing resources to meet their production goals. At the same time protected area managers have often seen pastoralists as a direct threat to the conservation of biodiversity (Homewood and Rodgers 1987). This is because of perceptions that pastoralist densities will grow, sedentarization increase, livestock production intensify and overgrazing will take place (Homewood and Rodgers 1991). As a result pastoralists have had difficulty securing access to natural resources that fall within protected areas because of state policies that are biased towards sedentary agriculture and exclusionary policies on the utilization of resources from these areas. However, many park-adjacent dwellers feel morally justified to encroach onto these lands because of ancestral occupation and customary rights to resources (Naughton-Treves 1999; Naughton-Treves and Sanderson 1995; Neumann 1998).



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Using the Serengeti National Park in Tanzania as a case study, Neumann (2001: 305-306) suggests that, “violence against people is inherent and perpetually latent in the practice of state-directed wildlife conservation” in East Africa, because of four main reasons: (1) people involved in hunting or defending crops against wildlife predation are armed with weapons; (2) the processes of modern state formation involved the government securing control over natural resources, such as wildlife, and are particularly conducive to violence because the stakes were high; (3) wildlife conservation efforts were closely associated with military activities (such as the fight against poachers), and; (4) the geographical isolation of protected areas from major towns and cities allows for the possibility of committing illegal acts of violence and escaping prosecution.

Coercive conservation proposes that the state will use ‘coercive-protective’ measures to appropriate control over endangered resources (Peluso 1993). Protected areas such as national parks, game reserves and forest reserves have become increasingly important to state for two main reasons: (1) the international pressure to adhere to conservation agreements (Western 1992), and; (2) the generation of foreign exchange from international tourism (Sindiga 1996). As a result, the state may, “apply the tools and equipment they use to establish their sovereignty beyond the conservation goals envisaged by international conservation facilitators, and appropriate the moral ideology of global conservation to justify state systems of resource extraction and production” (Peluso 1993: 200).

In much of the literature on coercive conservation tactics and outcomes, the state is treated as a broad administrative structure that controls and manages the rules of extraction and utilization in and around protected areas (Hitchcock 1995; Peluso 1992,



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1993; Agrawal 2001; Neumann 1997; Belsky 1999). The state is interpreted as the central government through numerous ministerial and institutional portfolios. In Kenya, for example, there are two ministerial offices (the Ministry of Environment and Natural Resources and the Ministry of Tourism and Wildlife), one government parastatal (the Kenya Wildlife Service) and a national environmental regulator (the National Environmental Management Authority), all of whom have some jurisdiction over the control over and management of natural resources within the country.

In many East African countries, systems of political control are both hierarchical (stemming from the national down to the sub-location level), while simultaneously maintaining a local government authority that is managed by local councils (such as county councils) (Western 1982; Talbot and Olindo 1990). Many large protected areas are managed by these local government authorities and not by the national government. Local government authorities often receive large amounts of money from the national government to maintain roads within their administrative boundaries and other social projects. Local authorities also generate revenue from park entrance fees which are used to maintain and conserve protected areas and to disburse a percentage of their revenue to their constituents (Walpole and Leader-Williams 2001). In many respects, local government authorities operate outside the sphere of influence of the national government and have periodically had antagonistic relationships over the projects that the revenue is used for (Western, Wright, and Strum 1994; Leakey and Morell 2001; Kemei 2005a, 2005b).

7.2 Representing Interactions among Actors

Conservation conflicts incorporate many actors such as herders, elders, park officials, tour operators and hotel managers that operate at different scales, levels and spaces. Each actor operates from a different epistemological base. This epistemology continually reworks the identities of actor and asserts a dominant perspective. Each actor's identity may then, either consciously or unconsciously, exacerbate conservation conflicts.

Representing interactions between and among different actors has taken various forms. Among the earliest representations of socio-ecological interactions are Blaikie and Brookfield's 'chain of explanation' which was devised to help explain the local, national and regional processes of land degradation and soil erosion in Nepal (Blaikie and Brookfield 1987; Blaikie 1994). The 'chain' has been widely cited and uses an eventual outcome such as land degradation as the starting point for the explanation. Stages, or links within the chain, call for the recognition of these changes, usually by virtue of their economic implications such as declining crop yields, or the increased morbidity of livestock. Subsequent explanations allows us to examine the environmental processes and the land use practices that are present at that site, such as overstocking of livestock in a pasture, or felling too many trees on a forested mountain slope. Once these have been identified and accounted for, we can begin to understand the access to, and control of, the natural resources, explaining how they are used and how the patterns of resource use are socially structured at the individual and household level. These explanations are then scaled up towards the national scale by reviewing the role of the state in environmental management under its jurisdiction. Such components may include laws on conservation



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or land tenure, or the state's ability to enforce laws. Finally, at the international level, global discourses on environment and the international economy ultimately form the ending point for the chain of explanation

Similarly Vayda (1983) has argued first 'progressive contextualization' whereby, "procedures involve focusing on significant human activities or people-environment interactions and then explaining these interactions by placing them within wider or denser contexts" (Vayda 1983: 265) and start, "with the actions or interactions of individual living things and can proceed to put these into contexts that make actions or interactions intelligible by showing their place within complexes of cause and effect" (Vayda 1983: 270). More recently Vayda and Walters (1999) support the notion of an 'event ecology' which moves towards research being, "guided by open questions about why events occur (such as local species extinctions or deforestation) rather than by restrictive questions about how they are affected by factors privileged in advance by the investigator" (Vayda and Walters 1999: 170).

The linear causal explanation, while good for identifying actors and linkages across different scales is problematic. Specifically Robbins argues that, "by always following explanations 'upwards' from produced environments, through producers, and on to increasing scales of interaction...a conceptual hierarchy of power and causal force is imposed onto political-ecological problems that is empirically unfounded and perhaps politically undesirable" (Robbins 2004: 210). Geographers have instead suggested that interactions between people and the environment should consider moving away from linear explanations of environmental change and outcomes to more complex representations that resemble 'networks' rather than 'chains.' Networks, "organize and

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are organized by a range of human and non-human actors, through systems of accumulation, extraction investment growth, exchange, cooperation and coercion...By explicating networks, therefore, we come to a better understanding of recurrent socio-natural situations, especially undesirable ones” (Robbins 2004: 212).

This theme has been picked up by Rocheleau and Roth (2007) who assert a more thorough insertion of networks in an understanding of nature society issues. The authors suggest that this will allow for a greater understanding of, “complex assemblages by treating them as networks, observing them from multiple standpoints (nodes) within a given structure. The methodology is one of ‘seeing multiple,’ from situated perspectives within polycentric models” (Rocheleau and Roth 2007: 433). This may be undertaken by addressing four pertinent issues. These are: (1) placing power in networks; (2) connecting networks to territories; (3) joining social and natural elements in polycentric networks, and; (4) integrating static network structures and dynamic systems behavior (Rocheleau and Roth 2007: 434-436). The key point that the authors argue for is, “to apply network metaphors, models and theories to questions of power (in type, patterns, degree and terms of connectivity), integration of culture and nature, and relations of rootedness and within and across territories” (Rocheleau and Roth 2007: 434). This chapter attempts to incorporate the key components of networks in an understanding of grazing conflicts so that that the viewpoints of each of the actors may be situated within multiple perspectives.

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7.3 Identity, Power and Conflict

In an effort to understand violence and its etiology as it relates to grazing and conservation conflicts, I examine the works of scholars who have dealt with conflict, albeit in different areas of the world and different interpretations of the subject matter. In this section I summarize the main aim of these studies. I return to these concepts in the discussion section where I interpret them in the context of the power and identities of Maasai pastoralists who reside along the border of a large protected area and protected area managers (rangers and game wardens).

Amartya Sen, drawing on his childhood experiences during the partition of India and Pakistan, confronts the ‘solitarist’ approach to human identity, which sees human beings as members of exactly one group (Sen 2006). Sen instead argues that such views are not only ‘morally undesirable, but descriptively wrong’ (Yoshino 2006). He suggests that individuals have multiple identities that transcend ethnicities, castes, nationality and ideology. Each individual person chooses to portray ‘an identity’ to share with the outside world, and at the same time has identities that they choose not to share. At the same time, there are competing identities ‘that everyone has’. Conflict and violence, Sen suggests, emanates from the desire to, “classify people into groups , which can restrain the exploitation of a specifically aggressive use of particular categorization” (Sen 2006: 4). These desires are, of course, rooted in power relations that dictate how and why such identities are chosen, privileged over others and continually reinforced (Foucault 1972; Widder 2004; Okolie 2003). Power and identity, as Paulson, Gezon and Watts have suggested, is essential to how “people, resources

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and places are constituted” (Paulson, Gezon, and Watts 2003: 209). They draw on the work of Judith Butler to understand this concept:

“We are used to thinking about power as what presses on the subject from the outside, as what subordinates...This is...a fair description of what power does. But is, following Foucault, we understand power as *forming* the subject as well, as providing the very condition of its existence and the trajectory of desire, then power is not simply what we oppose but also, in a strong sense, what we depend on for our existence” (Butler 1997: 7, cited in Paulson, Gezon, and Watts 2003: 209)

This statement exemplifies what Sen argues are the constraints that limit an individual’s freedom to express an identity that may be undesirable to others and thus promote or exacerbate conflict (Sen 2006: 5).

Identity is not only tied to power, freedom, and choice, but also to culture and the (re)creation of cultural identities from colonialism and neo-colonialism. The dialectics of colonial thought have been prominent in conservation strategies, largely because they are the product of non-indigenous ideologies imported to East Africa from developed nations at the turn of the twentieth century (Neumann 1998). Ngugi wa Thiong’o, one of Kenya’s greatest writers, argues that colonial subjugation resulted in the transformation of landscapes and economies, and to a much larger and significant extent on the mindset of individuals and groups (Thiong'o 1987).

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7.4 The study area in cultural, political and historical contexts

A detailed description of the study site has been provided in chapters 3, 4, 5 and 6. The historical processes that led to the creation of the present day Maasai Mara National Reserve and the bordering Koyake Group ranch have also been described in Chapter 3, as well as the demographic changes and subsequent high rate of natural increase. In addition, Reid et al. (2003) suggest that, “there has been above average population growth rates due to immigration and local growth (from) 0.8 people per square kilometer in 1950, to 14.7 people per square kilometer in 2002.”

Tourism is an important component of the Kenyan economy and tourism earning represent close to half of the Gross National Product (GNP). Pastoralism on the other hand represents less than 10 percent of the total agricultural GNP (Bourn and Blench 1999). The MMNR has been popularly represented as the very best that Kenya has to offer tourists and has been termed as, “the jewel in Kenya’s wildlife crown” (Walpole et al. 2003: 5). Tourism growth in and around the MMNR is high with approximately the highest rates of bed occupancy between July and September which coincides with the wildebeest migration and the northern hemisphere summer. There were approximately 13 airstrips, and 72 tourist lodges and camps in and around the MMNR in 2002 (Reid et al. 2003)

The income generated from wildlife viewing fees and other multiplier effects of tourism in Kenya over the past 20 years have accounted for between half and one-quarter of Kenya’s GDP’s and attracts over a million tourists every year. Within the national context the MMNR accounted for as many as 180,000 visitors annually in 1990

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decreasing to 133,000 in 1995 making the Reserve one of Kenya's most frequented protected conservation areas (GoK 2001, Akama 1999).

The beauty of the MMNR has been a haven for numerous entrepreneurs, heads of State, celebrities and entertainers who visit the MMNR. Recent visitors to the MMNR include Bill Gates, Sir Richard Branson, Chinese President Hu Jintao, Senegalese President Abdoulaye Wade, and several others who stay at the luxury tented camps and lodges inside the MMNR. Shortly after a high profile trip to the MMNR by US Senator Barrack Obama, America's ABC television along with USA today, proudly proclaimed that the 'site of the great migration is the new seventh wonder of the world' (ABC 2006). Broadcasting live from the MMNR, ABC news declared that, "the uniqueness of the area and the preservation it provides to so many species living in harmony landed it on our list" (ABC 2006). This prompted the Government of Kenya to list the acclaim on the official government website (GOK 2007). Within the popular media, the MMNR is cast as a Garden of Eden. Most recently Thomas Friedman of the New York Times writes:

"...surely of all God's creations, none is more beautiful than the sunrise on the Masai Mara grassland, Kenya's spectacular nature reserve and a backdrop for the movie 'Out of Africa.' The sun's ascent here is like a curtain going up on one of Mother Nature's richest ecosystems. Through the day you can be greeted by a bull elephant in hot pursuit of a cow, serenaded by tropical boubou birds, intimidated by two lionesses devouring a warthog, amused by the cattle egrets riding on the backs of African buffalos and impressed by how each small cluster of topi antelope 'assigns' one topi to stand on a small hill and keep watch for predators while the others graze. *Everything seems in perfect balance*" (*emphasis added*) (Friedman 2007: A21).

The image of the MMNR as a pristine wilderness unchanged for millennia plays into the conservation goals and tourism strategies of Kenya Tourist Board (KTB 2007).

In addition to some of the physical, social and economic aspects of the study site, it is also important to situate the centrality of the Maasai and their culture in the historical geography of Kenya. As described in Chapter 2, the Maasai have traditionally been regarded by the Kenyan government as peripheral to the national economy, partly because of the government's bias towards sedentary and commercial agriculture on the, as well as initial development practices that sought to incorporate pastoralists into the national economy by commercializing livestock production (Swallow 1994; Little 1980, 1992, 1996; Fratkin 1997). This strategy did not work for a number of reasons, that include, because of the poor management of government agencies responsible for slaughtering and marketing livestock products abroad, as well as reduced prices, poor marketing schemes, and low incentives for selling livestock (Evangelou 1984).

Despite these different and contradictory government approaches to the Maasai, history and politics have been successful at shaping Maasai identity in different ways (Spear and Waller 1993). First, the Maasai are often seen as the symbolic cultural group of Kenya. They are popularly portrayed in advertisements issued by government organizations such as the KTB and Kenya Tourist Development Corporation (KTDC) as well as in many commercials by Kenyan companies. As the Anthropologist Thomas Spear notes,

“Everyone knows the Maasai. Men wearing red capes while balancing one leg and a long spear gazing out over the semi-arid plains stretching endlessly to the horizon, or women heavily bedecked in beads, stare out at us from countless coffee-table books and tourists' snapshots” (Spear 1991: 1)

The Maasai are also often viewed as ‘coexisting’ with wildlife in savanna environments for centuries. Just as Friedman (2007: A21) writes about a ‘perfect balance’ between wildlife, the image of a perfect balance between the Maasai and wildlife is also marketed widely by tour operators seeking to attract tourists on safaris to Kenya and the Maasai Mara in particular .

Despite these erroneous representations, a closer look at Maasai history reveals that there has been a long history of cattle raiding activities, either as a result of being raided themselves and launching counter raiding activities to recover stolen livestock, or to increase their wealth by raiding other communities (Chapter 2 and Fleisher 2000).

Maasai identity around the MMNR today therefore contains elements of each of these historical representations: as historical cattle raiders who are willing to do anything to safe guard their cattle from raiding (in whatever modern form it may take), as icons of harmonious relationships with nature, as a forgotten part of the governments misinformed attempts to integrate them into the national economy (marginal peoples), and as a international representatives of a rich culture steeped in ceremony and song.

7.5 Methods

To help elucidate the etiology of grazing conflicts I relied on four datasets. The first datasets employ the use of an actor oriented approach (AOA) (Bryant and Bailey 1997) that encompasses key informant interviews across vertical scales and participatory observation techniques (Limb and Dwyer 2001). The purpose of these two datasets is to identify, describe and contextualize some of the driving process of grazing conflicts from the 1960’s to present. The third and fourth datasets involve the use of informant

interviews, household surveys and to document the cases of conflict over the course of the data collection period.

Interviews with actors: A series of semi-structured interviews were conducted with four main actors: Maasai elders, tourists, hotel managers and security officials, rangers and other park officials. Interviews were conducted during the wet season (May to June 2006) in Maa by me and one Maasai research assistant. Interviews with herders and elders were undertaken within the confines of Maasai households, while interviews with tourists and hotel managers were performed in the lobbies or conference rooms of the major tourist lodges within the study site. Interviews with park officials were conducted with at the major park entrance gates of the Maasai Mara National Reserve (MMNR). All the interviews were recorded using shorthand in notebooks and fully transcribed immediately after the interviews were completed.

Participant observation (PO) of actors: PO techniques included going on numerous game drives with tourists both within and outside the reserve in the vehicles of the tour companies. I also participated in herding cattle from selected households within the study area (Maasai households within two kilometers of the MMNR) and performed role playing simulations with herders. I was also able to witness actual events of the grazing conflict between herders/elders and rangers.

Daily interviews with herders: Interviews were conducted with individual herders after they returned to their enclosures. These procedures followed the same protocols of collection and analysis that have been described in Chapter 3 and 5. In this section of the post orbit reform, herders were asked if they encountered any rangers along the grazing orbit and if so what subsequent events occurred.

Household surveys with household representatives: These questions, contained within section 8 of the survey (park conflicts), revolved around the frequency of conflict between park officials and herders, and the subsequent events that herd owners face after cattle are apprehended. The procedures for the surveys have also been described in Chapter 3. Data are only drawn from the ten households that participated in the study.

7.6 Results

In this section I first describe the nature and frequency of conflicts experienced by herders while grazing, and in their homes. I then describe the etiology of grazing conflicts by linking narratives from each of the actors. The results are presented in a linear manner, similar to Blaikie's 'Chain of Explanation' (Blaikie 1994). This approach is not meant to infer the processes that lead to conflict are linear (they are in fact the product of synergisms and constant interactions between and among the different actors), but the approach is used as simplified way in which the processes may be discussed.

7.6.1 Quantifying Conflict

Conflicts between Maasai pastoralists and game rangers take place in two different spatial contexts: (1) while grazing away from the boma, and; (2) within and immediately around the household. The frequency of herders encountering rangers while grazing their cattle is highest during the drought (21.71%) and low during the wet and dry seasons (9.64% and 9.94% respectively) (Tab. 7.1).

The outcome of the encounters with rangers also varies seasonally (Tab. 7.2). During the wet season, events where rangers saw cattle grazing inside the park, but did

not chase cattle out of the park were as frequent (38.09%) as incidence of cattle being caught and herders being beaten, fined or chased out of the park (40.47%). During the dry and drought season rangers frequently chased herders, who then managed to escape from them (31.37% and 19.81% respectively), while cases of capture, abuse or fines were low in the dry season (25.49%) and higher during the drought (40.74%).

Of the ten Maasai households from which cattle were tracked throughout the year, three reported that women were also abused and beaten. Of these cases women from two households were beaten and verbally abused while attempting to gather firewood, while one household reported that after their children were caught grazing in the park, the rangers came to their bomas and upon finding only the women, proceeded to beat the defenseless women. Four households reported that rangers had come to the bomas and threatened the herd patriarch with violent action if their herders were found grazing inside the park. Nine households reported that they had experienced some type of conflict between August 2005 and 2006. Whenever cattle are caught and herd owners fined, all but one household reported being issued with a receipt or some sort of record that the fine was paid.

7.6.2 Narratives of Actors

Herders: Maasai herders vary by both age and gender and the labor dynamics (Chapter 6) and ecological factor influencing herding are the product of grassland greenness away from the boma (Chapter 5) and the avoidance of rangers and tsetse flies.

Movement into the MMNR occurs regularly as herders are unable to successfully satisfy the ecological factors of grazing outside the park. Transgressions into the park are

the norm rather than the exception, especially during the dry and drought period (between July and September). Many younger herders have heard the horror stories of what the rangers will do to herders when they are caught grazing inside the park. As a result, whenever large green land cruisers (the four wheel drive vehicles that the rangers drive around the park in) are spotted close to where the cattle are grazing, herders will instantly run and hide into the bush thicket and leave the cattle. On many occasions cattle have wandered into the thicket and are separated from the herd or been attacked by lions.

In some instances, rangers have driven off the designated road tracks in pursuit of cattle and herders. One young herder recalled how the rangers had chased him and sought safety in the branches of a tree. The rangers balked at him and ordered him out. When he refused, they took out their AK-47 rifles (the standard issue firearm for security personnel in Kenya) and cocked the gun. When he climbed down, they kicked him repeatedly and forced his face into a muddy pool of water. He was forced to drink the water until he vomited repeatedly. To date, he still suffers from chronic breathing problems. An older and more experienced herder was also chased down by the rangers. He adamantly refused to be caught and ran as fast as he could from the rangers. While running with his spear he accidentally impaled himself and the spear went through his thigh.

In some instances herders and rangers play a continual cat and mouse game along the Talek River, which is the only perennial river and forms the border of the MMNR. Rangers will often lie and wait for the herders to begin crossing the river before assaulting herders (Fig. 7.1). The degree of violence meted out by the rangers on the herders varies considerably. For example on a Monday, herders directed their cattle

towards one of several crossing points along the Talek River into the MMNR to be told that they were not allowed into the MMNR that day. The rangers had a complementary talk with the herders and no violence occurred. Herders then directed their cattle towards the upland zone north of the study site for much of the morning before returning to the crossing point at midday and grazing inside the MMNR for the afternoon and early evening. Four days later, herders returned to the crossing point and were assaulted repeatedly. The rangers had arrived hours before armed with their guns and sticks to cane the herders. The rangers immediately descended on the herders who ran back up to their households. The rangers followed them up to the households and proceeded to beat the older men in the family and occasionally hit the women as they tried to protect their husbands. Before the cattle were corralled and herded back to the park headquarters by rangers on foot, the rangers demanded the 10,000 shilling fine (an amount that is hard to produce on the spot); while some senior park officials suggested that the cattle would be released for 5,000 shillings. The cattle along with cattle from six other households, which in total numbered over 2,000, were held at the maintenance workshop at the park headquarters – a place the Maasai call ‘*olale*’ (a place with no grass or water). The cattle were not released until 3 days later and several cattle died from thirst and hunger. Fig.7.1 is an example of the cattle track log where cattle were caught inside the park and taken to the Sekenani park gate.

A common theme throughout the daily interviews with herders and additional key informant interviews, is that rangers force two herders (from different families) to fight against each other. Upon being caught by rangers, Kijana³⁹ and Waweru, 13 year old

³⁹ All names and identities have been changed to protect research subjects

herders from two families that live close to each other, were told to hit each other, slapping and wrestling each other until they fell to the ground. They lamented,

“...this is what they do to us...how can I be forced to hit my friend while they (rangers) sit there laughing and hitting us with *fimbos* (canes)?”

After their ordeal, they were kicked (with tough leather boots) and told to get out of the park and never to come back in again or their fate will be worse the next time around.

The antagonistic relationship between rangers and herders has become all too common and herders refer to the beatings casually and without hesitation. When I asked what the rangers did to 23 year old Simat after he was chased, he nonchalantly replied:

“...what else would they do, the beat me like I was a dog, they chased my cows like they were wildebeest, they left my cattle to be eaten by lions. These men are evil”.

Elders: Interviews with older members of the household were framed within the context of what was currently being observed in the study area. Based on the interviews with herders I sought to understand why rangers behaved in a violent way and how relationships between herders and rangers had changed over the last 20 years.

The historical relationship between herders and rangers was a ‘fair or a good one’ suggested Ole Kasoe, a 65 year old man who has lived within the study site for the last 40 years. He remembers with great fondness that:

“...when the drought persisted we visited the senior warden, Mr. Ole Mpeti. We asked the warden to allow us to access into the in the park due to drought. We took him a He goat and a sheep so as to please him. Since he was a livestock keeper and a Maasai, not a half caste, he surely allowed us to graze in some park areas until it rains. He was a good man who understood the problems facing the herders. May the Lord and the livestock bless him and his family forever!”

These statements along with many others, suggests that there had been a system of mutual respect between rangers and herders. Across many of the interviews elders refer to Ole Tipis or Mpeti (both former senior wardens of the MMNR) as not being ‘half-castes’. This statement is not related to mixed race, but mixed ideology because of the mutual respect and affection between the Maasai and park authorities. A ‘half-caste’ here refers to subsequent wardens of the MMNR who saw the Maasai not as their own, but as park adjacent dwellers whose activities were ‘degrading’ to the conservation of the ecosystem. Such an ideology could not have been formed without the increasing attention drawn to the MMNR and the tourism and conservation boom that Kenya experienced during the 1980s and early 1990s. Ene Keruke recalls that:

“...rangers did come to our houses for ‘*ntalengos*’ (ceremonies). They ate meat, drank homemade brews and made friends, mostly with the women. During Ole Tipis time, we had no traveling problems, that is, they could assist us by taking someone who is sick to the hospital in Narok (80 kilometers away) using a council vehicle. The senior wardens, Ole Tipis and Ole Mpeti, were always welcome in our homes and hear the problems we face.”

The mutual respect between rangers and herders was historically reinforced because both were Maasai. They share the same traditions and customs and respect for elders is tantamount within the society. The park officials were as much a part of the community as the inhabitants. They were active in fund raising activities when the Talek

Primary School was built in 1982 and providing school bursaries for children who wanted to study at the secondary school in Lemek or Narok. As demonstrated by these narratives herders would actively seek help from the park authorities, whether it was for sick people, or to ask for permission to graze in the park during periods of drought. Elders also acknowledged the help rangers offered them and voluntarily withdrew from the MMNR when their hardship had eased with the arrival of the rains. Ntookos Ole Sananka was part of a group of herders selected to go with the elders to visit the senior park warden during the drought of 1984. He recalls when:

“...we asked him (the senior park warden) to allow us to graze in the park because of the drought. He never hesitated, but rather he told us where to graze, in designated areas of the park (between ‘*Posse*’ and ‘*Oon’gila*’). As soon as the rain falls we graze livestock out of the park without being ordered to do so by the park authorities. The relationship was a good one. We respected the park authorities and they also respected us. Whenever we did something wrong, we were taken to Keekorok lodge (the site of a major tourist lodge) to cut/slash grass. We were given food and water and brought back home. We always accepted our faults.”

Nooltapari Reyia was one of the first women to move to the Mara area in the 1960’s. Today she is 86 years old, and recalls when the Maasai Game Reserve (MGR) was being expanded and managed by Major General Temple Borham (The British Army Officer charged with the responsibility of national parks in Colonial Kenya under the authority of the Royal National Parks of Kenya). Even though they were forced to leave their settlements and move out of the expanded area into the Talek area, Maasai enjoyed cooperation between park authorities and the Maasai. As she sat next me, now blind and restricted to her *enkagie*, she animatedly explained to me that:

“By the time this park was introduced, by a *mzungu* (white man) called Temple, we have just settled permanently here. And by that time the rangers were good because during the periods of drought they could give the herders permission to graze inside the park. Ole Tipis was a good man because whenever the herders visited him with a he-goat or without, he could simply assist and solve their problems. Also when cattle raiding incidences occurred, he instructed the rangers to assist the herders get back their livestock were taken by armed ‘*ilmutendes*’. I have seen this happen when Soit’s herd were raided and brought back safely by the game rangers. For today, I am sure that these rangers would even assist the cattle raiders to steal the livestock from us instead of returning them back. These are very bad people.”

For the last 20 years, the elders have seen these traditions change. Many elders have compared the violent acts carried out by rangers today to those of their historical archenemies, the Kuria cattle raiders. The Kuria are known to the Maasai as ‘*ilmutendes*’ and many elders have suggested that the rangers are no different from the *ilmutendes* because they take their cattle, their most prized possessions away from them. “They chase them like wildebeest and leave them without or water or are left to eaten by the lions” remarked Ole Saiylalel whose cattle had been stolen by the Kuria in the 1970’s.

When I asked about the nature of the relationships with the park officials today given the rich history of cooperation, many elders responded with powerful tirade against the officials who are now in control. Some responded rhetorically and in disgust with “what relationship? The relationship is dead!” Some suggested that the rangers no longer take part in community ‘*ntalengos*’ and turn a blind eye to the suffering of the people. Elders responded that in the time of the previous park warden, council vehicles were used to transport the sick to hospital, today they, “will even drive past a person who is dying on the side of the road.” Others commented on the decline and disappearance of the respect that herders had for park officials and vice-versa. In particular they remark with

dismay and disgust that a ranger may even hit and beat women, pregnant women and men of their father's age set – a cultural taboo. Many elders expressed their anger by cursing revenge on the rangers. Comments such as these were common amongst the men and women I interviewed:

“...I am sure that their sons and daughters will also beat them in the future.”

“...they will end up dying without anything because of the curses they have received from the community.”

“...never dare to become a ranger” (she warns me pointedly).

“...even the cows will curse them because they drive them to Sekenani (the park headquarters) and lock them for three to four days without any grass or water...”

Tourists: To cater to the large numbers of British, German, American, French and Japanese tourists, there are numerous camps and lodges inside and at the edge of the MMNR. The clientele ranges from low-end budget travelers and back-packer tourists to billionaires who stay at the most exclusive lodges and luxury tented camps. Almost every high profile visitor to Kenya has spent at least one night in the reserve. Entrance fees to the MMNR are US\$40 per day and many tourists come to the MMNR expecting to see the big five (rhino, elephant, leopard, lion, and buffalo). Tourists are driven on game drives in specially prepared four wheel drive vehicles or mini-vans with roof hatches for game watching (Fig. 7.2).

Many of the popular game drive circuits are within sight of grazing areas that cattle frequent and tourists regularly see cattle grazing inside the boundary of the MMNR. The popular response from tourists when they see cattle is, “...why those cows inside the

park? Isn't that illegal?" The question is directed towards tour drivers who sometimes respond with sympathy towards the herders, particularly if they see herders in the dry season and suggests that this is "...because all of the grass outside the park is finished." On several occasions I witnessed tour drivers respond with scathing criticisms of the herders such as, "these young boys are breaking the law, they should be removed from the park," or "...they have been warned by the rangers not to come to this area and disturb the wild animals." Many tour drivers are likely to provide responses that the tourists want to hear in the hope that they receive a handsome tip at the end of the trip.

On one occasion a group of tourists were watching a group of Thompson's gazelle on a game drive. Suddenly two young Maasai children ran after the gazelle trying to hit it with their clubs and kill the gazelle (their justification later was so that they could feed it to their dogs). The tourists were horrified and repeated yelled at the tour driver to try and stop them. Upon seeing this, the tourists and their driver cut short their game drive and headed straight towards the park gate to complain to the rangers about the 'brutality.' Later in the evening they lodged their complaint to the hotel manager, who later passed on the grievances to the rangers at the hotel.

Many of the tourists I interviewed at the lodges expressed anger at the fact that they had only seen cattle grazing on game drives and none of the big five. One frustrated tourist remarked, "why should I pay US\$40 a day to watch cows eat grass when I can do that back home!" At the height of the drought in January 2006, which coincided with the peak tourist seasons, many tourists expressed anger that there were no wild animals to see. Other tourists suggested that they would like to see the money they pay for entrance

into the park actually being used for conservation. As one tourist from the US state of Massachusetts remarked to me:

“...what are they (the park authorities) doing with all the millions of dollars that are gathered from park entrance fees? They should not allow cows into the park. They are damaging to this precious ecosystem and *it is not natural*. They eat all the grass and scare away all the animals that we have traveled thousands of miles to see!”

Another tourist, while sympathetic to the constraints faced by the Maasai after a tour of the cultural boma, expressed dismay over the lack of involvement on the part of the park authorities to limit grazing inside the park. He stated that he would have liked to see more of what the US\$40 collected from each tourist was being utilized for, as he saw no evidence of conservation practiced.

Hotel Managers/Security Officers: Many hotel managers and front desk clerks bear the brunt of the frustrated tourists. At the height of the dry and drought seasons, a front desk clerk will see as many as 10 to 15 complaints a week from tourists. Tourists often demand that hotel managers forward their complaints on to the relevant authorities and ensure that cattle are removed from the park. In an effort to protect their clientele and encourage repeat visitors, many hotel managers will show tourists that they are willing to comply with their demands by placing radio calls over the park network to the headquarters or the nearest park gate. In some cases the tour drivers will also complain to the front desk clerks and hotel managers after being prompted to do so by their guests. They argue that they risk their livelihood if the visitors do not get what they have come to see.

There are many tourists who arrive by air at one of the many airstrips and pay their park entrance fees to rangers posted at the lodges. I witnessed many occasions where tourists will refuse to pay the fees if they see cows grazing inside the MMNR. The hotel manager has to reason with the tourists and in some cases falsely reconcile with tourists and assure them that "...everything is being done to make sure that the cows to do not enter the park." Rangers have also shown their 'commitment to conservation' by taking tourists with them while they chase cattle out of the park, while inside tour vehicles and not the official ranger's vehicles.

High profile tourists often arrange visits to the MMNR with world renowned safari companies. These tour companies are managed and operated by professional safari guides, most of whom are wealthy white Kenyan's or expatriates. Many of these safari guides narrated how they have received complaints from tourists and demanded that, "something is done about the problem of livestock grazing inside the park." On several occasions these safari guides have chased cattle out of the park in their own vehicles in order to satisfy these demands. The safari guides will then proceed to the park gate and inform the rangers of their actions and warmly thanked for their efforts in, "helping to conserve the Mara."

One of the front desk managers, Peter, a well educated Maasai with whom I maintained a good friendship confided that he was torn between his identity as a Maasai and as an employee of the lodge that feeds him and his family. He bemoaned that his job was, "just to report to the manager what the tourists are saying, and when the manager is not there, I must report it to the rangers, otherwise I will be fired!" At the same time,

many of his Maasai friends ask Peter not to tell the rangers when the tourists see their cattle.

In rare cases, the park authorities will ask the hotel managers to take action against the herders and cattle when the rangers are unable to attend to the problem on their own. Hotel managers will rarely undertake this activity as they are also dependent upon the goodwill of the Maasai, many of whom are employed by the lodges and camps. One hotel manager stated that they did not want to, “create enemies where none exist.”

At each of the major lodges within the MMNR, a team of between two and four police officers from the Kenya Police are deployed to ensure the security of tourists and to act on any penal code offences. On numerous occasions, several police officers were asked by the park officials to stop cattle from grazing inside the park. The officers have repeatedly told the park authorities that they are employees of the national government and their mission is to protect tourists. They insisted that they are not employees of the Narok County Council and it is the responsibility of the NCC rangers to deal with matters of the MMNR, not the Kenya Police. As a compromise, police officers agreed to go and talk to the elders of the households from which the transgressing cattle originated from. The police officers are also asked repeatedly by tourists why cattle graze inside the park as they easily distinguishable in their combat fatigues. Their usual response is, “yes, we know about the problem and have informed the authorities.”

Rangers/Park Officials: Interviews with rangers and park officials were aimed at identifying the perspectives on cattle grazing inside the MMNR and to understand why rangers acted in violent ways. Many rangers, who are also Maasai, narrated that the ‘problems’ with herders grazing their cattle inside the park had occurred for many years.

The rangers also stood by the official position that cattle grazing inside the MMNR are a breach of the by-laws of the reserve and as such, “cattle must be forcefully ejected from the reserves boundaries.” Many were unable to tell me what the by-laws exactly stated. They also stated that the responsible families must pay a 10,000 shilling fine for breaking the by-laws. “Failure to pay the fine will result in the herder being taken to Narok (the headquarters of the Narok County Council and the Narok district) where they will be charged in a court of law and face jail,” said Meshack, a 40 year old sergeant with the Narok County Council.

When I asked who makes the decision to remove cattle from the MMNR, most if not all of the rangers stated that the orders came directly from the senior park warden and occasionally from the council headquarters in Narok.

“We use our council vehicles if they are working to chase them out of the park or arrest them. Sometimes we take the cows to Sekenani and leave the people at headquarters to deal with the mess,” stated another ranger.

The park authorities state that they have taken proactive steps to stop cattle from coming into the MMNR by holding community meetings and asking herders during the drought to graze their cattle in the park at night, but they must seek the official permission of the warden before they do so. During the course of the sixteen months of fieldwork, I did not witness any meetings with park officials.

Acts of violence towards herders are the result of herders, “not listening to what we have told them!” Meshack also commented that:

“...sometimes you see these young boys with the cattle and we tell them not to come into these areas and to graze their cattle outside the park. The tourists come and complain to us and threaten not to pay the entrance fees. Now, if the tourists do not pay the entrance fees, then where will I get the money to support myself? Sometimes you have to hit them because they are stubborn. You get frustrated that they don't listen to you; so you must '*chappa*' (hit) them so that they remember. When they resist use, we must teach them a lesson!”

Interviews with selected area wardens, who have been long serving members of the Narok County Council, also describe how they too have received numerous complaints from tourists as they pass through the park gates as they depart from, or return from game drives. Most of the orders he receives to stop cattle grazing originate from the park headquarters and the area warden expressed his frustration that he is sometimes unable to follow through on these orders because of a lack of working vehicles. The area warden was also adamant that there were no acts of violence. He stated that, “...these things you are being told are totally false, the herders are just saying that because they want to graze their cows inside the park,” and, “...no, no no, the rangers do not beat the children.”

Finally, recent ranger recruits expressed their anger at the herders for bringing their cattle into the park. They complained that, when the herders enter the park, we are forced to stop them and sometimes, “...it is us who have to capture the cows and herd them to Sekenani, where they are put in jail. We are the ones who have to walk the 20 kilometers to the Sekenani park gate with the cattle through the park, with all the wild animals and have the hot sun eating our backs!”

7.7 Discussion and Conclusions

The information attained from these interviews and background literature on the study area point to several key findings. These are: (1) the Maasai in the study area have traditionally utilized grazing areas that are today inside the MMNR; (2) their access into the reserve has been curtailed because of the expansion of the reserve boundaries in 1961 and a lack of involvement on the part of the national government to provide alternative grazing areas; (3) relationships between herders and park authorities have deteriorated from periods of mutual respect and cooperation to acts of violence perpetrated on herders for trespassing into the MMNR; (4) acts of violence are well documented amongst herders and rangers but denied by senior park officials; (5) western tourists express dismay and anger at having to pay high entrance fees only to find cattle grazing inside the MMNR; (6) tourists make an implicit link between the lack of wildlife and the presence of cattle while on game drives; (7) tourists complaints are forwarded to the park authorities by tour operators, drivers and hotel managers; (8) rangers respond by chasing herders out of the park, beating and arresting herders and locking up cattle until fines of 10,000 shillings are paid.

There are three main interrelated themes that can be drawn from these findings. The first concerns the role of the tourism industry in helping to create and perpetuate processes that ultimately result in violent conflict. The second examines the nature of the relationships between rangers and herders and how tourist satisfaction driven identity promotes conflict. The third relates to the nature of coercive conservation and the tactics employed by the park authorities to restrict

grazing inside the MMNR. Together these themes may help to explain the phenomena observed in the MMNR, and the nature of changing relationships between protected area managers and pastoralists

Tourism: Creating identities to blur reality. The increase in tourism in and around the MMNR over the last 20 years has significantly transformed the nature of the relationship between herders and park authorities from a reciprocal to an unrequited one. As tourism becomes more important financially to the Narok County Council, the management of the MMNR has become more concerned about the welfare of the tourists and by extension the protection of revenue generated from wildlife viewing fees. There is little evidence to suggest that active conservation is being undertaken in the MMNR and a blind eye is being turned towards cattle activities that may potentially impact the MMNR or the mitigate the rapid growth of Maasai settlements immediately around the major park entrances. There also appears to be a detachment between the protection of tourist revenues and the protection of wildlife, and where the latter is equated to the lack of cattle. Much of this can be attributed to the creation of an identity of nature conservation that is devoid of human occupation outside of tourism infrastructure (Adams and McShane 1992), despite evidence to suggest that cattle activities, at a moderate level, can increase biodiversity and stimulate grassland ecosystems (Reid et al. 2001).

The relationships between tourists, conservationists, pastoralists and cattle have been well summarized by George Monbiot writing in Britain's premier wildlife magazine. He found that after interviewing numerous conservation officials about livestock grazing inside protected areas:

“...every conservation official I have spoken to has argued that one factor above all others keeps them (park authorities) from considering the possibility of letting the nomads back in(to protected areas): *that tourists do not want to see them there* (emphasis added). They claim that if ever the Maasai are spotted by tourists inside their old grazing grounds, conservation bodies are bombarded with letters of complaint.” (Monbiot 1994: 12)

These trends point towards an ill-conceived view of nature conservation that is promoted by tour operators and willingly followed by tourists. The growth of tourism has resulted in the imposition of a power gradient between protected area managers/conservation organizations and local people's resident around protected areas. This has altered not only the local and regional political economy, but also ignored the historical relationships between pastoralists, livestock, wildlife, and rangeland environments. There is growing body of research to suggest that these trends are occurring not only in and around the MMNR, but also around many other protected areas in Kenya, East Africa and around the world. For example, in Latin America, Juanita Sundberg shows how local groups living around the Maya Biosphere Reserve in Guatemala conform to an 'essentialist views' of nature preservation and who portray to tourists an identity of living in harmony with nature in order to gain from project benefits (Sundberg 1998, 2004). Similarly, Emily Young shows how, in a study of whale watching along the Pacific coast of Baja, Mexico, the influx of large foreign tourism companies has resulted in a shift from common property management to centralized management (Young 1999, 2001). As a result there are few economic benefits that trickle down to local fishermen and less sustainable fishing practices are being employed.

Similarly Neumann has written extensively on how the preservation of nature as wilderness without human habitation takes place in protected areas of Tanzania. Specifically, he states that during the colonial era of Tanzania, there was a move away from 'preservation' policies practices by protected area managers and towards the 'production' of protected areas, whereby the production of nature is vital to the interests of state officials government policies (that privilege agriculture and nature conservation over pastoral development) (Neumann 2004a). Although Neumann argues that this 'recasting of the African landscape' began during the colonial period, there are a number of parallels that can be drawn to the conservation and development policies witnessed today.

Igoe (2004) suggests that the rapid rise in tourism has accelerated the shift from 'preservation' to 'production.' The rise may be attributed to globalization which is perpetuated by the western media and aggressive marketing campaigns by tour operators and conservation organizations that seek to present the isolationist view of nature. Igoe describes the Maasai and East Africa as forming two separate parts of, "an ecocultural theme park" (Igoe 2004: 13) where western fantasies about the Maasai and wildlife are played out. He states that,

"Both African people and African wildlife are portrayed as exotic and inhabiting an unspoiled world that no longer exists in the West. Just as important, the two are portrayed as separate from one another. People exist in one realm and animals in the other. Viewers may see lions on the *Discovery Channel*, and viewers will see Maasai on the *Discovery Channel*. It is unlikely, however, that they will ever see (both) lions and Maasai on the *Discovery Channel* at the same time. For most Westerners this seems like a natural arrangement: African wildlife exists in wilderness or nature, a place untouched by the ravaging effects of human

activities...national parks equal nature and nature does not include humans” (Igoe 2004: 13-14) (original emphasis).

These artificial binaries are partly due to the Maasai identity that hotels and camps portray to tourists. Bruner and Kirshenblatt-Gimblett (1994) and Bruner (2001) have described the relationships between the Maasai, tourism and identity. Bruner (2001) narrates the experience of the ‘sundowner safari’ where tourists are driven to a remote location (usually to a scenic spot on a hill overlooking the plains) and are entertained by Maasai dancers as they sip cocktails. This ‘staged authenticity’ is “produced by tour agencies and, by extension, by international tourism to meet a demand... as... Hollywood pop culture images of Africa are enacted for foreign tourists (Bruner 2001: 883, 896). This is in part due to realization that, “tourism gives colonialism and tribalism a second life, by bringing them back as representations of themselves and circulating them within a economy of performance” (Bruner and Kirshenblatt-Gimblett 1994: 435). Understanding why tourists would like to be a part of the colonial nostalgia, particular as it relates to the binaries between pastoralists and wildlife, is topic of discussion that would benefit from further research.

In a similar way to the sundowner safari, tourists are taken to Maasai ‘cultural bomas’, for a small fee (usually charged by the hotel or the tour guide/driver). Here they are given a tour of the boma as they side-step the accumulation of dung at the center of the boma and poke their heads inside the traditional dwelling units. Because these tours usually take place in the mid-morning or mid-afternoon (either after tourists return from their early morning game drives or before they depart for the evening game drive) there is no interaction or visual experience with cattle or herding, as they have already left for the

days grazing. Tourists therefore only see the Maasai without cattle and spatially separate from wildlife as the bomas are located outside the park.

Rangers and the formation of dual identities: The narratives from herders, elders, tourists and rangers all point towards interesting phenomena in the MMNR – that rangers have dual identities that they act out differentially. First, they are seen by tourists as protectors and defenders of wildlife. Rangers are often armed with rifles and dressed in combat fatigues. They accompany tourists on game drives, which sometimes occur at night (but only in the pastoral areas immediately outside the MMNR), as they enjoy a bush champagne breakfast (inside the park after a hot air balloon flight) and stand vigil in the lobbies of large tourist lodges. At one of the few selected locations inside the MMNR where tourists can get out of their vehicles and walk around (usually at scenic location such as the hippo pools, or look out hill), they are constantly accompanied and guarded from spontaneous attacks by wildlife by an armed ranger. Their presence in these areas allows for tourists to ask questions on their role and protection of species, such as whether they had caught any poachers, or what they do to poachers when they are caught.

Second, rangers have inherited the identity of the Maasai's historical enemies, the Kuria, who historically have historically taken part in reciprocal cattle raiding activities (Fleisher 2000, 2002). The Maasai whom I interviewed repetitively stated that the acts of rangers today are similar to those of the '*ilmutendes*' – the traditional Maa name given to cattle raiders. This is in specific reference to the similar ways in which cattle are taken from the Maasai (often without warning and with violent outcomes), treated by rangers (made to walk long distances, kept in a place without forage or water), and what the Maasai have to do to safeguard the return of their cattle (pay large fines). Rangers suggest

that they capture cattle inside the park largely due to complaints received directly by them at the lodges and camps, or complaints that have been forwarded to the wardens by hotel managers and are asked to confront the problem by the senior or area wardens.

Rangers therefore exhibit dual identities – the ‘protector’ (to the tourist) and as the ‘cattle raider’ (to the Maasai). Despite the fact that many of the rangers are also Maasai and who also have large herds of cattle (although the herds may not necessarily be based close to the MMNR), a critical question arises in this relationship is, ‘why do Maasai rangers act violently towards the Maasai herders within the study site?’ Amartya Sen (2006) might argue that there are constraints that limit the ranger’s freedom to express what they truly believe or feel about cattle grazing inside the park. This is because tourists are ultimately responsible for paying their salaries and gaining from direct financial support. The narratives presented by tourists to rangers concerned wilderness and pristine nature. Rangers did not offer alternatives to these narratives, instead choosing to enforce the popular image held by tourists. The power gradient in this instance swings towards the tourist. At the same time, the narrative of rangers to Maasai herders and elders is the narrative of the tourist and the vision of the park management to avoid having cattle inside the MMNR and more specifically in areas where the tourists go on game drives. This narrative does not contain the presumed effects of cattle on the physical environment and wildlife. The power gradient here swings towards the ranger. What rangers chose to use violent methods to keep cattle out of the park is a second area that would benefit from future research.

Coercive tactics outside the role of the State: The literature on coercive conservation suggests that the central state uses coercive tactics to ensure the

conservation of biological diversity and adhere to conservation agreements (Peluso 1993). However, in the case of the MMNR today, the national government has no visible involvement (implicit or explicit) in the use of coercive tactics. Instead it is the local government, dominated by people of the same ethnic group, uses coercive means to protect the popular image of the MMNR as a pristine wilderness and to protect the revenue generated from wildlife viewing fees.

The study also finds that traditional means of buffering the effects of environmental variability such as seeking audience with the protected area managers, no longer take place. Herders and elders attribute this breakdown to the coercive actions and violent means by which herders are treated by park authorities, while park officials suggest that herders continually flaunt the rules and by-laws of the MMNR. The NCC appears to have overlooked acts of violence in order to satisfy their revenue generation and the demands of tourists. Nancy Peluso's discussion of coercive conservation holds true for many conservation conflicts around the world, and her argument,

“...applies to states willing to comply with international conservation agreements or with western conservation principles, as such agreements or principles are often used to justify the state's resource management practices” (Peluso 1993: 200).

In this research I found the local government authority that manages the protected area is willing to apply coercive means to ensure that their 'means of production' that is wildlife viewing fees are not harmed by herders and their cattle that are seen to be a threat to revenue generation.

The changing nature of the relationships between herders and protected areas described in this study has shown that it is possible for an individual actor (rangers) to encompass multiple identities and roles within the changing dialect between nature and society which political ecology as a broad field of study seeks to interrogate. Duality and its various components should therefore be considered alongside the different scalar interactions between nature and society.

Figure 7.1: Sequence of actual events demonstrating capture by rangers on cattle grazing inside the MMNR.

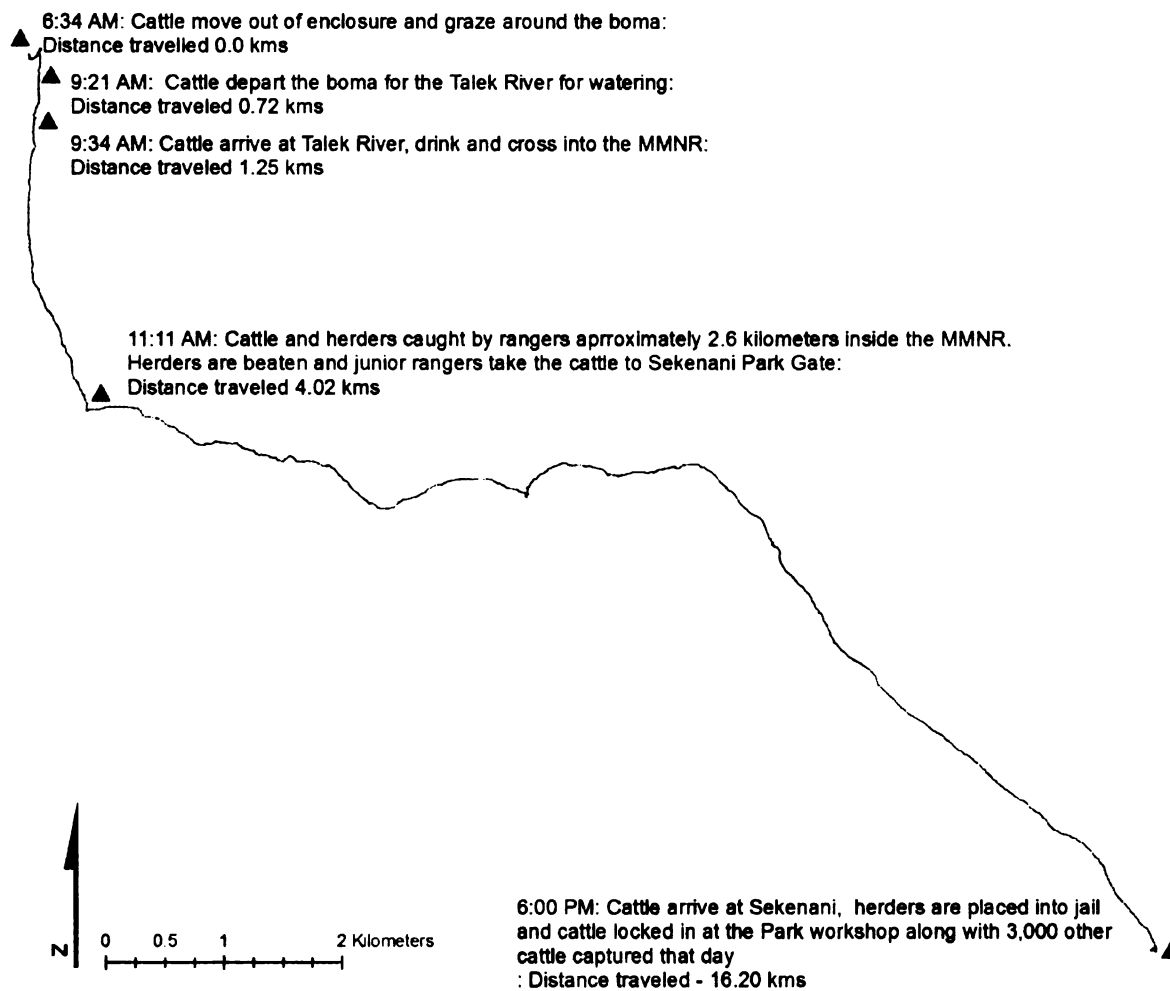


Figure 7.2: Tourists on a game drive inside the MMNR. In the upper right part of the picture are a herd of cattle grazing inside the MMNR. Tourists often complain to hotel managers and rangers on the presence of cattle inside the park, such as on this occasion (Photo by author).



Table 7.1: Responses to the question, “did you encounter any rangers along the grazing orbit today?”

Rangers encountered?		Wet	Dry	Drought	Total
Yes	43	53	28	124	
No	403	474	99	976	
Unknown	0	6	2	8	
TOTAL	446	533	129	1108	

$\chi^2_{(4)} = 22.279, p = < 0.0001$

Table 7.2: Outcome of the encounter with rangers

Rangers outcome	Wet	Dry	Drought	Total
Saw, did not stop	12	16	4	32
Stopped did not chase	4	6	7	17
Chased and escaped	9	16	5	30
Caught, fined, and beaten	5	9	9	23
Caught, beaten and chased out of the park	12	4	2	18
TOTAL	42*	51**	27*	120

$$\chi^2_{(8)} = 18.862, p = 0.016$$

* 1 unknown response

** 2 unknown responses



CHAPTER 8

Summary, conclusions, implications and recommendations for further research

8.0 Introduction

This dissertation has sought to understand Maasai pastoral cattle mobility around the Maasai Mara National Reserve in south-western Kenya. The research addressed four integrative components of pastoral mobility: (1) patterns of mobility and pastoral herd management; (2) the relationships between patterns of mobility and savanna vegetation dynamics; (3) the influence of wealth on herding strategies; and (4) the etiology of grazing conflicts between herders and protected area managers. The study was framed within the geographical sub-field of political ecology and employed both the ‘political ecology of pastoralism’ approach, and the ‘violent environments’ framework. The study was motivated by theoretical, conceptual and methodological gaps in the literature which address pastoralism, cattle mobility, conservation, herding strategies and environmental variability. Specifically, I found that existing nature-society frameworks that examine pastoralism did not explicitly address *both* social and ecological factors that influence pastoral herding strategies, and where they are considered, they do not account for seasonal variability. Secondly existing studies are undertaken at broad scales of space and time. Third, these studies do not seek to understand socio-economic or political variability. In addition, three of the four data chapters incorporate a spatially and temporally explicit measure of cattle mobility that is then used to aggregate and understand how seasonal variability influences both mobility and the driving processes underlying mobility patterns. These considerations move beyond conventional

approaches to understand pastoralism by utilizing empirically rigorous testing frameworks that account for this variability.

In this concluding chapter, I first summarize the main findings from each of the four data chapters. Thereafter, I discuss the implications of these findings in the context of the theoretical motivations from which the study was born out of, and the methodological efficacy of the tools and techniques employed. Cumulatively, these discussions contribute to the on-going debates on the efficacy of mixed method research and their ability to elucidate complex people-environment relationships. This dissertation is a micro-scale study, both in space and time. Because of this micro scale approach broad generalizations to existing studies and landscapes are difficult to make. However, where possible, I have tried to discuss how the relevant findings from this study can be generalized to larger pastoral and protected spaces around East Africa and around the world. Finally, I provide recommendations for future research that addresses shortcomings with the theoretical, conceptual and methodological components of the framework I utilized.

8.1 Summary of Main Findings

Research on pastoralists, cattle and savanna environments has typically been conducted and analyzed at different levels of aggregation and stratification. Data in this study was categorized into three seasons: *wet*, *dry* and *drought*, three different herd size classifications: *small* (less than 60 head of cattle), *medium* (between 60 and 150 cattle), and *large* (greater than 150 cattle), two types of enclosure locations: *temporary camps* and *permanent settlements*, three different wealth categories: *poor*, *medium* and *rich*, five

different groups of people: *herders, elders, tourists, hotel managers/security officers, rangers, and game wardens*. Collectively these different groups and categories are used to accurately control for, compare, and contrast different social and ecological factors. To restate, the aim of this study was to:

- (1) Document, characterize and delineate the patterns and processes of pastoral resource use at the periphery of a protected area;
- (2) Understand and contextualize incidences of grazing conflict between herders and protected area managers.

Patterns of Cattle Mobility: The aim of the first data chapter (Chapter 4) was to determine how parameters of mobility changed with seasonality and herd size for permanent settlements and temporary camps. I sought to achieve two objectives: (1) to determine how relocation of cattle to temporary camps reduces the effects of drought and; (2) to determine the periodicity of cattle movement into protected areas.

There are three main results that this study uncovered. These are that household relocation reduces the stress faced by pastoralists during the drought by: (1) lowering the average total daily distance and time; (2) directing cattle towards the inside Maasai Mara National Park (MMNR) and; (3) concentrating the direction to distinct grazing zones inside the MMNR. The statistical findings also indicate that permanent settlements that do not relocate face the highest degree of stress on their cattle. However, we do not as yet understand why herd managers from these settlements chose not to relocate their herds. For the second objective, the results also indicate that livestock movement into the

MMNR occurs during the wet, dry and drought periods, but the direction of travel is more diffuse in the wet and the dry season, with movement during the drought being most concentrated. For all three seasons, the mean bearing is indicative of movement towards tall grass plains inside the MNNR. These results therefore provide empirical support and explanation for the rationale to relocate households during the drought. This study provides empirical evidence to prove that household relocation does reduce the stress faced by pastoral families beyond descriptive accounts by other scientists (Bassett 1994; Fratkin 1998). The implications for biodiversity conservation on increased mobility into protected areas are highlighted as one of the priority areas for future research, and are discussed in greater detail later in this chapter.

Relationships between ecological process and cattle mobility: The aim of the second data chapter (Chapter 5) was to infer some of the findings from the previous chapter and relate cattle mobility of sampled Maasai households to savanna vegetation dynamics.

Results of the analysis suggest that woodlands demonstrate the highest mean NDVI values across all seasons and NDVI values differ significantly between land-cover types throughout the seasons. During the dry and drought season, differences in mean NDVI are more pronounced between woodland and the other land-cover categories. These results are not unexpected as woodland areas have the highest density of green leaf biomass and are likely to be located close to areas of surface water such as rivers and streams. The results of the analysis for the second hypothesis reveal that there are significant differences between the NDVI of each of the different land cover types inside versus outside of the MMNR, where NDVI values are higher inside the MMNR than

outside and with the exception of bushland and mixed bushland/grassland in the dry season, which demonstrates higher NDVI values outside the MMNR than inside. In general, the margin of difference is highest during the wet season. These findings suggest that pastoral activities outside the MMNR have a definitive impact on NDVI and that the impacts are greater during the wet season than either the dry or drought periods.

Results of the statistical tests for hypothesis 3 suggest that mean NDVI values for grassland are significantly higher furthest away from all pastoral households in the study site during all seasons, with the highest differences recorded for the wet season. Similarly, using a sample subset of cattle mobility from ten pastoral households (hypothesis 4), mean grassland NDVI values also increase as the distance cattle travel away from the boma increases. The incremental gradient is highest during the wet season. Finally, as grazing intensity increases, mean grassland NDVI decreases during the wet season, remains stable in the dry season, and increases in the drought season. The spatial location of high intensity areas differ by season and demonstrate that cattle intensively utilize different parts of the landscape at different time periods. High intensity areas during the wet season are found closer to the boma; while during the dry season high intensity areas are located further away from the boma. During the drought high intensity areas are located furthest away from the boma. Areas within 500 meters from the boma contain high intensity cells throughout the year.

Cumulatively, these findings demonstrate resiliency within the pastoral livelihood system in adapting to changing environmental conditions. However, the consistency demonstrated in each of the hypothesis suggests that wet season impacts are likely to be greater than dry or drought periods. While conventional wisdom suggests that impacts are

likely to be greater during periods of high stress, this research suggests otherwise. A possible explanation of this may lie in the timing of wet season. In 'normal' year the temporal sequence of seasonality is the long wet season (March – May), followed by the dry season (June to September) and then the short wet season (October – November). However, the temporal sequence observed during the study period is dry (August – December), followed by drought (January – February), and then wet season (March – June). The failure of the short wet season and drought conditions (resulting in reduced soil moisture conditions) are what are most likely attributed to the greater impacts of cattle that are observed during the wet season. Additional research that addresses field measures of soil moisture and bulk density is identified as a future area of research.

Relationships between social process and cattle mobility: The aim of the third data chapter (Chapter 6) is to understand the factors influencing the herding strategies of Maasai pastoralists around the MMNR and what effect wealth has on these strategies.

I found that: (1) herding strategies are similar between all three wealth categories during the wet and dry seasons; (2) rich households cope better with drought by: (a) utilizing a greater number of herders that are more experienced; (b) making herding decisions earlier; and (c) encountering more herds with larger numbers of cattle, and; (3) cattle from rich households travel longer distances in a shorter amount of time, than cattle from either poor or medium wealth households. The findings from this chapter reinforce those from the first data chapter on patterns of mobility, whereby over 75% of the grazing orbits in the wet and the dry season record their maximum distance away from the boma inside the MMNR. During the drought this percentage increases to over 95%.

The results of this study also suggest that the poor continue to be disproportionately marginalized in their herding strategies during the drought. Poor households are unable to afford, or do not have sufficient labor, to match the qualities of herders from rich households. Although cattle from poorer households do not suffer proportionally higher numbers of infections from trypanosomiasis, their herd sizes are smaller and the cost of investing in trypanocides is higher. These findings echo existing studies on Maasai herding strategies conducted in various parts of Eastern Africa and supports the notion that, wealthier households have greater management and control over grazing resources than poor households. In addition, the study found that factors that are unique to pastoralists around protected areas such as attacks by wildlife on livestock and the transmission of epizootics were not found to be a significant factor in the herding strategies. The research found that drought strategies are vastly different from either wet or dry season strategies and the chapter concludes with calls for greater research in other periods of stress, specifically floods, to understand existing coping strategies in order to better manage and reduce the effects of these environmental extremes on herding strategies in order to ensure the flexibility and resiliency of the pastoral livelihood system.

From pattern to process to conflict: The final data chapter (Chapter 7) explicitly examines the nature, magnitude and frequency of grazing conflicts experienced by herders through the actions of protected area managers for grazing inside the MMNR. There are several key findings that this chapter uncovered. These are: (1) the Maasai in the study area have utilized grazing areas that are today inside the MMNR; (2) their access into the reserve has been curtailed because of the expansion of the reserve

boundaries that took place in 1961 and a lack of involvement on the part of the national government to provide alternative grazing areas; (3) relationships between herders and park authorities have deteriorated from periods of mutual respect and cooperation to acts of violence perpetrated on herders for trespassing into the MMNR; (4) acts of violence are well documented amongst herders and rangers but denied by senior park officials; (5) western tourists express dismay and anger at having to pay high entrance fees only to find cattle grazing inside the MMNR; (6) tourists make an implicit link between the lack of wildlife and the presence of cattle while on game drives; (7) tourist complaints are forwarded to the park authorities by tour operators, drivers and hotel managers; (8) rangers respond by chasing herders out of the park, beating and arresting herders and locking up cattle until fines are paid.

By relying on new frameworks on identity and violence, I suggest that the rise and importance of tourism in and around the MMNR has resulted in the creation and perpetuation of dual identities among rangers. Rangers feel their priority lies with the protection of tourists and maintaining tourist satisfaction. The presence of cattle inside the MMNR results in tourist dissatisfaction and thus rangers enforce a vision of nature conservation that is devoid of cattle after complaints by tourists. This is also done to ensure their employment as rangers. Tourists also feel as though they contribute to nature conservation by reporting the location of cattle inside the MMNR and (in some cases) demand that rangers eject cattle out of the MMNR. The temporality and selectivity of keeping cattle outside the MMNR is closely correlated with periods of high tourist numbers.

The dominant paradigm of coercive conservation stems from the international and national level, where the national government upon the influence of international conservation bodies, is willing to overlook coercive tactics in order to ensure the conservation of biodiversity and the protection of tourist revenues. Instead, this research found that coercive tactics, such as the verbal and physical abuse of herders found grazing inside the MMNR occurs at the local scale, often without the involvement of the national government or conservation organizations, and is carried out in order to protect tourist revenues and tourist satisfaction in the safari experience.

8.2 Recommendations for Future Research

Embedded within each of the data chapters, I have attempted to identify future areas of research. Throughout each of the data chapters the most common theme that emerges is the absence of a rigorous ‘on-the-ground’ ecological appraisal. In the following section, I describe how I plan on conducting future research which will be carried out as part of my post-doctoral training.

Interactions between soil, vegetation and cattle activities: The proposed future research entails field sampling to capture key ecosystem attributes at locations where livestock graze and do not graze. I will rely on soil and vegetation indicators to capture these dynamic attributes. To identify the locations to conduct sampling I will: (1) identify control locations where there is a complete absence of livestock grazing and; (2) rely on an adaptive-dynamic sampling design to sample areas where livestock are grazing. The individual sampling techniques are shown in Table 8.1. The soil and vegetation indicators

proposed in Table 1 are common indicators of rangeland ecosystems that are used to infer ecological processes (Kuehl, Breckenridge, and Panda 1995; Herrick 2005; Breckenridge, Kepner, and Mouat 1995) and have been tested and validated (Herrick and Whitford 1995; Herrick 2005).

The intellectual merits of this proposed research include an enhanced understanding of the impacts and feedbacks of pastoral grazing around protected areas in East Africa by contributing to the work of other scientists in this area (Brockington and Homewood 2001; Serneels and Lambin 2001b; Homewood et al. 2001; Homewood and Rodgers 1991). The continued use of geospatial technologies to map ‘herding orbits’ and identify areas of high grazing intensity along with structured analyses of soil and vegetation attributes will generate new and important biophysical evidence needed to assess the ecological processes influencing pastoral grazing around protected areas. The hybrid methodology employed for the study will also allow for the development of critical thresholds of savanna ecosystems as they transition between multiple stable states (Stringham, Krueger, and Shaver 2003). The research also has profound significance to the development of the political ecology sub-field of the discipline of geography, which rest on the notion that relationships between nature and society are ‘dialectical and non-linear’ (Walker 2005). This future research will explore these relationships with the expectation that a narrowing of scales will demonstrate these relationships more clearly. Finally, this study will meet the requirements needed to understand pastoral livestock mobility as outlined by the ‘mobility paradigm’ (Niamir-Fuller 1999b).

8.3 Theoretical Implications

The theoretical implications of this study can be divided into three broad contributions to the literature on: (1) the political ecology of pastoralism approach; (2) violence, identity and conflict, and; (3) conservation and development practices in pastoral and protected area borderlands.

The political ecology of pastoralism: As stated in the introduction to the dissertation, political ecology lacks a coherent conceptual definition, but does incorporate a number of different components that when integrated together allow for the understanding of nature-society issues in a holistic yet integrative and selective manner. In this study, the foci were on understanding pastoral-cattle-savanna relationships along the periphery of the MMNR. My contribution towards this literature relates to *practicing political ecology* and defining what type of ‘political’ or ‘ecology’ can be inserted into a study of pastoralists, livestock and the environment.

‘Ecology’ in this dissertation is related to the dynamics of vegetation across seasonality. Because of logistical constraints my research team and I were unable to collect on the ground measures of vegetation variability (through soil and vegetation attributes) that were originally proposed. As a result, I had to rely on remotely sensed measures of this variability through 16-day Normalized Differential Vegetation Indices (NDVI) that spanned across the study site. However NDVI, while a good indicator of how seasonality, and more specifically how precipitation influences vegetation growth, *does not tell us about the degree to which cattle activities influence the environment*. On the ground measures such as aggregate stability and soil bulk density would have portrayed these influences more clearly. Social-scientific appraisals of changing

ecologies were also very valuable in this study but are only approximate indirect measures. As shown in Chapter 6, herder's perceptions of grass height and color - as well as water quality and quantity - match the seasonal constraints faced by pastoralists and their cattle, but they *do not tell us the magnitude of change or gradients of change*, between for example, fresh green and dry brown.

Ecology as it has been critiqued by several scholars in political ecology, does not need to be a rigorous ecology, but needs to be situated within the overall aim or goal of the research. As has been the case with numerous researchers, there has been a bias towards quantifying the impacts of cattle on the ecosystem (Oba and Kotile 2001; Rowntree et al. 2004; Thomas and Twyman 2004) without understanding the potential problems with such approaches. Livestock impacts are highly variable in space and time as has been shown in West Africa (Turner 1998a, 1998b, 1998c, 2006). This study also found that 'high-intensity' cattle utilization areas are in spatially different locations during different seasons. Second, livestock impacts are also often largely perceived to be negative, when in fact they can have positive impacts to the ecosystem as has been shown in the Serengeti ecosystem (McNaughton 1993; Skarpe 1991a, 1992). Clearly identifying hypotheses on the potential impacts of cattle grazing on ecosystems should therefore consider these multi-faceted dimensions of pastoralism along with empirical testing and contextualization across the ecosystem and livelihood system. This concern is identified as a priority area of future research (subsequent section in this chapter).

A second contribution that I make to the political ecology literature relates to the seasonal variability exhibited in the social, economic and political dimensions of herding. The results clearly reveal that herding strategies are similar between wet and the dry

seasons and vastly different from during the drought. This finding is unsurprising given that pastoralism is well adapted to these conditions (Rodgers and Homewood 1986; Horowitz and Little 1987; Fratkin and Roth 1990). The period of drought was quite short in comparison to other drought periods experienced around Kenya. However, there remains an unclear understanding of how the length of the drought would alter drought coping strategies. As found in other political ecology studies, mobility is enhanced during the drought and its effects on cattle are less severe than if households do not relocate. Hence, what would happen if the household does not have the ability to relocate during a drought that 2 or even 3 years (as have been the case in northern Kenya)?

A third contribution to the political ecology literature is that *the poor continue to be marginalized in their herding strategies and constraining mobility. The implications of these findings are that the poor are likely to cause greater impacts on the ecosystem given their reduced and concentrated mobility.* These constraints faced by the poor are exogenous to the livelihood system (such as the increased monetization of the economy as a result of tourism and the shrinking of existing grazing lands through the creation of protected areas) and are related to the general decline in traditional strategies of cooperative herding that are being recorded in several different pastoral ecosystems around the world (Rohde et al. 2006; Rutten 1992; Fernandez-Gimenez and Le Febvre 2006).

The political ecology framework, as I practiced it in this research was successful at orienting the field work and synthesizing the various components of the data. Political ecology was not very successful at providing methodological support for research (this narrative is expanded on in detail in the following sections). The eloquence of the

political ecology framework is that it allows the individual researcher or group of researchers to select the components that are important towards the overall goal of the research, so long as there is a sound justification for the approach and method and returns to the theoretical motivations of the study.

Violence, identity and conflict: The second framework relied on in this dissertation is the ‘Violent Environments’ framework proposed by Peluso and Watts (2001). Unlike other studies utilizing the framework, this study found that the individual actors within a shifting dialectic around nature-society interactions *are a product of different identities that, within a single actor, can be dualistic and often contradictory*. This dualism is necessary for the survival of those that perpetrate conflict in order to satisfy the demands of tourists who form the core revenue base of the protected area. Additionally, environmental conflict is exacerbated by the perception of environmental degradation by cattle and natural wilderness that is devoid of anthropogenic disturbance despite the fact that cattle are ultimately seen as less unnatural than a van full of tourists.

Implications for conservation along pastoral and protected area regions: This study focused on protected area border and revealed that pastoral cattle movement into protected areas is frequent at all times of the year. Movement is most common and concentrated during the drought period. The study also speculated that wet season impacts are higher during the wet season than the dry or drought period. Data from the vegetation analysis shows that areas close to pastoral settlements always have the lowest grassland NDVI compared to any other region and are the fastest to brown down. The implications of cattle mobility into protected areas have commonly been cited as a major cause for concern on ecosystem stability within and around the MMNR (Lamprey and

Reid 2004; Homewood 2004; Boydston et al. 2003; Waithaka 2004). As Zimmerer (2000) suggests, the problems of conservation borders have resulted in the separation of areas that were once both pastoral and wildlife areas. The creation of the MMNR and subsequent border modifications (Chapter 2) has led to this separation. Subsequent human and livestock population growth as well as growing commercialization and tourism influences are resulting in increased sedentarization and concentration of Maasai pastoral settlements. Therefore, my contribution to the literature has been to data provide empirical evidence to support Zimmerer's (2000) statement that current boundary demarcations may widen the existing divisions that separate between degraded areas and conservation areas. *The very acts of nature preservation that rangers and protected area managers use to keep cattle out of the park may result in this increased 'degradation' in areas immediately outside the park, hence increasing the gradient of ecological change between these two areas.*

8.4 Methodological Implications

This study is first and foremost a study on mobility, and as such would not have been possible without relatively recent advances in geospatial technologies that allow for greater accuracy on mobility that is independently derived. The use of Global Positioning Systems (GPS) units along with Geographic Information Systems (GIS) software allowed for the tracking of cattle from representative households at fine scales of space and time. A key limitation of the study was despite the high number of grazing orbits collected ($n = 1108$), data was gathered from only ten households due to logistical constraints. After the data was aggregated by either wealth herd size (chapter 4), or wealth status (chapter 6)

and seasonality (chapters 4, 5, 6 and 7), there are a high number of orbits from two or at most three households. *As a result the methodological limitation of this study is, "How does a researcher balance logistical constraints with collecting a representative sample of sufficient data, while at the same time satisfying and adhering to and without violating the assumptions and statistical requirements to test hypotheses"?*

Second, the main method used to elucidate mobility patterns, a modified GPS collar with an ordinary handheld GPS unit, was for the most part successful in tracking fine scale mobility. However, there were instances where the GPS would inadvertently switch off during the grazing orbit and the incomplete data was discarded. Given the relatively low costs of the units and the canvas collar, this method and tracking technique was very efficient and provided an alternative method to high costs GPS collars. The success of this method came at the expense of a difficult, time consuming and laborious process, despite data being collected from only ten households, and tracking conducted for a maximum of six households per day.

A third methodological implication concerns *the positionality of the researcher and research assistants*. Fieldwork in East Africa is often a difficult, dangerous and expensive enterprise that summons strength, vision and preparedness beyond any planning, all this in the face of what might be construed as chaos, anarchy and general bedlam. Beyond these experiential realities lie the narratives of individual people and their cattle that they revere that to some scientists, scholars and observers does not conform to a rational explanation. Capturing these narratives within the scientific framework is not an easy task. In this study, I have tried to encapsulate both the variability and commonalities exhibited both within and between aggregated categories,

as best I can. The methods used to do this have been critiqued amongst scholars in the field. Despite these generally accepted methods, there were a series of problems that I encountered throughout the process of field data collection, the most dogmatic of which is *the issue of expectations*. Areas of environmental and livelihood change have been sought out by researchers in the same way that a journalist seeks out a new story or alternative expectations. The Maasai Mara is no different. I was another researcher in a long line before me that selfishly sought out the academic narrative. Doing this came with the knowledge that the Maasai and other actors in the study area were not new to the researcher's persistent questions and were initially reluctant to divulge indigenous knowledge that had been acquired over centuries of 'dwelling' in place. It was only after my research assistants and I abandoned our roles as researchers and adopted a humanitarian role, especially during the drought between January and February 2006 that Maasai families were more welcoming and later appreciative of the research that we sought to undertake. Our primary reason for being in the study was first and foremost to collect data, but a researcher's role is seldom that of collecting data. Balancing humanitarianism and data collection was a very challenging part of fieldwork and is something I was ill equipped (at least initially) to handle.

8.5 Policy Implications and Broader Impacts

Two main policies are reviewed in this section and recommendations are provided on how to improve on each of the existing policies. The first concerns existing policies related to the restriction of cattle into protected areas. The general tenant regarding wildlife conservation in Kenya has been the exclusion of extractive use of resources from

inside the protected areas. This has been expressly stated in the Wildlife (Conservation and Management) Act of 1985 (GOK 1985), and was subsequently amended in 1989 (GOK 1989). It was further revised in order to establish the National Environmental Management Authority (NEMA) in the Environmental Management and Coordination Act of 1999 (GOK 1999). According to these pieces of legislation, tourism and scientific research are permitted, but local income generating activities such as cattle grazing, honey collection, and fuel wood collection inside the protected area are strongly prohibited. Data from this research has shown, despite these prohibitive ordinance, cattle grazing by Maasai pastoralists actively takes place during all seasons and the frequency of movement is highest inside the MMNR. The primary reasons given by protected area managers and conservationists has been that cattle grazing is a destructive form of land use and detrimental to wildlife conservation efforts. Homewood (2004: 128-129) citing Bell (1987) notes that many of these dominant views have been exaggerated and originate from a false myth regarding pristine nature (Neumann 2003; Brockington 2002; Adams and McShane 1992).

Many scholars and development practitioners have argued for the inclusion of local peoples in the decision making strategies and planning policies of protected areas (Western 2000; Western and Pearl 1989; Western, Wright, and Strum 1994). Despite the best efforts of NGOs and community based conservation strategies, there has been little evidence to suggest that the involvement of local people will yield positive results over the long term (Newmark and Hough 2000; Neumann 1997). However, continued efforts must be placed on gathering the views and perspectives of the local people during the policy preparation stages. In order to ease the pre-existing tensions between herders and

protected area managers a committee should be formed to bring together perspectives from the two groups and should be convened by a neutral party. It is important that this committee meets both regularly and frequently in order to gather how the different views and perspectives change by seasonality, as different circumstances arise for both the herding calendar and the tourist calendar.

From the narratives presented in this dissertation, it is apparent that much of the antagonisms over cattle inside the MMNR are driven by the views of tourists. As paying clients to the Narok County Council (NCC), the management of the MMNR has an obligation to adhere to these views despite the incorrect basis upon which these views are founded. One possible way by which this can be overcome is to *regulate night grazing practices inside the MMNR*. As noted previously night grazing strategies are common in West Africa (Ayantunde et al. 2000; Ayantunde et al. 2002) and were also practiced within the study site. A formal arrangement between herders and protected area managers could potentially allow for herders to access forage areas inside the MMNR particularly during extended dry and drought periods. This arrangement would mean that cattle depart their enclosures after tourists return from their evening game drives and before the morning excursion. The arrangement would have to be carefully planned and coordinated by both parties and more importantly should be adhered to. However, actually undertaking this exercise would involve careful dialogue with both groups and should also be conducted by a third party. A potential drawback to this strategy is that, while it would potentially avoid conflicts driven by the views of tourists, it does not address the ecological consequences and potential impacts of cattle grazing inside the MMNR. Based on the available literature, night grazing inside the MMNR could adversely affect animal

behavior. As stated previously, researchers have noted that the increased frequency of cattle movement into the MMNR has resulted in hyenas becoming more nocturnal (Boydston et al. 2003).

The second policy recommendation reviews the relationships between herders and protected area managers. As described previously, the way in which protected area managers, particularly rangers treat herders (particularly children) is a clear violation of basic human rights and the rights of the child. The NCC managers of the MMNR should therefore be made aware of the tactics used by their rangers and herders should be informed and briefed on their rights regarding treatment and procedure when found grazing inside the park. The narratives of elders presented in Chapter 7 illustrate that herders were treated with dignity and respect in the 1960s and 1970s, despite transgressions into the park. In order to do this effectively return to that level of respect an office should be set up to facilitate a *pre-defined procedure on dealing with pastoralists entering the MMNR*. One recommendation would be to avoid the heavy fines of 10,000 shillings (142 US\$) and instead focus on sustainable environmental management. This could be conducted with the assistance of eco-tourist lodges and a grass roots environmental organization run by the Maasai known as ‘Green Warriors’.

These efforts would need to be sustained over a long period of time in order to gain the trust of both rangers and herders that they will be treated fairly and with dignity and respect. The management of the MMNR should avoid the policy of confiscating cattle and corralling them in areas that have no forage or water. In addition the practice of beating anyone, and especially children should be avoided at all costs. Whenever children are caught grazing inside the park, they should not be ill-treated or denied food and water

as has previously been the case. Their parents and guardians should be summoned and the children released immediately. All these procedures should be conducted by a neutral body or organization but funded by the NCC.

This dissertation has attempted to address both social and ecological dimensions of people and protected area relationships and has directly answered calls to bridge, “the gap between natural and social sciences, and western versus local understandings, in order to achieve more effective policy” (Homewood 2004:139). However, this research only partially contributes towards achieving more effective policy in around the MMNR. Effective policy can only be achieved with the full cooperation and support of protected area managers, tourists and tour operators, local pastoralists, conservationists and scientists. This is an enormous task and the road to achieving sustainable development is full of obstacles. To tackle these obstacles, it is essential that the plurality of competing roles and opinions among these different actors should be openly presented and debated without prejudice. There remains a great deal about the MMNR, Maasai herding strategies and conservation efforts that we need to learn about such a complex ecosystem. However, over the last half century there has been a large amount of information that we have attained and now is the time to put our scientific efforts to good use. How exactly we do that, remains to be seen.

Table 8.1: Sampling techniques proposed for soil and vegetation estimates

Ecosystem Attribute	Indicator	Technique	Reference
<i>SOIL</i>	Bulk Density	Volumeter	(Arshad and Coen 1992)
	Aggregate Stability	Aggregate Stability Kit	(Seybold and Herrick 2001; Herrick et al. 2001)
	Soil Moisture	Soil Moisture Probe	(Dougill, Heathwaite, and Thomas 1998)
	Soil pH	pH Pen	(Doran 1995)
<i>VEGETATION</i>	Percent Cover	Pin Frame	(Augustine 2003b; Georgiadis 1989)
	Species Comp.	Pin Frame at 33/53° angle	(McNaughton 1979a; Mwangi and Western 1998)
	Grass Height	Pasture Meter	(Barnhart 1998)
	Grass Color	Munsell ® Plant Tissue Book	(Karcher and Richardson 2003)

APPENDICES

Appendix 1: The actual pre and post herding orbit report forms used in the study

PRE-HERDING ORBIT REPORT

of: _____ Cows HH: _____ Date: _____
 _____ Sheep Temp: _____ Time: _____
 _____ Goats Ccover: _____ GPS X: _____
 _____ Donkeys Wind: _____ GPS Y: _____
 _____ Dogs Precip: _____ GPS Z: _____

Where do you want to go and graze today?

What is the general *habitat type*?

Why do you want go graze in that area?

Decision on grazing location made by whom?

Age	Gender M F	Names	Any Contact with Rangers or Others That Disrupted Herding Earlier If Yes, please describe what happened?
H1			
H2			
H3			
H4			

POST-HERDING ORBIT REPORT

WEATHER: _____ TIME OF RETURN: _____

Did all herders return together? _____

If not, why? _____

Did you go to the same area to graze as planned? _____

If not, where did you graze and for how long? _____

At what time did the cows graze most? _____

Where is this area? _____

Did you join herders from another enkang? _____

If yes, from which enkang? _____

How many cows and herders? _____

How long did you undertake joint herding? _____

Did animals fall sick along the orbit? If yes, how many cows and what disease? _____

Did you encounter any rangers along the orbit? _____ If yes, what events transpired?

Did you encounter any wildlife along the orbit? _____ If yes, what species?

Additional Notes:

Appendix 2: Question guide for the key informant interviews

BEFORE BEGINNING INTERVIEW PLEASE READ VERBAL CONSENT FORM IN ITS ENTIRETY AND LEAVE A COPY WITH SUBJECT

English version of question guide for interviews

1. Where were you born and in what year?
 - a. Describe general area and name of town/district, division, location, sub-location if known
 - b. If exact year born unknown use alternative measure, i.e. before Independence, during the Kenyatta years, before the military coup, before multi-party era, etc.
2. Which areas have you lived in prior to living in the Talek area? How long did you live in these places?
3. What prompted you to move here? What year did you move to the Talek area?
4. When you first moved here, in what general area did livestock graze in the wet season? In the dry season?
5. How often did you move your livestock around? Where did you move? Did you move all the cattle, sheep and goats, or just the cattle?
6. Did you graze your livestock near or inside the park? Did the park authorities allow you to graze inside the park?
7. During the droughts of the 1960's where did you move your livestock? For how long did you stay at that place? Where did you move to next?
8. Where there any incidence of cattle raiding during those years? If so where did they occur and when and how many livestock were lost?
9. How many people were involved in herding at that time?
10. What were the relative sizes of sheep and goats and cows relative to today? Were there more or less and why have these numbers changed?
11. Where were the good grazing areas at that time? Do you recall grass species were abundant for the cows?
12. Were there any ol-olkieri (reserve grazing pastures) at that time? If so where were they located and when were they used?

13. Were these reserves guarded? If so, who guarded them?
14. Were these reserves shared? If so who did you share them with?
15. How did you negotiate who shared them and how they were to be used?
16. Did all livestock (cattle, sheep and goats) access the reserves or just the cows?
17. Where did you move the sheep and goats if they did not use the grazing reserves?
18. During other periods of drought, where did you move your livestock? Have you been back to this area since then?
19. What routes did you take to get to that area?
20. Were any problem encountered along that route?
21. Who moved with the herds and who stayed behind?
22. What were some of the conflicts that took place between wildlife and livestock at that time? What did you do to try and alleviate the conflict? Did you receive any assistance in trying to alleviate the conflict, either from the Narok County Council, the Kenya Wildlife Service or other agencies such as the World Wildlife Fund, Friends of Conservation or anyone else?
23. Did you purchase any veterinary medicines for you livestock at that time? If so which ones and how often?
24. Did you pay (in monetary or other terms) to graze in any areas during that time?
25. Was there a dip nearby and if so, how often were the livestock dipped?
26. What were the milk yields at that time? Have they changed and if so why?
27. What sort of relationship did you have with the park authorities at that time?
28. Did all members of the family herd the livestock? If no, please explain who did the herding and when?
29. Have women's roles in herding changed since that time?
30. What was the worst drought you experienced since the time of Kenyatta (approximately 27 years ago)?
31. What did you do to cope with the drought?

32. Do you recall how many livestock were lost during that drought?
 33. If your estimation, have the number of wildlife increased, decreased or stayed the same?
 34. Which species have increased or decreased or stayed the same?
 35. What were some of the 'big' livestock diseases that claimed livestock losses?
 36. Did the colonial government or the Kenyatta government make any improvements to this area? If yes, what type (e.g. were roads built, were dips constructed, were there any veterinary shops, did the government send out any livestock extension officers, were they any holding grounds)
 37. How often did you sell your livestock and where was the major market?
 38. Did you ever receive any relief aid?
 39. Over the last 30 years have you noticed the growth of any invasive plant species?
 40. Changing relationships with the park authorities
 - a. How has your relationship with the park authorities changed over the last 30 years
 - b. Have the rangers become more strict in recent years
-

Appendix 3: Verbal consent form following human subjects research protocol

English version of verbal consent process

Summary Explanation of Research

Hello, my name is Bilal Butt. I am a student studying geography at Michigan State University, USA. As part of my student research, I am examining the movement of livestock in this area, what factors influence movement and want to know why and where grazing conflicts take place. I would like to gain some feedback from you as part of my research study. In order to do this I would like to have a conversation with you, where I hope to gain some insight on topical discussions on issues such as the variation in the movement of your livestock and how this movement changes with different factors such as rainfall, the wildebeest migration, diseases and how much labor is used to herd livestock.

You are being asked to participate in this research because you reside close to the park boundary and my research is examining livestock movement of herders in areas close to the park.

Estimate of Subjects' Time

This interview should take approximately between 30 minutes and 1 hour of your time. I shall be in the Talek area continuously between July 24 and August 22, 2007. If you any additional information that you think might be of use to my study, please feel free to contact me.

Experimental Procedures

My tasks are to examine the movements of livestock. These will be done through a series of questions and follow-up discussions related to the questions. This is dependent on your willingness to participate in the study. It is therefore necessary for me to brief you on some of the possible risks and benefits of the study. There are no major risks associated with this procedure either to you or your livestock. However, some of the possible risks may be that the some of the information you provide me will be forwarded to conservation agencies and park authorities so as to improve the current conservation and livestock development practices. These responses may or may not be specific to identify you as an individual or the movement of your livestock. Having said that, I will ensure that your responses will be kept confidential and no real names or identities will be revealed as part of the study.

To help capture the information that will be gained from this interview, I would like to record the responses given using an audio tape recorder. This will help me to transcribe the contents of the interview in its entirety. This of course is dependent upon your consent. The tape will be destroyed after the interview has been transcribed into a digital format on the computer.

Voluntary Participation

This is a voluntary activity and you are free to participate in this study. Please do not feel obligated to participate in this study. You may also discontinue participation at any time.

However, your participation in this study is invaluable to me and will help to make this study a successful one. In appreciation of your time and effort, I can offer you with a kilogram of tea leaves and a kilogram of sugar.

Confidentiality

The information that I collect from you will be kept confidential. This means that it is only I and members of my research team who will be able to identify you and the responses that you give me, and no one else. Your privacy will be protected to the maximum extent allowable by law.

Contact Persons

If you have any questions about this study, please contact me at the maendeleo manyatta where I will be based for the next one month or in Nairobi at the International Livestock Research Institute (ILRI) at P.O. Box 30709 00100 Nairobi, Kenya or telephone number 4223000 extension 4804. Alternatively you can contact me through my cell phone number 0722-427970. If you have any questions or concerns regarding your rights as a study participant, or are dissatisfied at any time with any aspect of this study, you may contact - anonymously, if you wish, Peter Vasilenko, Ph.D., Director of the Human Research Protection Programs (HRPP) at Michigan State University: (517) 355-2180, fax: (517) 432-4503, email: irb@msu.edu, or regular mail: 202 Olds Hall, East Lansing, MI 48824.

Thank you very much for your time. If you agree to participate in this study, please say that "I voluntarily agree to participate in this study," and if you agree to have the interview recorded on audio tape, please sign or place your thumb print on the following page, which means that you agreed to have the interviewed recorded on audio tape.

*****Provide copy of oral consent to subject if they agree to participate in the study*****

I (please provide name) _____ have agreed to have my comments as part of the interview recorded on audio tape.

_____ (Date)

_____ (Signature or Thumb Print)

Appendix 4: Institutional Review Board (IRB) Approval Form from Michigan State University

MICHIGAN STATE UNIVERSITY

Renewal Application Approval

June 13, 2007

To: Antoinette WINKLERPRINS
207 Geography Building

Re: IRB # 05-533 Category: EXPEDITED 2-6, 2-7
Renewal Approval Date: June 14, 2007
Project Expiration Date: June 13, 2008

Title: PASTORALISM, CATTLE MOBILITY PATTERNS, AND ECOLOGICAL DYNAMICS AT THE MICRO-SCALE IN SOUTHERN KENYA

The Institutional Review Board has completed their review of your project. I am pleased to advise you that the renewal has been approved.

Revision to include a change in the title and the addition of the NSF Fellowship as a source of funding. The new study title is reflected above.

The review by the committee has found that your renewal is consistent with the continued protection of the rights and welfare of human subjects, and meets the requirements of MSU's Federal Wide Assurance and the Federal Guidelines (45 CFR 46 and 21 CFR Part 50). The protection of human subjects in research is a partnership between the IRB and the investigators. We look forward to working with you as we both fulfill our responsibilities.

Renewals: IRB approval is valid until the expiration date listed above. If you are continuing your project, you must submit an *Application for Renewal* application at least one month before expiration. If the project is completed, please submit an *Application for Permanent Closure*.

Revisions: The IRB must review any changes in the project, prior to initiation of the change. Please submit an *Application for Revision* to have your changes reviewed. If changes are made at the time of renewal, please include an *Application for Revision* with the renewal application.

Problems: If issues should arise during the conduct of the research, such as unanticipated problems, adverse events, or any problem that may increase the risk to the human subjects, notify the IRB office promptly. Forms are available to report these issues.

Please use the IRB number listed above on any forms submitted which relate to this project, or on any correspondence with the IRB office.

Good luck in your research. If we can be of further assistance, please contact us at 517-355-2180 or via email at IRB@msu.edu. Thank you for your cooperation.

Sincerely,



Peter Vasilenko, Ph.D.
SIRB Chair

C: Bilal Butt
315 Natural Science Building
Department of Geography



OFFICE OF REGULATORY AFFAIRS Human Research Protection Programs

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Fax: 517-432-4503

www.humanresearch.msu.edu
SIRB & BIRB: IRB@msu.edu
CRIB: critb@msu.edu



MSU is an affirmative action
equal-opportunity institution

Appendix 5: Actual household survey used in the study

PART 1: BACKGROUND AND GENERAL INFORMATION

A i. Date of interview:

Date	Day	Month	Year
------	-----	-------	------

A ii. Start Time

HR	MIN	AM/PM

B. Enumerator:

--

C. Village/General Area:

--

D. Northing

--	--	--	--	--	--	--	--	--	--

E. Easting

--	--	--	--	--	--	--	--	--	--

F. Altitude

--	--	--	--

G. Name of Respondent:

--

H. Is respondent the household head? (if No, go to PART 1 I.)

YES	NO
-----	----

I. Relationship to Household Head

--

J. Age set:

--

K. Approximate age:

--

L. Gender:

M	F
---	---

M. Marital status:

--

N. Number of wives and age of wives

	Wife 1	Wife 2	Wife 3	Wife 4	Wife 5	Wife 6
Age						

O. Years of primary education

NONE	CLASS 1-3	CLASS 4-6	CLASS 7-8
------	-----------	-----------	-----------

P. Years of secondary education

NONE	FORM 1-2	FORM 3-4
------	----------	----------

Q. Years of university education

NONE	Incomplete University	Completed University
------	-----------------------	----------------------

R. Vocational Training

PLACE		QUALIFICATION		NO. OF YEARS	

S. No. of housing structures that household utilizes

None	1	2	3	4	5	6	7	8	More than 8 (Specify)
------	---	---	---	---	---	---	---	---	-----------------------

T. Describes structures

	S1	S2	S3	S4	S5	S6	S7	S8
Purpose								
Roof								

Wall								
------	--	--	--	--	--	--	--	--

U. Type of Fence for Cattle

--

V. Type of Fence for Sheep/Goats

--

W. No. of Adult (greater than 18 years of age) **Males** in Family

--

X. No. of Adult (greater than 18 years of age) **Females** in Family

--

Y. No. of children from Wives

Wife No. 1		Wife No. 2		Wife No. 3		Wife No. 4		Wife No. 5	
Gender	Age	Gender	Age	Gender	Age	Gender	Age	Gender	Age

Z. Number of children in School and level in school

Child name	Age	Gender	Which School	Level in School

AA. Other Dependents

Adult Males		Relationship to HH		Current Activity	
Adult Females		Relationship to HH		Current Activity	
Children Males		Relationship to HH		Current Activity	
Children Females		Relationship to HH		Current Activity	

AB. Did you ever, or do you currently hold a leadership position?

NO			
YES	POSITION:		YEARS:

AC. How far do you go to collect firewoodkm / PLACE:

AD. How far do you go to collect material for livestock enclosureskm / PLACE:

AE. How far do you go to collect material for Housing structures.....km / PLACE:

AF. Diameter of cattle enclosure: (measure number of paces)

AG. Diameter of sheep/goats enclosure:(measure number of paces)

AH: Sketch rough diagram of household, including residential structures, livestock pens and other structures

**DIAGRAM OF BOMA GOES ON THE REVERSE BLANK PAGE – PLEASE
LABEL APPROPRIATELY**

A. WHEN did you move/settle here?

B. WHY did you move/settle here?

C. For how many years have you been living at your current location?

D. Where did you live prior to moving/settling here?

[illegible]

E. Where were your grandparents born?

F. Which person in your family first moved to this area?

Person:	How many years ago?
---------	---------------------

G. Do you recall what year that was?

A. How many livestock do you own/owe/owed?

	Own	Owe	Owed
Cattle			
Sheep			
Goats			
Donkeys			
Dogs			
Chickens			

B. Who owns the livestock that are within the herd?

[illegible]

* Categories are: Calves, Bulls, Immature Steers, Mature Steers, Heifers, Cows

B. Please tell us about the composition of your CATTLE, SHEEP AND GOATS

CATTLE		# As of Aug 2005	Breed of Animals*	Bought	Sold	Slaughtered	Died	Gifts	Number As of Aug 2006	
		Type by %	# in Herd	Total #	Total #	Total #	#	Cause	# Given	# Received
ALL CALVES	Calves (0-2 yrs)									
Males	Immature Steers (1-3 yrs)									
	Mature Steers (> 3 yrs)									
	Bulls									
Females	Heifers (1-3 yrs)									
	Cows (>3yrs)									
SHEEP										
GOATS										

* Breed Types: Sahiwal, Boran, Zebu, and crosses between each type

** Cause of Death:

- 1 = Killed by predators;
- 2 = Starvation/stress from drought;
- 3 = Stolen;
- 4 = Lost;
- 5 = East Coast Fever (Oltikana);
- 6 = Foot and Mouth Disease (Olkuluk);

- 7 = Malignant Catarrhal Fever (Inkati);
- 8 = Brucellosis (Olkibirito);
- 9 = Heart Water Disease;
- 10 = hypothermia after the rains;
- 11 = Kiroboto;
- 12 = Other reason not listed

PART 4: LAND OWNERSHIP

A. Is the land that your boma is on, your own land?

YES	
NO	

A i. If NO, are you _____?

Renting the land	
Staying because of the owners goodwill	
Owner is a family relative	
Other (specify)	

B. How much land do you own?

Size (acres)		Location	
--------------	--	----------	--

C. How did you acquire the land?

Allocated after sub-division	Inherited	Bought	Other (Specify)

D. Do you have land or entitlement to land elsewhere?

Yes	No	Size		Cost		Location:
-----	----	------	--	------	--	-----------

E. Have you SOLD any land in the last 5 years?

Yes	No	Size		Cost		Location:
-----	----	------	--	------	--	-----------

F. Have you BOUGHT any land in the last 5 years?

Yes	No	Size		Cost		Location:
-----	----	------	--	------	--	-----------

G. Have land prices, in your opinion, been increasing, decreasing or staying the same?

Increasing		Decreasing		Staying the Same	
------------	--	------------	--	------------------	--

H. Are you planning on SELLING any land in the next 2 years?

Yes	No	Don't' know as yet	Size		Cost		Location:
-----	----	--------------------	------	--	------	--	-----------

I. H. Are you planning on BUYING any land in the next 2 years?

Yes	No	Don't' know as yet	Size		Cost		Location:
-----	----	--------------------	------	--	------	--	-----------

J i. Have you fenced any land?

Yes	No
-----	----

J ii. If Yes, what type of fencing material

Bush	Mabati	Wire	Combination (Specify)
------	--------	------	-----------------------

J iii. If Yes, where is the land and how much of the land is currently fenced?

Location		Fenced Area	
----------	--	-------------	--

J iv. How much land do you hope to fence in the next 2 years and why do you want to fence it?

Fenced Area (acres)		Reason for Fencing	
---------------------	--	--------------------	--

J v. How much land do you hope to fence in the next 5 years and why do you want to fence it?

Fenced Area (acres)		Reason for Fencing	
---------------------	--	--------------------	--

K i. Do you rent land for grazing your animals

Yes	No
-----	----

K ii. If yes, how much land do you rent and what do you pay to rent it per year/month

Land area (acres)		Cost (per month)	
-------------------	--	------------------	--

PART 5: LIVESTOCK MOVEMENTS

A. How many different livestock herds at HOME and AWAY do you have now?

Total No. of Herds		HOME		AWAY	
--------------------	--	------	--	------	--

B. Where are the herds now and how many livestock are in each place

Place Names	No. of cattle		No. of sheep		No. of goats	
	AWAY	HOME	AWAY	HOME	AWAY	HOME

At the following times, please tell us the general movement of your livestock

Time of Year	Livestock Type	Within Koyake Group Ranch							
		Place 1	Place 2	Place 3	Place 4	Place 5	Place 6	Place 7	Place 8
Aug – Nov 2005	Cattle								
	Sheep & Goats								
Dec 2005 – Jan 2006	Cattle								
	Sheep & Goats								
Feb 2006 – Mar 2006	Cattle								
	Sheep & Goats								
Apr 2006 – Jun 2006	Cattle								
	Sheep & Goats								
Jul 2006 – Aug 2006	Cattle								
	Sheep & Goats								
Sep 2006 – Nov 2006	Cattle								
	Sheep & Goats								
1997 El-Nino Rains	Cattle								
	Sheep & Goats								
1999/2000 Drought	Cattle								
	Sheep & Goats								

D. In the **DRY SEASONS**, how would you rate the following factors that influence where livestock graze?

FACTOR	Very Important	Somewhat Important	Not Important	Not Relevant
QUALITY of Grass				
QUANTITY of Grass				
Clean FLOWING Water				
Presence of TOURISTS				
Presence of RANGERS				
Proximity to SALT LICK				
Presence of ENDOROBO				
Avoidance of ELEPHANTS & LIONS				
Presence of ZEBRAS, GAZELLE & IMPALA				
Experienced HERDERS				
Number of other HERDS in the area				
OTHER (please specify)				
OTHER (please specify)				
OTHER (please specify)				

E. In the **WET SEASONS**, how would you rate the following factors that influence where livestock graze?

FACTOR	Very Important	Somewhat Important	Not Important	Not Relevant
QUALITY of Grass				
QUANTITY of Grass				
Clean FLOWING Water				
Presence of TOURISTS				
Presence of RANGERS				
Proximity to SALT LICK				
Presence of ENDOROBO				
Avoidance of ELEPHANTS & LIONS				
Presence of ZEBRAS, GAZELLE & IMPALA				
Experienced HERDERS				
Number of other HERDS in the area				
OTHER (please specify)				
OTHER (please specify)				
OTHER (please specify)				

F. In most cases, **WHO** makes the decision on where to graze the livestock in the DRY AND WET SEASON?

Person	DRY	WET
Younger herder		
Experienced herder		
Older men		
Younger women		
Young men		
Other (please specify)		
Other (please specify)		

G. In most cases, **WHEN** is the decision made on where to graze the livestock in the DRY AND WET SEASON?

When is Decision Made	DRY	WET
A few days in Advance		
During the previous day		
The night before		
The morning before herding		
While herding		
Other (please specify)		
Other (please specify)		

PART 6: LIVESTOCK PRODUCTION STRATEGIES

A. How many people herd your CATTLE in the DRY SEASON?

Usually 1		2 herders		3 or more herders	
-----------	--	-----------	--	-------------------	--

B. How many people herd your CATTLE in the WET SEASON?

Usually 1		2 herders		3 or more herders	
-----------	--	-----------	--	-------------------	--

C. How old are the herders for LARGE CATTLE and are they usually male or female?

Less than 7 years	7 – 15 years	16 – 20 Years	Over 20 years
MALE	FEMALE		

D. How old are the herders for CALVES and are they usually male or female?

Less than 7 years	7 – 15 years	16 – 20 Years	Over 20 years
MALE	FEMALE		

E. How old are the herders for SHEEP & GOATS and are they usually male or female?

Less than 7 years	7 – 15 years	16 – 20 Years	Over 20 years
MALE	FEMALE		

F. Are your livestock managed together or separately with livestock of other households in your village / kijiji?

Together		Separately		Both		Sometimes	
----------	--	------------	--	------	--	-----------	--

G. With whom do you make arrangements to graze your livestock?

--

H. What is your arrangement for each of the following?

	CATTLE			SHEEP & GOATS		
	Together	Separate	Both	Together	Separate	Both
Paying for vet. Drugs						
Paying for dipping/spraying						
Herding livestock						
Watering livestock						
Buying livestock						
Selling livestock						
Selling milk						
Selling firewood/charcoal						
Selling beer/muratina						
Selling hides and skins						

I i. Do you plan seasonal breeding for the CATTLE?

Yes	No
-----	----

I ii. When does the seasonal breeding occur?

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

I iii. When are the calving seasons for CATTLE ?

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

J i. Do you plan seasonal breeding for the SHEEP & GOATS?

Yes	No
-----	----

J ii. When does the breeding occur?

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

J iii. When are the calving seasons for SHEEP & GOATS ?

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

K. Are any calves born in the driest seasons?

Yes ☐ No ☐

L. At What age do you wean the calves (CATTLE)?

M. At What age do you castrate the bulls?

N. How often (in years) do you change or purchase your breeding bulls

Once every 6 months	Once every year	Once every two years	Other (specify)
---------------------	-----------------	----------------------	-----------------

O. Source of breeding bulls?

Own	Borrow	Other (specify)
-----	--------	-----------------

P. When did you last obtain or purchase breeding bulls from elsewhere?

Q i. Did you purchase any semen?

Yes ☐ No ☐

Q ii. If so, where from and how much did it cost?

Place of Purchase	Cost (kshs)
-------------------	-------------

Please estimate the number of days worked by the type of worker for livestock production?

R. Family Labor input for CATTLE grazing

Cattle	No of People	No of days per month worked	No of months worked per year	Wage rate per month (if not paid, state 0)	Other kind of payment for labor(specify)
FAMILY labor: Children ≤ 14 years					
Adult female 15+ year old					
Adult male 15+ year old					

S. Hired Labor input for CATTLE grazing

Cattle	No of People	No of days per month worked	No of months worked per year	Wage rate per month (if not paid, state 0)	Other kind of payment for labor(specify)
HIRED labor: Children ≤ 14 years					
Adult female 15+ year old					
Adult male 15+ year old					

T. Family Labor input for SHEEP & GOATS grazing

SHEEP & GOATS	No of People	No of days per month worked	No of months worked per year	Wage rate per month (if not paid, state 0)	Other kind of payment for labor(specify)
FAMILY labor: Children ≤14 years					
Adult female 15+ year old					
Adult male 15+ year old					

U. Hired Labor input for SHEEP & GOATS grazing

SHEEP & GOATS	No of People	No of days per month worked	No of months worked per year	Wage rate per month (if not paid, state 0)	Other kind of payment for labor(specify)
HIRED labor: Children ≤14 years					
Adult female 15+ year old					
Adult male 15+ year old					

V. When marketing your animals, how do you decide which animals to sell?

1 st choice	
2 nd choice	
3 rd choice	
4 th choice	

W. Where do you normally sell your livestock?

--	--	--	--

X. Livestock losses during the drought

LIVESTOCK LOSSES			
Month	Cattle (number)	Sheep (Number)	Goats (number)
Aug 2005			
Sep 2005			
Oct 2005			
Nov 2005			
Dec 2005			
Jan 2006			
Feb 2006			
Mar 2006			
Apr 2006			
May 2006			
June 2006			
July 2006			
Aug 2006			

Y. If you dip your livestock, where do you dip them and how do they charge

Z. Veterinary inputs for livestock

Spraying and dipping costs If you spray some of your animals, please provide the following information:

Type of livestock		Cattle	Sheep/Goats
Type of acaricide			
No. of animals sprayed			
Quantity of acaricide per 20 liter jerrycan			
Total no of jerrycans per spray			
No of spray per month	Dry season		
	Wet season		

AA. Where do you buy the acaricide?

--

AB. From whom do you buy the acaricide?

Vet shop	Chemist	Neighborhood shop	Other (specify)
----------	---------	-------------------	-----------------

AC. What is the price of acaricide?

Price	Quantity (ml)
-------	---------------

AD. Drugs/Injectables cost

Please fill in the information in the table below, the expenses are from August 2005 to September 2006

	Season	Preventive/ Vaccines Type	Preventive/ Vaccines KShs/Month	Curative/ Antibiotic Type	Curative/ Antibiotics KShs/Month	Veterinary Service/ equipment
Cattle	Wet season					
	Dry season					
Sheep	Wet season					
	Dry season					
Goats	Wet season					
	Dry season					

AD i. Do you purchase any livestock feeds?

Yes No

AD ii. If so, please complete the table below

	Type of feed	Type of animals given feed	Kgs used per month	Price KShs/Kg	Kgs used per	Estimate of other cost labor etc KShs
Cattle						
Sheep						
Goats						



AE. Livestock Management Interventions

Do you know of any ways to improve livestock production or to reduce the predation problems with livestock in this area?

Interventions	Taken Yes/No	If yes, when taken?	If you have not done this activity, why not?	Successful? Yes/No/Partly	If no, why?

For example, the intervention can be

- | | | |
|-----------------------|---|----------------------------|
| 1. young stock house, | 8. watchman, | 15. planting fodder trees, |
| 2. stone boma, | 9.spear, | 16. better feeds, |
| 3. barbed wire, | 10. collective herding, | 17. better breeds, |
| 4. chicken net wire, | 11. start herding early and come back early | 18. others (specify) |
| 5. trenches, | 12 adult herding, | 19. avoiding inbreeding, |
| 6. torches, | 13 night guard, | 20. scarecrows, |
| 7. dogs, | 14. poisoning, | 21. trapping, |
| | | 22. thorn bomas, |

PART 7: LIVESTOCK PRODUCTS

A. Milk Products

	Milk Production (bottles per day)	Milk Consumption (bottles per day)	SELLING OF MILK				
			APPROXIMATE MONTHS (CIRCLE APPROPRIATE MONTHS): JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC				
GOOD YEAR	(example date)		No. of bottles/day	No. of months	Price per bottle	Location of sale	Customers
Wet Season							
Dry Season							
BAD YEAR	(example date)						
Wet Season							
Dry Season							

SIZE OF BOTTLE IS _____ ml

TYPE OF BOTTLE IS _____

B. Other Livestock Products

	Sale of Products (YES OR NO)	Amount sold last year 2005-2006	Price per quantity sold
Manure			
Hides and skins			
Meat			

PART 8: PARK CONFLICTS

A i. In the last 12 months (up to August 2005) have you, or any members of your family, been caught for grazing inside the park?

Yes ☐ No ☐

A ii. If yes, what did the rangers do to you?

B. What is the most severe thing that you have heard that the rangers have done to herders caught herding inside the park?

Ci. Have any women in household been beaten by rangers?

Yes ☐ No ☐

C ii. If yes, please describe how the women are beaten by rangers

D i. Have any children in household been beaten by rangers?

Yes ☐ No ☐

D ii. If yes, please describe what the rangers do to the children?

E i. Have any rangers come to your house and threatened any person in your family?

--

E ii. Who did they threaten and what did they say?

F i. When you are caught grazing inside the park and fined, are you issued with a receipt?

--

F ii. In your opinion, where do you think the money that you pay for the fine goes?

G. In your opinion, why do you think the rangers catch the cows inside the park at some times and not at other times?

H. What do you think of the rangers and the park authorities?

I. Have you received any money from the park entrance fees from Narok County Council, If Yes, how much per year?

--	--

J. In the last few years (upto 2000) have you ever lived in the park?

--

PART 9: REMITTANCES AND EMPLOYMENT

A. Please tell us about any INFORMAL income-earning activities of household members (including you) and describe what they are doing. Participation in non-herding activities over the past 12 months

Activity	Over the past 12 months, did anyone in your household engage in any of the following activities 1=yes 2=no	If yes, how many people (# of persons)	Relationship to head of household (see categories below)	Living within household 1=living within household 2=living elsewhere	Frequency of contribution of cash to household (How many times per year?)	Estimate of average monthly income from this source in KShs.						
						< 500	500 to 1K	1K to 3K	3K to 5K	5K to 10K	10K to 20K	Over 20K
INFORMAL/BUSINESS ACTIVITIES												
Firewood or charcoal sale												
Curios/crafts for tourist												
Sale of sand												
Livestock trade												
Rental properties												
Local brewing												
Retail shop/kiosk												
Transport business												
Membership in group or association												
Other (specify)												

B. Please tell us about any FORMAL income-earning activities of household members (including yourself) and describe what they are doing. Participation in non-herding activities over the past 12 months

Activity	Over the past 12 months, did anyone in your household engage in any of the following activities 1=yes 2=no	If yes, how many people (No. of persons)	Relationship to head of household (see categories below)	Living within household 1=living within 2=living elsewhere	Frequency of contribution of cash to household (How many times per year?)	Estimate of average monthly income from this source in KShs.						
SALARIED EMPLOYMENT						< 500	500 to 1K	1K to 3K	3K to 5K	5K to 10K	10K to 20K	Over 20K
Receive remittances												
Teacher												
Driver												
Manager												
Ranger with NCC												
Ranger with KWS												
Watchman												
Chief/assistant chief												
Civil leader												
Clerk												
Other (specify)												

1= household head
5=brother

2=spouse
6=mother

3=son
7=others (specify)

4=daughter

PART 10: WILDLIFE POPULATION AND ENVIRONMENT DYNAMICS

A i. Did the wildebeest come for calving in your grazing areas during the 2005-2006 year?

☐ Yes ☐ No

A ii. If yes, were there more wildebeest than in 2004-2005?

☐ Yes ☐ No

B. Based on the movements and locations of your livestock, what wildlife species were near, or had an impact on your livestock and what kinds of impacts did these interactions have on your livestock (start with most positive and negative first)

Positive	Season*	Wildlife Species	Reasons	
Negative	Season	Wildlife Species	Victim	Agent

Seasons are Long Wet season (inkakwa); Short dry season (Oladalo); Short wet season (Oltumuren) Long dry season (Olameiyu)



C. In your estimation, which of the following wildlife species have increased or decreased or stayed the same, and why do you think that change has occurred?

Wildlife Species	Increase/Decrease/Stayed the same	Reason for change
Lions		
Cheetahs		
Leopards		
Hyenas		
Jackals		
Topi		
Impala		
Grants Gazelles		
Thompsons Gazelles		
Zebra		
Wildebeest		
Buffalo		
Elephant		
Giraffe		
Hippo		
Warthog		
Ostrich		
Dik dik		
Other (specify)		

D i. Do you think that the number of fires has increased, decrease or stayed the same?

Increase

Decrease

Stayed the same

D ii. Why do you think that change has occurred?

E i. Does your household currently or in the past benefit either directly or indirectly from wildlife?

Yes No

E ii. What sorts of benefits have you accrued (e.g. CAMPFIRE LAND, CAMSPITE FEES, etc) – please give monetary cost of benefit if possible?

F i. Has the amount of bush land increased, decreased or stayed the same?

Increase

Decrease

Stayed the same

F ii. Why do you think that change has occurred?

PART 11: HOUSEHOLD EXPENSES

A. How much on average does your household spend on food?

Food Item	Approximate Cost per week (kshs)
Ugali	
Sukuma	
Beans	
Tomatoes	
Potatoes	
Onions	
Cabbage	
Sugar	
Tea Leaves	
Meat	
Cooking Fat	
Rice	
Other (specify)	

B. What are some of the other NON-FOOD related major household expenses?

Other Expenses	Approximate Cost per week (kshs)
Clothing	
School fees	
Transport	
Medical care	
Emergency costs (specify)	
Other (specify)	

A ii. END Time

HR	MIN	AM/PM

**REMEMBER TO THANK RESPONDENT AGAIN OF BEHALF OF MYSELF AND MICHIGAN
STATE UNIVERSITY
PLEASE ALSO GIVE SHUKA TO RESPONDENT**

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