Chapter 9

FRAGMENTATION OF A PERI-URBAN SAVANNA, ATHI-KAPUTIEI PLAINS[1], KENYA

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1. INTRODUCTION

Many pastoral ecosystems around the globe are under pressure to produce more livestock or to make way for more intensive agricultural systems or new uses (Blench 2000). Some rangelands that used to be managed under communal land tenure are being privatized, with establishment of individual holdings; others are under state control (Galaty 1994). This is happening first in rangelands that receive more rainfall, are closer to urban centres, and/or contain significant key resources that are essential for successful crop cultivation (Galaty 1994). In these systems, pastoralists are either pushed onto more marginal lands for grazing or they begin to take up crop agriculture themselves, becoming agro-pastoralists (e.g., Campbell 1993, Campbell et al. 2003). One result is increased permanent settlement.

Pastoral people also choose to settle because they desire better education and health care for their families, their diets have changed and they have new needs for marketed goods and services (Little 1985, 1992, Fratkin and Smith 1995). In wetter, semi-arid savannas of East Africa, settled agro-pastoralists often build fences and take up cultivation to protect their access to forage and diversify their sources of food production (Rutten 1992,

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Kimani and Pickard 1998, Reid et al. 2004). These pressures (described generally in Chapters 1-2 and 13) fragment these rangelands into smaller holdings, which can have significant consequences for pastoral and agro-pastoral livelihoods and for biodiversity conservation (described generally in Chapters 1-3 and 15).

A few pastoral ecosystems are further along in this process of fragmentation than others, because of their history, their proximity to markets, human population pressure, policy, or other reasons. One such rangeland is the Athi-Kaputiei Plains (part of which is called the Kitengela) in Kenya. This area is unique because it continues to support migration of large wildlife over long distances despite its proximity to Kenya's capital of Nairobi, currently a city of over 2 million people (Figure 9-1). Only a fence separates wildlife from this bustling city. Nairobi National Park (117 km^2 in area), located at the northernmost tip of this 2,456 km^2 ecosystem, begins just 5 km from the central business district of Nairobi. South of the park stretches the rest of the ecosystem that is 21 times larger than the park itself. Twenty-four species of large mammals live on these rich plains, although not elephant, which was exterminated before 1962 (Stewart and Zaphiro 1963, Gichohi 1996). Migrating herds use the park during the dry season for its water and abundant grass and then move south into the open pastoral lands (the second and third of the three triangles shown in Figure 9-1) during the calving season when the rains begin. Here, the Kaputiei Maasai live along with a wide variety of other peoples. Together, they use the land for grazing their livestock, cultivation, horticulture, quarrying, settlement, local commerce, cement production, and export processing businesses.

The Athi-Kaputiei resembles many parts of the world—it is affected by processes that operate globally: urbanization, rapid in-migration, expansion of land use with little planning, high poverty rates, and shifts in systems of land tenure. However, this area is unusual because of its exceptional wildlife. We chose to describe this system as an example of the causes and consequences of fragmentation because this pastoral-wildlife system is one example of the ways that other rangelands in East Africa may change over the next few decades. If so, there is a great opportunity to learn from the issues and challenges in the Athi-Kaputiei as pastoral peoples struggle to understand and adapt to change, and decide, with others, whether or not to maintain viable (and potentially valuable) wildlife populations on their lands. We start the chapter with a description of fragmentation processes in the Athi-Kaputiei over many millennia, with a strong focus on the present.

We then present a synthesis conceptual model of the processes and feedbacks of change here. We next detail the current state of land use in this ecosystem and some of the consequences of fragmentation for people, livestock, and wildlife. We end with a brief description of some collaborative efforts to reverse fragmentation of the Kitengela part of the Athi-Kaputiei Plains to support movement of pastoral livestock and wildlife and finally, a discussion of future implications.

2. LOCATION AND ENVIRONMENT OF THE ATHI- KAPUTIEI PLAINS

Nairobi city bounds the Athi-Kaputiei ecosystem on the north, with the Lukenya hills to the east, the Rift escarpment to the west, and lower-lying rocky and hilly land to the south. The plains lie principally at the northern end of Kajiado District, but include a small piece of Machakos District; Nairobi National Park, at the northern tip of the ecosystem, though administratively falling in Nairobi District, is usually considered part of Maasailand. Today, many residents refer to the three 'triangles' that make up the pastoral part of the ecosystem: the first triangle bordering the park and the second and third triangles farther to the south (see Figure 9-1). Rainfall is moderate here, with 800 mm falling each year in the northwest and 500 mm in southeast (Norton-Griffiths 1977). Most precipitation occurs during two rainy seasons, but rains often fail; farmers say that crop production is generally successful only one year in five (Kristjanson et al. 2002). This ecosystem sits on very rich soils derived from phonolitic lava (Baker 1954) and thus is a nutrient-rich 'eutrophic' savanna, probably able to support 2-3 times more wildlife biomass than nutrient-poor 'dystrophic' savannas that are widespread elsewhere in Africa (Bell 1982, Huntley 1982, Fritz and Duncan 1994). The vegetation is principally wooded *Acacia/Balanites/Themeda* grassland, with gallery forests along rivers of *A. xanthophloea* and small forest patches of *Croton macrostachys* and *Olea africana*. Only two permanent rivers, the Kiserian and Empakasi, run through the northern part of the plains, and much of their flow is extracted by a pipeline running to Kajiado town (from the Kiserian River) or for irrigation and household consumption (Gichohi 1996). In the early 1990s, only 21% of the plains were within reach of permanent water for pastoral herders and their livestock within their normal grazing radii (Gichohi 1996), but this has likely changed with recent water development.

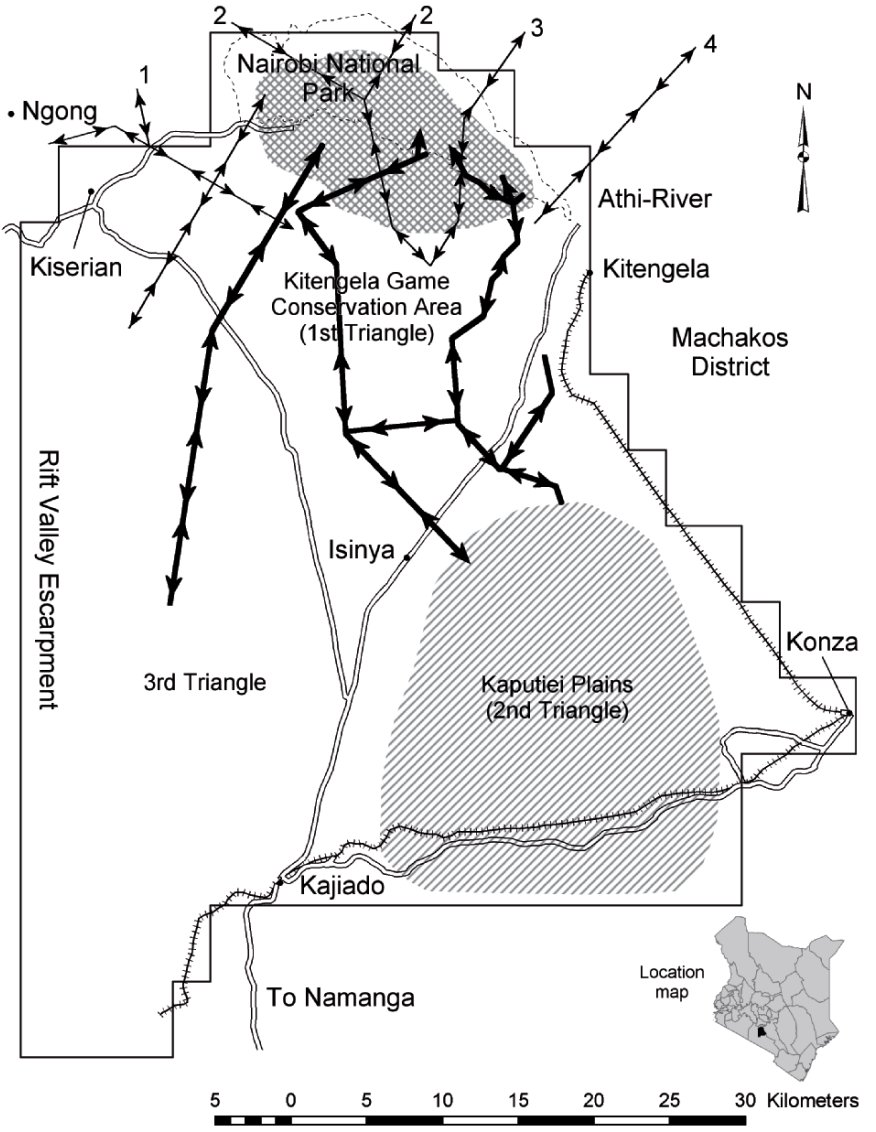

Figure 9-1. Map of Athi-Kaputiei ecosystem (outlined in light gray), showing the three triangles, Nairobi National Park, historical (thin solid lines and arrows, numbered) and current (bolded solid lines and arrows, not numbered) wildlife corridors and livestock grazing routes, and dry season (dark hatching) and wet season range (light diagonal striping) for wildebeest. The city of Nairobi is on the northern edge of the park, which is in south-central Kenya.

3. HISTORICAL FRAGMENTATION OF THE ATHI- KAPUTIEI PLAINS

Like other areas of East Africa (Leakey and Hay 1979), hominids and wildlife very likely lived together in the Athi-Kaputiei Plains ecosystem for millions of years; it seems unlikely that they actively fragmented this landscape in the distant past. Farmers began cultivating native sorghum, millet, and root crops in East Africa about 3,500 years ago, with crops from other continents like maize and cassava arriving much later (Robertshaw 1991). However, in East Africa, pastoral people with livestock arrived more than a millenium before crop cultivation, pushed south from the Sahara by a drying period that began about 5,500 years ago (Smith 1984, 1992, Marshall 1998, 2000, Marshall and Hildebrand 2002). The first pastoral people were likely Cushitic-speaking pastoral people, followed by Maa-speaking people thousands of years later, the latter migrating south from the Uganda-Sudan border region in the 1400s, probably reaching south to the Athi-Kaputiei Plains in the 1600s (Jacobs 1975, Robertshaw 1991, Sutton 1993). Over the last 400 years, the Maasai occupied much of the land in Kenya's southern Rift Valley and surrounding highlands (including Nairobi), defending this rich savanna and forest land from neighboring tribes (Rutten 1992).

At the end of the 1800s, some observers claimed that this ecosystem supported the "most spectacular concentration of wildlife in all of East Africa" (Simon 1962). In 1891, rinderpest reached this part of Maasailand, killing all but 5-10% of Maasai cattle herds and most of the grazing wildlife (Waller 1988). Human disease also took its toll. The Kaputiei Maasai in the Athi-Kaputiei were particularly hard-hit by smallpox (Rutten 1992). Wildlife counts in 1902 showed there were probably more wildlife than we see today in the Athi-Kaputiei Plains, despite the rinderpest epidemic about a decade earlier (Meinertzhagen 1957:58). The difference between then and now is that there were four times more wildlife than cattle in 1902/3, while nearly a century later, counts by the Kenyan Department of Resource Surveys and Remote Sensing show the reverse: livestock outnumber wildlife by 4:1.[2]

3.1 Policy

Over the last century, the Athi-Kaputiei pastoral-wildlife system became progressively compressed, bounded, and fragmented. British colonists appropriated land from pastoralists and brought private land ownership to East Africa, much as they did to eastern North America 150 years previously (Cronon 1983). Maasai gave up 60% of their best watered pastures in the early 1900s, and moved to two reserves in southern Kenya (Rutten 1992). Nairobi city grew next to the principal key water resource for people,

livestock, and wildlife, at the border of the highland forest and lower and drier savannas, and along the Ugandan railway that runs along the eastern edge of this ecosystem today. Slowly, expansion of European and African settlement and farmland began to fragment this ecosystem that once stretched unbroken from just south of Mt. Kenya to Tanzania, progressively cutting off four of the known historical wildlife migration routes to the north (historic migration routes #1-4, thin solid lines and arrows in Figure 9-1) and to the east (Foster and Coe 1968, Gichohi 1996). The four historical routes for wildlife, livestock, and pastoral movement included: 1) to the Ngong Hills, 10 km from the current edge of the ecosystem; 2) to Nairobi, 5-10 km away; 3) to Ruiru-Thika, 40 km away; and 4) to Ol Doinyo Sabuk, 70 km.

In 1946, the colonial government excluded pastoral peoples from the wettest part of the existing grazing system (800 mm rainfall) by creating Nairobi National Park (dark cross-hatching, Figure 9-1). In the 1950s and 1960s, farmers and settlers gradually took up the land around the base of the Ngong Hills (migratory route #1 in Figure 9-1), until all the land north of the current Nairobi-Magadi road (the westbound road that goes through the town of Kiserian) was settled and unavailable for pastoral herders or wildlife by the 1970s. In 1963, the Royal Parks, the colonial park authority, built a fence around the western and northern sides of the park, between the park and the city, effectively ending migration of wildlife to the north from the park area, but also protecting the park wildlife from city residents. Ten years later, in 1976, there were still kongoni and Grant's gazelle in the highland areas of the Ngong Hills (northwest corner, Figure 9-1), an area that had been completely converted to housing (Foster and Coe 1968, Hillman and Hillman 1977).

In the late 1960s, development of group ranches was proposed as a way to help ensure Maasai ownership of land in Kenya, encourage development of rangelands, and solve the perceived degradation of rangelands (Njoka 1979). The first group ranches were formed in the Kaputiei section of Maasailand, in the Athi-Kaputiei ecosystem (Pasha 1986, Rutten 1992). In 1986, the Kaputiei Maasai again led the way in Kenyan Maasailand and began adopting individual private ownership of land. By 1990, forty of the original 52 group ranches in Kajiado District had subdivided or were in the process of doing so (Rutten 1992, Kimani and Pickard 1998). This meant splitting each group ranch into smaller plots: each member of the 15 former Kaputiei group ranches received title to private plots ranging in size from 51 to 298 acres (Rutten 1992). Kimani and Pickard (1998) found that the Kajiado group ranches with the smallest plot sizes were those that had subdivided first and/or those with the highest proportion of the plots sold to non-Maasai. They also found that those with the smallest plots were closest to Nairobi and received the most rainfall, although group ranches with many

members at sub-division also have small plot sizes (J.S. Worden, pers. comm.). In the 1980s and 1990s, small towns, like Athi River and Kitengela (Figure 9-1), continued to grow, industries and the export processing zone (EPZ) were established nearby, and some pastoralists and farmers started to grow crops for the first time (Gichohi 2000). Land further fragmented as owners sold parts of original private plots or passed on plots to several inheritors. These changes are now having profound implications on how this landscape is used and how easily herders, livestock, and wildlife can move from one place to another in search of good pastures and water.

3.2 Human population

In addition, human populations in Kajiado District more than quadrupled from 4 to 19 people/km^2 in three decades from 1969-1999, with a slight slowing of growth recently (Katampoi et al. 1990, GoK 2001). Growth was four times faster than the district average in the Kitengela location within the first triangle, principally around the Kitengela shopping centre and other smaller villages (GoK 2001). Throughout the district, rapid population increase has led to more settlements, which, in this area, brought more fencing (Figure 9-2). Many of the new residents are non-Maasai farmers and townspeople who, unlike the pastoral Maasai, have a long history of eating wild meat (Nkedianye 2003).

4. CURRENT PROCESSES OF LOSS AND FRAGMENTATION IN THE ATHI-KAPUTIEI PLAINS

As described above, these historical events, and other cultural, natural resource, economic, and political conditions set the context for the wide range of ultimate (underlying) and proximate (nearby) forces that cause this landscape to fragment into smaller patches of different land uses and change the access of people and grazing animals to key forage and water resources (Figure 9-3). It is important to recognize that these same forces also initiate a range of changes beyond fragmentation, like improvement in crop production with the expansion of cropland, but we focus on fragmentation processes for the purpose of this book. We propose here that the most important of these causes are, as described above, land tenure, settlement and protected area policy, inheritance by multiple inheritors and land sales, urbanization (particularly expansion of settlements and industrial activities), and human population growth. In addition to these, high access and use of

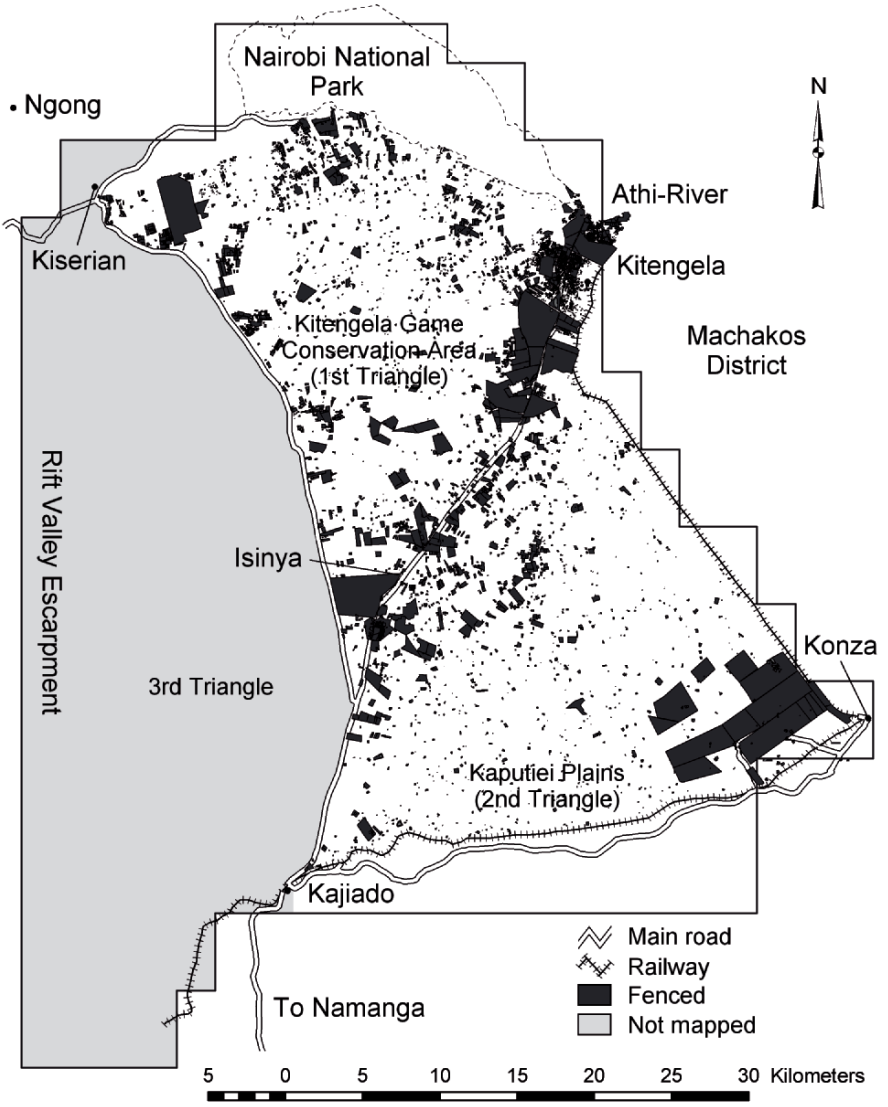

Figure 9-2. Fences and land use in first two triangles of the Athi-Kaputiei Plains, July-October 2004.

markets (e.g., for flowers), commoditization of livelihoods in response to these markets, and good access and use of educational opportunities also contribute to fragmentation.

Today, we see a strongly truncated and fragmented landscape in response to these forces, with a fragmented pastoral-wildlife savanna bounded on the north and east by towns and the city, and rapid demarcation of private

plots through fence building by pastoral people themselves and by subsistence farmers, commercial (flower) farmers, city dwellers, non-governmental organizations (NGOs), the export processing businesses, and others (Figure 9-2). These changes affect the amount and spatial arrangement of rangeland open for wildlife and livestock grazing. Pastoral families sometimes fence their land to keep wildlife away from their homesteads, forage, and water (Mwangi and Warinda 1999). In 1999, nearly all the families in the first triangle had a small fence around their homes, 83% around their small cultivated plots next to their homes, but only 16% around any of their grazing land.

5. EFFECTS OF LOSS AND FRAGMENTATION ON WILDLIFE MOVEMENTS AND POPULATIONS

Historically, wildlife (wildebeest, zebra, and probably others) as well as pastoral people and their livestock accessed water and forage in the dry seasons and droughts at higher elevations near the footslopes of Mt. Kenya and in the Ngong hills (Figure 9-1). They then likely migrated back into the drier rangelands in the wet season to reach high quality forage (Gichohi 1996) and salt licks. Since the 1940s, loss of corridors restricted this migration to a somewhat circular pattern for the wildebeest between Nairobi National Park and their calving grounds in the drier 'second triangle' (see Figure 9-1) to the south. Zebra move widely, spending the wet season in particular areas in each of the three triangles, while other species like eland can move as far south as Amboseli (Hillman and Hillman 1977). Pastoral people and livestock cannot access the park legally, but often do so at night. Herders also have sole daytime access to pastures crowded with people (although wildlife may graze in these areas at night). During the 1999-2000 drought, like other recent droughts, it was common to see Maasai herders grazing cattle on the verges of highways and roads deep in the city of Nairobi.

In the rest of this section, we look at more recent trends in wildlife and livestock populations based on ground counts in Nairobi National Park from 1961-2004, and aerial survey data from the rest of the Athi-Kaputiei Plains from 1977-2002. In Nairobi National Park, counting teams completed total ground counts of wildlife from vehicles in 15 blocks, from 1961-1979, resuming again in 1990 to 2004, about six times a year (Gichohi 1996). In the three triangles in the Athi-Kaputiei Plains, the Department of Resource

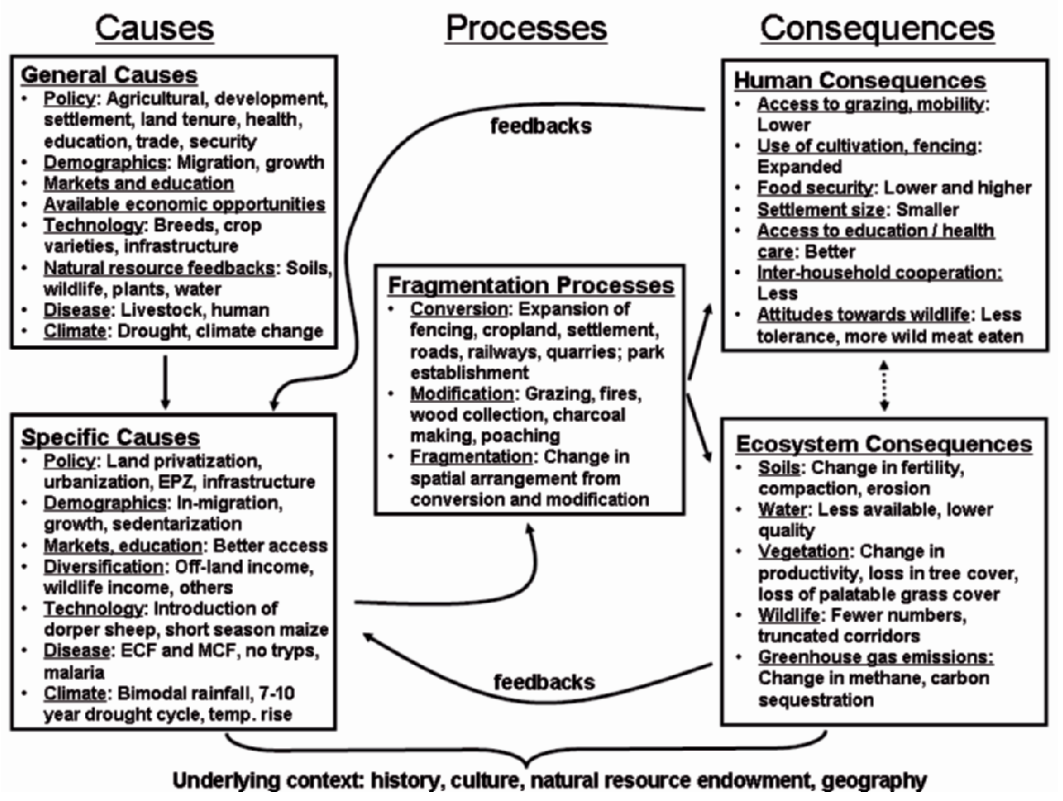

Figure 9-3. Conceptual model of the causes and consequences of fragmentation in the Athi-Kaputiei ecosystem. Arrows indicate directional connections between boxes. ECF = East Coast Fever, MCF = Malignant Catarrhal Fever, EPZ = Export Processing Zone, tryps = trypanosomosis.

Surveys and Remote Sensing counts used systematic reconnaissance flights from the air. Wet season counts were generally conducted between April and June and dry season counts between October and March (Gichohi 1996). In this study we used the wet season aerial counts to analyze animal trends for the Athi-Kaputiei. The trend analysis was based on the 5 x 5 km transects and covered the period 1977-2002. We used a polynomial regression of the log-transformed animal counts for each year and accounted for temporal autocorrelation in the counts using continuous-time generalizations of the first order autoregressive model. Model selection based on the corrected Akaike information criterion was then used to select the appropriate model from a set of candidates comprising linear, quadratic, and cubic polynomial trend models.

These counts show that from 1977-2002, wildlife populations fell precipitously by 72%, or an average of 5% per year, in the three triangles outside Nairobi National Park (Figure 9-4), nearly identical to the rate of loss of resident wildlife in the Mara ecosystem over a similar time period (Ottichilo et al. 2000). More than 90% of the eland, giraffe, and wildebeest disappeared over this 25-year period, twice the average wildlife loss. Impala and Thomson's gazelle declined by 78% overall, while Grant's gazelle populations halved. Much of these changes are probably due to mortality of animals, but some could be due to movement of animals out of the ecosystem.

The total density of migratory wildlife species (wildebeest, eland, and zebra) declined faster than the non-migrants (Grant's gazelle, Thomson's gazelle, kongoni, impala, giraffe, and ostrich, 76% vs. 63% loss). Only zebra numbers showed no overall change, with a humped distribution. Even browsers and mixed feeders (giraffe, eland, impala, gazelles), species likely to compete only with goats for forage, declined strongly. Wildlife populations declined dramatically during the droughts of 1960/1 (Foster and Coe 1968, Hillman and Hillman 1977), 1973/4, 1983/4, 1994 and 1999/2000. Loss during drought may indicate livestock or wildlife deaths, but also indicates movements of animals outside the system, which are usually temporary (Hillman and Hillman 1977, Nkedianye 2003).

With declining wildlife populations, one might expect livestock populations to rise in this pastoral part of the ecosystem, as more forage and water become available, and wildlife-livestock disease transmission presumably might decrease in some parts. Remarkably, sheep and goat populations dropped by 63% in the last 25 years, at the same rate as the small-bodied wildlife. Donkeys nearly disappeared altogether. Our key informants suggest that recent losses in sheep and goats are caused by the increased susceptibility of improved dorper sheep (introduced during the last decade or so) to diseases like blue tongue, which was widespread after a prolonged period

of drought followed by unusually high rainfall. Cattle populations were stable except for heavy declines during the more recent droughts, between the periods 1994-96 and 1998-2000. Families in the first triangle of Kitengela lost, on average, 54% of their cattle herds during the most recent (2000) drought (Nkedianye 2003). The total biomass of wildlife and livestock together was almost halved in the pastoral part of the Athi-Kaputiei system in the last 25 years (Figure 9-4). It is possible that free-ranging wildlife and livestock decline for some of the same reasons, as the savanna fragments.

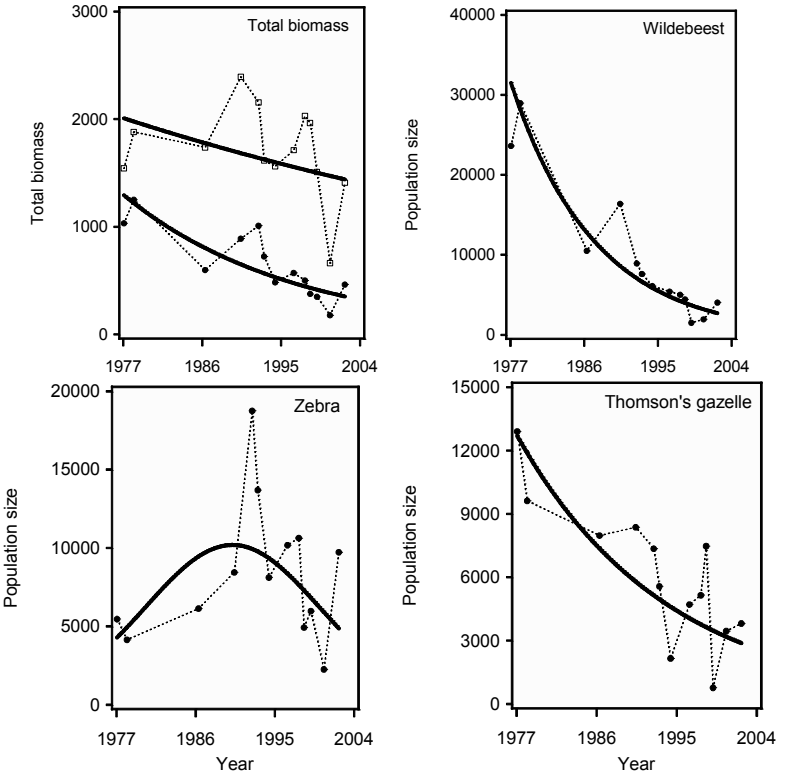

Figure 9-4. Wet season trajectories and trends of wildlife and livestock biomass (kg/km^2) and selected wildlife species numbers from 1977-2002 in the three triangles of pastoral lands of the Athi-Kaputiei Plains south of the park. Total biomass shows wildlife biomass (lower line) and livestock biomass (upper line). Dotted lines with markers show actual data, solid lines show trends.

We expected fewer losses of wildlife inside Nairobi National Park than in the three triangles outside the park, because of differences in land use. Our data support this. Before the national ban on wildlife hunting in 1977, wildlife in the park was in decline. Since 1977, while total wildlife biomass dropped strongly outside the park, there was no perceptible change, over the same period, inside the park, with some indication of a slight increase in total biomass (1977-2002, Figure 9-5). Wildebeest in the park increased during the late 1980s and then declined strongly in the late 1990s. Populations of zebra, also a migrant, grew strongly from 1977 to 2002 in the park, as did rhino. Thomson's gazelles changed little in the park, like buffalo and eland. Note that buffalo were introduced into the park in 1966. Kongoni increased to a peak of 3,323 by 1973 then declined to only 179 following the 1974 drought and have since stabilized around 380 individuals. Giraffe and ostrich consistently declined between 1990 and 2004. These trends suggest that there were only weak links between wildlife inside and outside the park in the period 1977-2002, except for wildebeest. Wildebeest, eland, and zebra populations in the park fluctuate strongly between the wet and dry seasons, suggesting significant movement of wildlife inside and outside the park (Hillman and Hillman 1977, Gichohi 2000), a phenomenon often observed by local people. Other species of wildlife varied less strongly between seasons during the 1961 to 2004 period, implying that some animals do stay relatively permanently within the park boundaries.

In the Machakos commercial ranches to the southeast of the Athi-Kaputiei, there was no decline in overall numbers of large mammals between 1991-2000 (Parker 2003). Fencing here prevents most movement between these ranches and the surrounding farming land to the east and the pastoral land to the west. Despite the stable populations, ranchers commonly find poaching snares on their properties on these ranches.

5.1 Causes of wildlife decline

Why are wildlife in decline in some places and not others? We cannot definitively establish the causes, but we can suggest likely candidates and their relative importance. Poaching of wildlife by people is probably the primary cause, with strong secondary causes. We assume poaching rates are rising in the Athi-Kaputiei Plains, caused by a rapid influx of outsiders who historically hunt, sell, and/or consume wild meat (Barnett 2000), but we know of no data that shows how fast poaching is growing. However, today, 61% of pastoral families in the Kitengela triangle currently consume some wild meat, especially when food is scarce, shifting away from their traditional prohibition on consuming non-domestic meat (Nkedianye 2003).

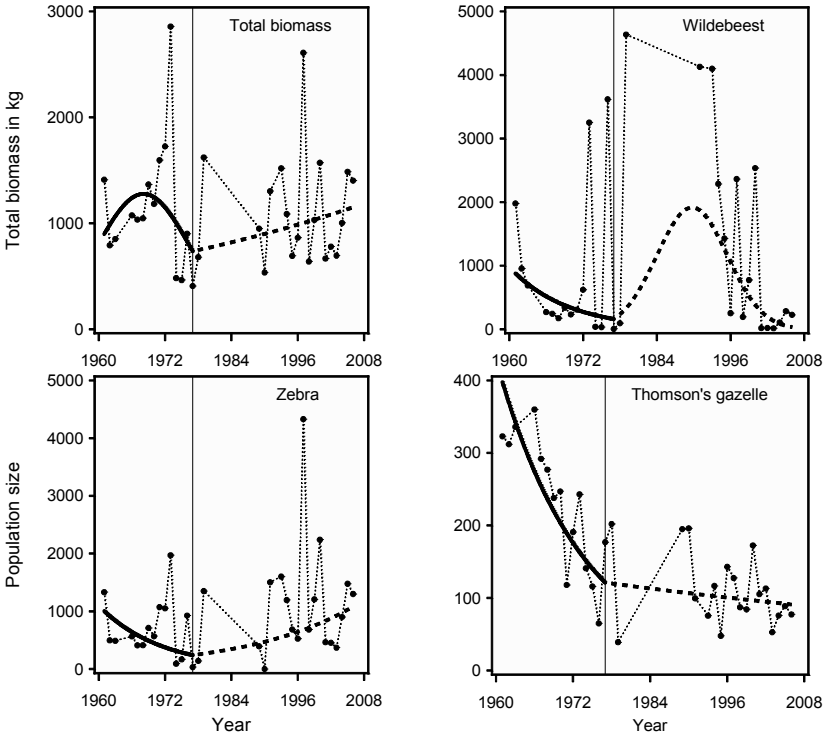

Figure 9-5. Trajectories and trends in numbers and biomass of selected wildlife species from 1961-2004 in Nairobi National Park based on averages of monthly counts conducted within each year. Dotted lines with markers show actual data. Solid lines without markers show trends before 1977, while dotted lines without markers show trends during 1977-2004 to facilitate comparison with the data from the pastoral lands in Figure 9-4. Trend lines were calculated separately for these two time periods.

Maasai respondents in the first Kitengela triangle say that people prefer the taste of eland and wildebeest meat and find that zebra is unpalatable and hard to catch, preferences that match the decline in numbers by species. However, non-Maasai poachers sell meat by weight and will kill almost any type of grazer. There are few controls on poaching because anti-poaching efforts are weak across Kenya (Barnett 2000). We speculate that increasing poverty also leads pastoral and non-pastoral people to eat more wild meat. On the other hand, increased education and diversification of incomes seems to reduce dependence on wild meat among pastoral families in this system (Nkedianye pers. obs.) Consumption of wild meat by Kamba farmers/hunters in Kitui District to the east of the study area was 67 grams/person/day or 14 kg/month/family in the late 1990s (Barnett 2000). Poachers cut fencing to make snares and burn pastures to create patches of green grass that

attract wildlife and then ring these areas with snares (Parker 2003). Local organizations find large numbers of snares along the southern, and unfenced, edge of the park, so animals passing from the park to the pastoral land are at risk of injury or death. Ranchers in Machakos fence most of their properties, which presumably reduces the rates of poaching inside these large fenced properties.

As in southern Africa, loss and fragmentation of habitat (forage, water) by fencing and some cultivation is probably also a major cause of the decline in migratory wildlife (Whyte and Joubert 1988, Spinage 1992, Perkins 1996, Boone and Hobbs 2004) and likely elsewhere. The incidence of poaching may be related to land use and fragmentation because poachers often corner wildlife by driving them from open rangelands into fencelines to trap and kill them (Nkedianye pers. obs.). On the other hand, well-fenced land may deter poaching inside the fence, as is probably the case in the Machakos ranches. But it is unlikely that fencing is the sole cause of wildlife loss in the Athi-Kaputiei because the loss in wildlife (72%) is far higher than the proportion of land fenced (14%) from 1977 to 2004 (assuming no fences in 1977, although the relationship may not be linear). Even though the amount of fenced land is relatively low, there were a total of 6,741 parcels with fencing. Many scattered fences probably disrupt wildlife behavior and movement, even if their areal coverage is still low. In Kitengela, the fenced parcels are spread throughout the range of wildlife, suggesting that wildlife are almost always in visible distance of people, wet season or dry, whenever they are outside the park.

Fences may differentially enclose wildlife habitat of high value (good grazing lands, water points). Changes in the distribution of wildlife across the ecosystem show that few wildlife still use areas around roads and towns, where fencing and human population growth are highest (Figure 9-3). Furthermore, fences may cause a disproportionate loss in wildlife if there is a threshold of habitat area needed to sustain healthy populations (caused, for example, by fencing key resources first). Gardner et al. (1987) and Stauffer (1985) predicted that the ease of movement of animals through a connected landscape is rapidly lost when 30-50% of the landscape is converted to uses incompatible with animal movement.

Fences may also reduce the number of animals particular parts of the landscape can support (Boone and Hobbs 2004, Boone et al. 2005). Using a model of the Amboseli ecosystem, just 70 km south of the Athi-Kaputiei (BurnSilver et al., Chapter 10), they found that the diversity of types of patches that wildlife and livestock can access declines as their access to the landscape becomes restricted to smaller and smaller areas. For example, the amount of variation in green forage (measured by greenness) accessible to a herd of

livestock declines by 12% when the parcel they can access halves from 20 to 10 km^2, similar to their findings for cattle in northwest South Africa.

But fencing may represent more than mere fragmentation; if herders, farmers, and townspeople exclude wildlife entirely from fenced areas, there is less wildlife habitat altogether. This is sometimes the case in the Athi-Kaputiei, particularly around settlements. So far, expansion of subsistence cultivation is limited, and thus probably has limited impact on wildlife, similar to Ngorongoro to date (Boone et al. 2002, McCabe 2003). Currently, expansion of commercial cultivation (in this case flower farms) seems to be more of a threat to wildlife, as it is elsewhere (e.g., Homewood et al. 2001, Serneels and Lambin 2001).

Recurrent droughts can cause up to a 50% loss in wildlife populations, as happened between 1958-1962 because of the 1961 drought (Stewart and Zaphiro 1963). From Figures 9-4 and 9-5, it appears that the 1999-2000 drought had more effect on animal populations than any other drought since the early 1960s. Some of this loss is through starvation, but animals also move out of the ecosystem in the hardest times. Drought is probably a less important cause of long-term wildlife loss, unless droughts are becoming more frequent or more severe because of climate change. Or, other changes, like fragmentation, may make wildlife (and livestock) populations more vulnerable to drought or make recovery after drought more difficult (e.g., Holling and Meffe 1996). In southern Africa, a quarter to half of selected mammal species are predicted to go extinct by 2050 because of climate change (Thomas et al. 2003), principally because of decreased rainfall. Predictions of climate change near the equator are uncertain, with a good possibility of increased rather than decreased rainfall (as measured by length of growing period) in 50 years (Jones and Thornton 2003). But temperatures are also increasing (Altmann et al. 2002, Hemp 2005), which will likely negate the impact of increased rainfall by increasing evapotranspiration.

Pastoral Maasai in the Kitengela often observe that wildlife cluster just outside the park on the short, 'grazing lawns' created by livestock grazing and avoid the coarse, tall grasses in the park to access better food and avoid predators (Nkedianye, Reid, pers. obs.). Park management burned and mowed park grasslands to attract wildlife into the park from the late 1950s to 1963 and from 1968 to the mid-1970s, but from then until the late 1990s, no burning was done (Gichohi 1990). The Kenya Wildlife Service recently resumed burning, and wildlife are clearly more abundant on burnt, short grass than in unburnt, tall grass. However, significant numbers of wildlife still cluster outside the park in the areas grazed by livestock (Nkedianye, Reid, pers. obs.).

6. EFFECTS OF LOSS AND FRAGMENTATION ON LIVESTOCK POPULATIONS AND MOVEMENTS

At the time of sub-division of the Kaputiei group ranches in 1986/7, there were few fences on the communally owned land (Nkedianye, pers. obs.). Livestock moved freely among the three triangles, from Empakasi (northeast) to Oloosirkon (northwest) to Enkirgirri (southeast), depending on where the pastures were better, similar to wildlife. By 2004, herding cattle on foot from Isinya to Oloosirkon took at least twice as long as it did in the late 1980s (Nkedianye, pers. obs.). Landowners have fenced pastures, salt licks, and water, making it difficult for the majority of the pastoral residents and their livestock, as well as wildlife, to access these resources, thus magnifying the effect of fencing beyond the area the fences enclose.

To better understand the effects of fencing on livestock movements, we contrasted the movements of herds of cattle in open rangeland with little fencing and congested ('closed') rangeland with abundant fencing. We collected data at a temporal scale of one minute to capture feeding behavior at three scales: the feeding station, micro-patch, and plant community scales (Senft et al. 1987). Future work will capture regional-scale herd movements over time through interviews. Herders carried a GPS unit which logged the position of the herd they were following every minute automatically throughout the day; in addition, every ten minutes the herders recorded the distance to the nearest fence from the cattle herd. Observations were made 15 times between March 2003 and April 2004.

Fencing strongly changed the speed, pattern, and area grazed by cattle at fine scales. In the open rangeland, cattle grazed, on average, 200 m from the nearest fence; in the congested rangeland, this fell to 50 m. The total area grazed was significantly smaller for the herd in the area with many fences than in the open area. Although the sizes of the herds were relatively similar in the two areas (45-54 animals), the grazing orbits for the herd in the congested rangeland were more convoluted than in the open rangeland, where fencing did not hinder cattle choices of where to feed (Figure 9-6).

Cattle moved more slowly in the landscape with few fences. On average, the herd in the "open", less fenced area, walked 35% more slowly than the other herd in the "closed" area ($\overline{U}_{open}$ = 0.227 m/s vs. $\overline{U}_{close}$ = 0.308 m/s; $p < 0.001$). Cattle in the unfenced landscape walked quickly from place to place and then lingered to feed and rest throughout the day (Figure 9-7). Cattle in the fenced areas did stop to feed and rest but were more constantly on

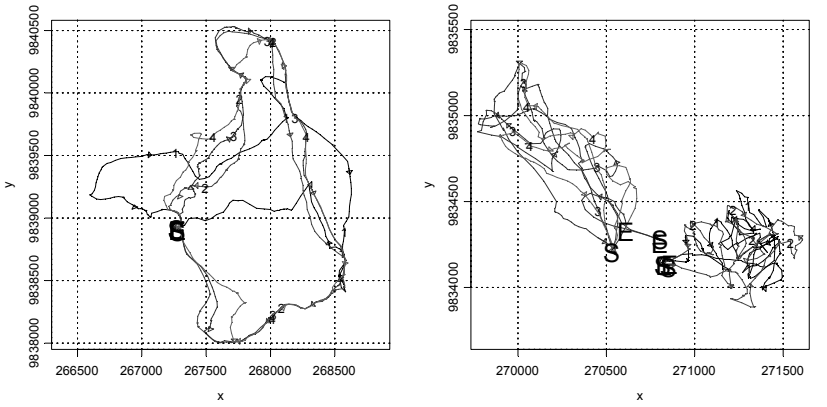

Figure 9-6. Four daily grazing orbits in April 2003 in a relatively enclosed area with a herd size of 54 (right) and in an open area with a herd size of 45 (left). The letter "S" and "E" designate the start and end of the track respectively. In both maps, each grid square represents 500 meters in length and the axes are in UTM coordinates.

the move from place to place than the unfenced herds. It is possible that food quality and quantity are different in the two areas, but we did not measure this.

We hypothesize that fences affect livestock foraging by limiting the number and diversity of plant patches and communities that livestock have access to at moderate scales (e.g., Senft et al. 1987). This will be particularly true where good quality plant patches are clustered in certain locations on the landscape. At a finer scale, fencing likely has little effect on the choice livestock make about which plant part to eat, because these choices are made once the animal chooses to stop at a feeding location which should be independent of the presence or absence of fencing. Fences may also affect the quantity and quality of food available at each feeding station if the intensity of grazing is different in fenced compared to unfenced areas, which we think is likely. This may explain the greater velocity of the cattle herd in our fenced landscape. Fencing will also increase travel costs for short or long-distance movements because travel paths will need to be more convoluted to avoid fences. Indeed, there is some evidence that higher walking speed can incur higher energy expenditures, which, in turn can affect milk yields (Homewood and Rodgers 1991, Figure 9-7).

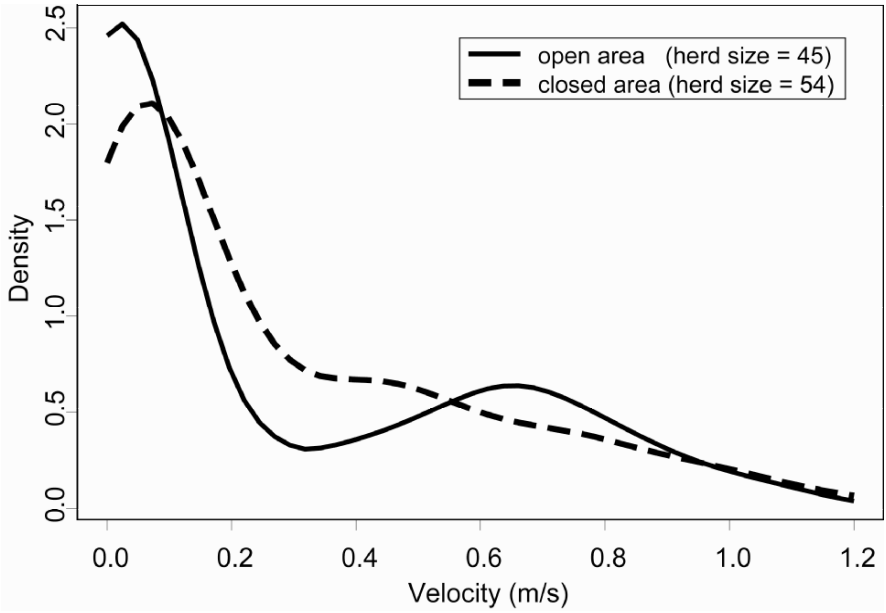

Figure 9-7. Herd velocity (m/s) profile (probability density function) based on four grazing orbits for two herds in a relatively open and closed area.

7. LIKELY EFFECTS OF LAND SUB-DIVISION ON PASTORAL LIVELIHOODS

We did not design data collection to assess the consequences of fragmentation through land sub-division on pastoral livelihoods. However, several recent surveys, in and near the Athi-Kaputiei ecosystem, allow us to briefly summarize some of these impacts as well as the linked processes of sedentarization and diversification of livelihoods (BurnSilver et al., Chapter 10).

Land privatization and sub-division initiates a suite of processes in the pastoral communities of Kajiado. The number of families that share the same homestead declines after sub-division as families move to their own piece of land (Njoka 1979). This and other changes mean that family members have less leisure time (Rutten 1992). Kaputiei Maasai, only a few years after sub-division, said that cooperation among herders was about the same, but they made fewer cooperative decisions on where cattle should graze, because the land was privately owned (Rutten 1992). Herd movement can become more

difficult as people settle, as we saw above, but this was not the case for a sample of sedentary households in northern Kenya, because herds moved but households did not (McPeak and Little 2005). During the drought of 2000, herders started moving in search of pastures a bit earlier in the Athi-Kaputiei Plains than in previous droughts partly due to the loss of grazing lands as a result of land sales and fencing (Nkedianye 2003). Marcel Rutten (1992) calculated that only 10% of all households in Kaputiei would have enough grass to support their livestock on their own plots following sub-division in 1986. Thornton and colleagues (2006), using a linked savanna ecosystem-pastoral household model (SAVANNA-PHEWS) found that sub-division into smaller parcels can have significant consequences for long-term food security in southern Kajiado. If households only have access to their own parcels, even if those parcels are relatively large, the former group ranch supports fewer households at the same level of well-being after sub-division than before sub-division. In addition, there are some particular disadvantages to having a homestead fixed in some locations; for example, Maasai with plot allocations in the wildebeest calving area in the second triangle have to move their cattle for three months each year from their plots to avoid contracting malignant catarrhal fever between March and May (Nkedianye 2003, Bedelian et al. 2007).

Once land is privately held, herders can sell land for the first time and they often do. Particularly important to fragmentation, Maasai often sell land to non-Maasai who come from nearby farming cultures. For example, Maasai land owners had sold 30% of their plots in Kisaju Group Ranch, mostly to non-Maasai, only six years after privatization (Rutten 1992). While the sales bring in much-needed cash, these cash gains can be short-lived, followed by decreases in income from the remaining, smaller parcels. In the Kitengela triangle, sales will continue in the future because a third of the landowners plan to sell an average of 22 acres of land in the next three years (Nkedianye 2003). However, Nkedianye (2003:52) notes that there is widespread "disillusionment among the landowners as a result of the poor performance of those who rushed to sell land, most of whom ended up poorer".

Nearly all residents now fence their homesteads and adjacent gardens, but most leave their grazing lands open (Mwangi and Warinda 1999). However, new landowners with a farming tradition put up more fences than the Maasai families who were given plots when the group ranch was sub-divided (Kimani and Pickard 1998, Nkedianye 2003). Three-quarters of all farmers involved in cultivation in Kajiado District were non-Maasai only a few years after sub-division (Rutten 1992). Non-Maasai have more need to fence than Maasai because non-Maasai have smaller plots, they cultivate most of their land and thus must protect crops from wildlife, and they are also more familiar with fencing (Kimani and Pickard 1998). By so doing,

they deny herders and wildlife access to water, pastures, salt licks, and routes that they have used over the years (Nkedianye 2003). Interestingly, rules restricting grazing access on private lands that are not fenced have not yet arisen in Kitengela.

But land sub-division does have its advantages. From a Maasai perspective, the biggest advantages are security of land ownership, easier access to credit, access to land ownership by younger Maasai who were too young to acquire land when group ranches were formed, and ending their frustration with group ranch management (Grandin 1986, Pasha 1986). However, the Kenyan government initially did not support sub-division because it was concerned about the ecological and economic viability of individual parcels (Bekure et al. 1991). In addition, sometimes the poor fare better once they are allocated their share of land and the associated resources (Nkedianye, pers. obs.). Kristjanson et al. (2002) found that younger, more educated households with diverse income sources who were more market-oriented typically had overall incomes that were significantly higher than more traditional, older and less educated households. During droughts, the wealthy may pay to access the pastures of the poor who have fewer livestock, a common practice today in Kima, Arroi, and Nkama areas of Mashuuru division of Kajiado district (Nkedianye, pers. obs.). However, Kimani and Pickard (1998) suggest that both pastoral viability, tenure security, and ecological integrity will be met better by maintaining group ranches rather than privatizing land. All the same, privatization is already with us, so the key question is how to soften the disadvantages of this process and magnify the advantages. Although we know something about the more immediate advantages and disadvantages of sub-division over the short term, we have little idea of the wider and longer-term consequences. Most Maasai feel that they had to sub-divide to gain secure tenure of their land and water; they are acutely aware that sub-division will be injurious to their long-term interests and well-being (Nkedianye, pers. obs.).

Land privatization or sub-division usually results in increased sedentarization and is often linked to livelihood diversification and/or intensification, although it is not a necessary pre-condition for either process. In the Kitengela survey, households that had smaller land holdings earned more income per acre from farming and livestock than the more traditional pastoral households, suggesting a move towards more intensive crop and livestock production with shrinking landholdings for some households (Kristjanson et al. 2002). But, when wildlife incomes are available, sedentarization may be incompatible with maintenance of wildlife populations, and thus sedentarization and fencing removes this potential source of income for pastoral families.

Although sedentarization implies a loss in herd mobility, it is not always so. In northern Kenya, McPeak and Little (2005) found that pastoral

households use paired sedentary homesites and satellite livestock camps to gain the advantages of sedentary life around towns, like access to wage employment, education, and health care, while maintaining herds that can access water and pasture far from town and can move in response to a variable environment. Sedentarization also can provide income-earning opportunities for poorer women (Little et al. 2001, Nduma et al. 2001).

Diversification is widely seen as a response to declining livestock holdings per household (Little et al. 2001). Sedentary households tend to diversify the ways that they earn their incomes beyond pastoralism (McPeak and Little 2005). Pastoral households often use crop agriculture to support pastoralism, by reducing the need for the family to sell livestock to buy grains during dry periods. Crop growing is particularly important after droughts to provide a food source if herds are decimated in northern Kenya (Little 1985, 1992), but is only advantageous when cropping occurs in wetter areas where returns to cropping are reliable (Little et al. 2001). Similarly, in Kajiado, PHEWS model results suggest that rainfed cropping has an adverse impact on household food security because farming is so risky in this region (Thornton et al. 2006) and (even small) crop input costs are incurred in years when yields are very low or zero. These findings are supported by survey data from Kitengela showing negative net crop incomes even in good rainfall years (Kristjanson et al. 2002). The range of off-land income-earning activities was very large in Kitengela, with 31% of households obtaining over 30% of their total income from income-earning activities other than crops and livestock, 34% saying that off-land income made up 10-30% of their total household income, while 34% of households had no off-land income. In Kitengela and northern Kenya, more educated households were more diversified (Kristjanson et al. 2002, McPeak and Little 2005). PHEWS model results also suggest that more diversified households are better off in southern Kajiado (Thornton et al. 2006), particularly poor households with few livestock. This was not always the case in northern Kenya; richer households often benefited from diversification, but poor households often did not (Little et al. 2001).

8. THE KITENGELA LEASE PROGRAM: UN-DOING SOME OF THE NEGATIVE ASPECTS OF SUB-DIVISION

As we have seen, one disadvantage of sub-division is the fragmentation of land, loss of wildlife habitat, and restriction of the movement of both domestic and wild animals. Initiated in April 2000, the Wildlife Conservation Lease Program was created to ensure that wildlife in the Athi-Kaputiei

Plains could move freely to their traditional habitats. The program requires participants to allow free movement of wildlife on their land, refrain from poaching themselves, report poaching by others, protect natural vegetation, and avoid fencing or sub-dividing their land. In return, they receive Ksh 300/acre/year (US $4.25 in late 2006). The program started by leasing 214 acres from two participants in 2000 and grew to leasing 8,600 acres from 118 families in the first triangle of Athi-Kaputiei Plains by late 2004. In late 2004, the project disbursed approximately Ksh 3,000,000/year. The installments of Ksh 1,000,000 per school term to the 118 families ensured many local parents found school fees for their children, particularly those in secondary school. Participants in the leasing program have more positive attitudes towards wildlife, are more willing to share water and pastures with wildlife, and strongly support keeping the range open without fencing (Table 9-1).

Table 9-1. Attitudes of pastoral households who do and do not participate in the conservation leasing program about wildlife and conservation, measured by percentage of respondents who strongly agree with statements posed by the interview team (extracted from Nkedianye 2003:106-107). NNP = Nairobi National Park. N = 104 respondents, 52 participants and 52 non-participants.

Statement	% of non-participants who strongly agree	% of participants who strongly agree
Wildlife is important to you	24	62
Wildlife conservation is important to society and future generations	33	56
Area be left open for livestock and wildlife with benefits	42	59
Area be left open for livestock and wildlife without benefits	10	10
All landowners to fence their land to keep away wildlife	28	6
Livestock and wildlife to share basic resources (water and pasture)	12	38
Development of tourist related activities be encouraged	51	67
Government to plough back revenue from NNP to the area	71	77
Government policy re: human-wildlife conflict resolution fair	4	6
Government policy re: wildlife revenue sharing with communities fair	4	0
Lease Program an adequate method for saving wildlife	20	50
Fenced Nairobi National Park would be more beneficial	17	6

Many participants say that the lease program allows them to choose not to sell land because the strongest motivation for the sale of land among most Kitengela households is the need for school fees (Nkedianye 2003). In a bad rainfall year (when the long rains fail), lease program payments double the income of the poorest households (Kristjanson et al. 2002). There is some indication that lease payments are allowing parents to afford to send more girls to school (Nkedianye, pers. obs.).

9. IMPLICATIONS: ALTERNATIVE FUTURES FOR PASTORALISM AND WILDLIFE IN ATHI-KAPUTIEI ECOSYSTEM?

It is clear that the lease program is a success in the eyes of the participants, but is this effort too limited currently to allow continued pastoral and wildlife use of the Athi-Kaputiei ecosystem? Urbanization of the Athi-Kaputiei is so rapid that the lease program will need to be expanded significantly, which is the focus of current efforts. Land prices are rising in desirable areas next to the all weather road, near the national park, and in areas contiguous to shopping centers, reducing incentives for landowners to participate in the lease program in these areas. Such a program also requires strong collective action and community support since a few individuals can spoil the efforts of many (e.g., by putting up fences along key migration routes). New strategies of land purchase, permanent conservation easements, tax incentives, implementation of land zoning, and others will be needed if the massive wildlife losses in this area are to be reversed. There also has been no study, to our knowledge, that looks at the effects of sedentarization, intensification, and diversification on the attitudes of pastoral/agro-pastoral families towards wildlife, nor on their incentives to participate in different conservation initiatives.

Also critical is a strong government policy on land use and enforcement of current anti-poaching regulations. Significant progress in policy has been made in the last 50 years, so that wildlife conservation is not just focused on protected areas, and communities have started to receive some returns from conservation (Hulme and Murphree 2001). However, it is still the case that government policy tends to favor farmers, since administrators come predominately from agricultural backgrounds (Horowitz and Little 1987). There is also a strong assumption that food security is only gained through production of crops, rather than livestock products. There is deep irony in this prejudice. In late 2004, tourism was the biggest foreign exchange earner for Kenya, with 42 billion Kenya shillings (US $560 million) in earnings

from 1.4 million visitors, supporting thousands of livelihoods throughout the country (Mugambi 2005). The existence of the wildlife-related returns rests almost entirely on the long history of compatibility between wildlife and pastoral land use in savanna regions of the country; the future viability of these returns also depends, in part, on the continuing good will of these same pastoral communities towards wildlife. It is ironic that government policy does not support pastoralism: pastoral families are responsible for maintaining the livelihoods of many people outside pastoral lands through conserving the wildlife that forms the base of employment in the tourism sector. Development and implementation of strong land-use policies that consider pastoral livelihood needs and wildlife conservation on equal ground with other development needs, will allow these communities to meet these responsibilities. This policy would ensure, for example, that sub-division below a certain acreage is illegal (and enforced). Just as important is effective education, an appropriate legal framework, and enforcement of anti-poaching by a wide range of actors. Political and financial support of pastoralism from individuals and businesses supported by the tourism will help also.

10. EPILOGUE: AND WHAT OF THE ROLE OF RESEARCH?

This research just begins the collection of information needed to allow actors to fully assess the societal trade-offs of different futures for the Athi-Kaputiei. Such research is interesting, but not particularly useful, unless it gets beyond academia into the hands of actors (communities, policymakers). In cases like this, researchers can strengthen management of natural resources by communities and improve policies affecting the sustainability of pastoral livelihoods and their ecosystems by listening to policy makers and community members and designing research to address their pressing questions (e.g., Tomich et al. 2004). Our research group is attempting to do exactly this in the Athi-Kaputiei Plains. The research group consists of a united researcher – community facilitator team that attempts to knit the needs of communities and policymakers throughout the research process and strengthen researcher-community-policymaker networks. One key to this approach is identification of the salient, policy-relevant issues for research with local community members and leaders and also with national-level research and management institutions (e.g., Cash et al. 2003). The team attempts to strengthen the legitimacy of the research for different stakeholder groups by including and addressing the concerns of a wide range of actors (individuals, institutions) that focus on agricultural development, land-use planning, water

resources, and wildlife conservation. Another effective strategy is for the core research – communication team to act as a convener and catalyst for other national and international researchers working in the same ecosystems to communicate with communities and policymakers. Specific activities to strengthen these links include community involvement in all data collection, interpretation and feedback with the wider local communities, meetings with policymakers to revise policy acts on wildlife and pastoral development, grants to national and international students to report their PhD results back to communities and discuss policy and management options, and meetings for researcher – policymakers to discuss salient issues. The goal of this engagement is to help stakeholders to better evaluate the trade-offs of alternative ways of using the Athi-Kaputiei Plains landscape, so that they can create more viable and vibrant futures for themselves, their communities, and wildlife.

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ENDNOTES

[1] These plains are marked on maps as the Athi Kapiti Plains. Kapiti is a shortened spelling of the name of the sectional tribe of Maasai, the Kaputiei, after which the plains are named. We choose to use the latter spelling here.

[2] Calculations made by R. Reid based on Meinertzhagen (1957), Gichohi (1996).

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