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Seasonal Home Range Sizes, Transboundary Movements and Conservation of Elephants in Northern Tanzania

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SEASONAL HOME RANGE SIZES, TRANSBOUNDARY MOVEMENTS AND CONSERVATION OF ELEPHANTS IN NORTHERN TANZANIA

A Dissertation Presented

by

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DEDICATION

To the local people who share their land with elephants in northern Tanzania and southern Kenya.

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31 game scouts of Hifadhi Network at West Kilimanjaro. I am proud of you; keep protecting your elephants in your land. "*Twiwona Kwihala, kama Yimagava Yisaka twiwone*"

ABSTRACT

SEASONAL HOME RANGE SIZES, TRANSBOUNDARY MOVEMENTS AND CONSERVATION OF ELEPHANTS IN NORTHERN TANZANIA

SEPTEMBER 2009

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Although the unprotected lands of northern Tanzania support large numbers of elephants, and provide critical linkages for wildlife movements across the region, there is little information on the dispersal patterns of elephants in these unprotected lands. Our home range measures (100% MCP) of 21 elephants with satellite collars in four study regions were highly variable (191 to 3,698 km2). Home range sizes (95% fixed kernel) of bulls were typically larger than those of females, and wet season ranges were typically larger than dry season ranges. There were large differences in average home range sizes reflected varying strategies for obtaining food and water and avoiding humans. All eight radio-collared elephants (3 bulls, 5 females) in the West Kilimanjaro study region crossed the Tanzania-Kenya border, but typically elephants crossed more frequently in the wet than the dry season, and bulls crossed 47% more frequently than females. These extensive transboundary movements indicate that the elephant populations of West Kilimanjaro and Amboseli NP constitute a single transboundary population. Based upon 14,287 fixes from eight collared elephants, the vast majority of time was spent in unprotected ($\bar{X}$ =91.5%) versus protected ($\bar{X}$ =8.5%) areas. Amboseli NP was visited by all eight elephants and was the protected area most utilized ($\bar{X}$ =8%, range 2-24%). Based upon the movements of 15 GPS-collared elephants in northern Tanzania, we identified eight areas that we considered important for wildlife conservation corridors/linkages for elephants. Our conservation priorities for these corridors were based upon the levels of threats and conservation potential. Community interviews and hilltop surveys were used in two Maasai villages to determine the extent of wildlife conflict, community attitudes towards elephants, and if elephants were using a vegetation corridor to move between Tanzania and southern Kenya. Elephants were the most problematic wildlife species and were considered a nuisance. However, they believed they attracted tourists, and generally did not believe elephant numbers should be reduced. Based upon elephant conflict and use and the communities' need to maintain areas for cattle grazing and medicinal plant collection, the two communities established the first wildlife conservation corridor in Tanzania.

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CHAPTER I

INTRODUCTION

Background

Unprotected lands in northern Tanzania provide important ecological links with protected areas in Tanzania and southern Kenya. Although these unprotected lands support large numbers of elephants and other wildlife, and provide critical linkages for wildlife movements across the region, there is little information on the abundance, distribution and dispersal patterns of elephants in these unprotected lands. Limited ground and aerial surveys indicate that as many as 600 elephants use the West Kilimanjaro (Wes Kili) region in the dry season (Kikoti 2003); however, there are no movement, distribution and wildlife survey data available for much of the region. In addition to their diverse natural and wildlife communities, West Kili, Lake Natron, Loliondo and Manyara regions also host diverse human populations. There are many traditional Maasai communities and extensive grazing lands across the region, and small and large agricultural fields, especially at lower elevations on Mt. Kilimanjaro. This complex mosaic of agricultural fields, grazing lands and human settlements interspersed with diverse natural communities poses significant challenges for elephant conservation in northern Tanzania.

Research Goals and Objectives

The goals of this study are to provide resource managers with information on the seasonal home ranges, transboundary movements and conservation needs of elephants in northern Tanzania. This study is the first to quantify the seasonal home range sizes and transboundary movements of elephants in the unprotected lands of northern Tanzania. It also provides new information on the locations of wildlife movement corridors that facilitate movements of elephants across the region and between unprotected and protected lands. In addition, I provide a case study important to elephant conservation describing the process of working with local communities, government authorities and other stakeholders for establishing the first wildlife conservation corridor in Tanzania. This case study is presented with the hope that it provides tools for establishing additional wildlife conservation corridors in Tanzania and other African elephant range states.

My specific objectives were to:

a) quantify the seasonal home range sizes of elephants within the unprotected lands of northern Tanzania;

b) determine the extent of transboundary movements of elephants between northern Tanzania and southern Kenya in the West Kilimanjaro region;

c) identify the locations and conservation needs of wildlife conservation corridors important to elephants in northern Tanzania;

d) describe the processes used to establish the first wildlife conservation corridor in Tanzania;

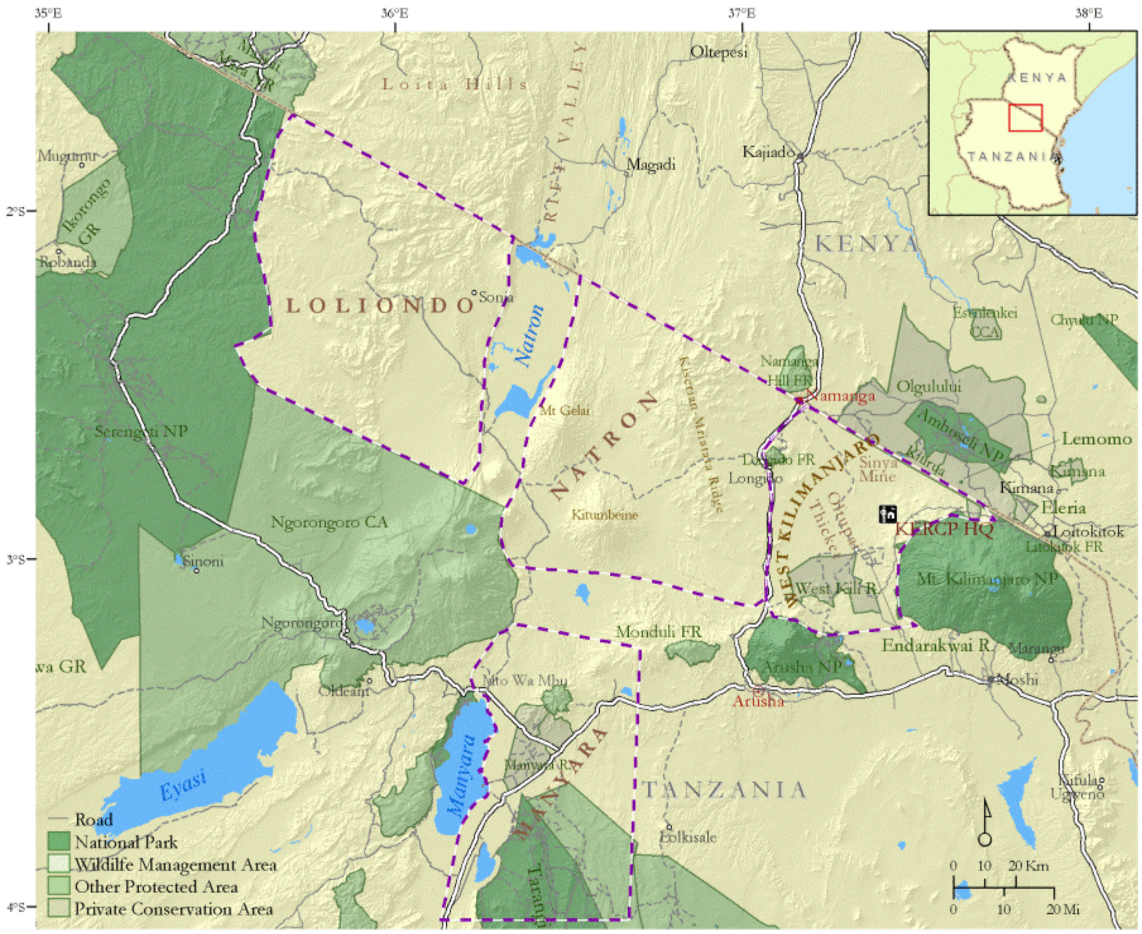
In addition to this introductory chapter, this dissertation is organized into four additional chapters based on several research objectives. Each chapter constitutes a separate publication for subsequent submission to an appropriate journal. Chapter 2 focuses mainly on the seasonal home range movements of elephants in four regions of northern Tanzania, including West Kilimanjaro, Lake Natron, Loliondo and Manyara. Chapter 3 provides details on the trans-boundary movements of elephants between West

Kilimanjaro in northern Tanzania and the Amboseli region of southern Kenya. Chapter 4 integrates all the movement data to identify conservation corridors that link protected and unprotected areas throughout northern Tanzania and to assess their status and conservation needs. Chapter 5 is a case study describing elephant use of a vegetation corridor between two Maasai communities, extent of wildlife conflicts, and the process for establishing Tanzania's first wildlife conservation corridor. Throughout these chapters, I have used the personal pronoun "we". I have done so primarily because each chapter is a self-contained manuscript, intended for publication in a refereed journal. Additionally, although I alone am responsible for its content, this dissertation represents the efforts of myself, my field assistants, my major advisor, and colleagues at the African Wildlife Foundation.

Literature Cited

Kikoti, A.P.(2003) . Elephant dispersion in West Kilimanjaro, Northern Tanzania. Presentation at Annual Scientific Conference, Arusha. December 2003. Tanzania Wildlife Research Institute, Arusha. Tanzania.

Figure 1.1. Study area: study regions, protected areas and key features in the northern Tanzania and southern Kenya.



CHAPTER II

HOME RANGE MOVEMENTS OF ELEPHANTS IN UNPROTECTED LANDS OF NORTHERN TANZANIA

Introduction

With recent estimates in excess of 140,000 elephants (MNRT 2008), Tanzania hosts one of the world's largest elephant populations. Despite the extensive network of protected areas, comprising nearly 15% of the country (Categories I-V; UNEP-WCMC 2008), much of the elephant range in Tanzania occurs outside of its protected areas. This large elephant population in combination with Tanzania's large and growing rural human population (26,487,000; National Bureau of Statistics Tanzania 2002) is causing elephant home ranges and dispersal areas to become increasingly fragmented and a rise in human-elephant conflicts increasing (Dublin et al. 1997, Hoare and du Toit 1999, Sitati et al. 2003). Further, human settlements and farms around protected areas in Tanzania increased their isolation and restricted traditional wildlife migration routes (Newmark 1996).

A wide variety of proximate factors influence the home range sizes and movements of elephants. In semi-arid and arid regions, seasonal variations in rainfall ultimately affect elephant movements in response to water and food availability (Leuthold 1977; Verlinden and Gavour 1998; Sukumar 2003; Osborn 2004; Cushman et al. 2005; Legget 2006). Yet, in more mesic environments, the fruiting chronology of certain trees may be the major factor affecting elephant movements (Whyte 2002). Additionally, human settlements (Hoare 1997; Douglas-Hamilton et al. 2005; Guldemond and van Aarde 2006), habitat heterogeneity (Hoare and Du Toit 1999, Grainger et al. 2005), and a variety of demographic characteristics (e.g. sex, age, reproductive status, social behavior) can influence elephant movements and home range sizes (Stokke at al. 2002). Further, conservation areas surrounded by fences or dense human settlements can restrict elephant movements and home range sizes (Douglas-Hamilton 1973; Lindeque and Lindeque, 1991; Hoare 1997; Roux 2006).

Prior to this study, three telemetry studies of elephant movements were conducted in Tanzania (Douglas-Hamilton 1972; Galanti et al. 2005; Hofer et al., 2004). The first two studies were primarily focused on elephants in relatively small conservation areas (Lake Manyara and Tarangire NPs, respectively) where elephants may not demonstrate their full movement potential (Calef 1992; Thouless 1995; Guldemond and van Aarde 2006). The third study (Hofer et al. 2004) centered on elephants using the Selous-Niassa Wildlife Corridor between the Selous Game Reserve in southern Tanzania and the Niassa Game Reserve in northern Mozambique. Still, much of the elephant range in Tanzania (63%) occurs outside of protected areas (Blanc et al. 2007) where rural human populations are growing rapidly and cultivation and grazing are reducing the remaining large, contiguous habitats into smaller, isolated remnants. Consequently, elephant home ranges and dispersal areas are increasingly fragmented and human-elephant conflicts increasing (Dublin et al. 1997; Hoare & du Toit, 1999; Sitati et al., 2003). Thus, the purpose of this study was to determine identify the home ranges and movements of elephants in the unprotected lands of northern Tanzania, providing resource managers tools for reducing human-elephant conflict.

Study Area

Although the study was conducted over a large area (~21,000 km^2) in northern Tanzania, our primary focus was on elephants in the unprotected lands between the four national parks of Kilimanjaro, Arusha, Serengeti, Tarangire, Lake Manyara, and the Ngorongoro Conservation Area (CA). We radio-collared elephants in four study regions (West Kilimanjaro, Natron, Loliondo, and Manyara) (Fig. 2.1). Overall, the study area is a complex landscape mosaic, including small- to moderate-sized human communities, extensive communal grazing lands, small- to large-scale agricultural lands, hunting concessions, and several types of conservation lands (national parks, conservation areas, game controlled areas, and wildlife management areas). In 2002, the human population in the study area was estimated at 214,190 (National Bureau of Statistics Tanzania 2002). Typically, there are two rainy seasons with the long rains from March to May and the short rains in November and December, but rainfall amounts vary much over the four study regions.

The West Kilimanjaro (West Kili) study region (3,067 km^2) is within the Longido, Arumeru, Ngorongoro, Monduli and Siha districts of Arusha and Kilimanjaro region of northern Tanzania. The northern extent of the region is the Tanzania-Kenya border from near the border town of Namanga southeastward to Irkaswa. The eastern border extends around the northern and western flanks of Mt. Kilimanjaro defined by the boundary of Kilimanjaro National Park (NP) extending southward to near the community of Sanya Juu. The southern extent of this study region extends west from Sanya Juu to the northeast corner of Arusha NP, continuing along the northern park border to the Arusha-Nairobi Road that also defines the western extent of the study region. The region is a complex mosaic of diverse natural communities, extensive grazing lands, and large agricultural fields at lower elevations on Mt. Kilimanjaro. There are traditional, agro-pastoral Maasai communities (n=12) that graze cattle and other livestock and raise subsistence crops. In addition, there are five other medium-sized agricultural communities in the region. There are several protected areas in the study region, including Kilimanjaro NP (1,665 km^2) on the eastern boundary, Arusha NP (137 km^2) to the south, and Amboseli NP (390 km^2) in southern Kenya, 20 km north of the Tanzania-Kenya border. Additionally, there are two private conservation areas, West Kilimanjaro Ranch (303 km^2) and Endarakwai Ranch (44 km^2), Longido Game Controlled Area (GCA)(1,700 km^2), and Ngasurai Open Area (200 km^2) that provide important habitats for wildlife. Although variable with elevation (1,230 to 1,600 m), the predominate ecological zone is semi-arid savannah (Pratt et al. 1966) interspersed with woodlands, and there are extensive agricultural fields along the lower, western flank of Mt. Kilimanjaro and lowland forests within the boundary of Kilimanjaro NP. Distribution of rainfall is unpredictable, especially at lower elevations, and highly variable from year to year. Rainfall amounts average 341 mm/yr in semi-arid lower elevations (Moss 2001) and 890 mm/yr in agricultural areas at lower elevations on Mt. Kilimanjaro (Rey and Das 1996).

The Natron study region (7,500 km^2) is to the west of the West Kili region with its northern extent defined by the Tanzania-Kenya border, extending from the border town of Namanga on the east and continuing northwest along the border to the northern terminus of Lake Natron. The western extent is along the east side of Lake Natron continuing south along the eastern border of Ngorongoro CA (8,288 km^2). The southern boundary extends from the southeast corner of Ngorongoro CA eastward to the northwest corner of Arusha NP. The region is a mosaic of diverse natural communities and extensive grazing lands. There is a unique Maasai grazing area extending westward from the Kiserian-Mriata Ridge (on the eastern side of the study region) extending westward encompassing the grasslands adjacent to Gelai (2,942 m) and Ketumbeine (2,858 m) mountains. This area is characterized by well-drained savannah grasslands and woodlands where Maasai graze their cattle during the dry season and no permanent human settlements are allowed. Within this study region, there are 15 traditional Maasai communities that graze cattle and other livestock and raise subsistence crops. The entire region is included within the Natron GCA and the northern portion of the Monduli GCA where wildlife is managed primarily for hunting. The predominate ecological zone is semi-arid savannah interspersed with open acacia woodlands (*Acacia-Commiphora*), especially on the western side of the Kiserian-Mriata Ridge. Distribution of rainfall is unpredictable and highly variable from year to year with rainfall amounts typically ≤ 350 mm/yr.

The Loliondo study region (5,000 km^2) is to the west of the Natron region. Its northern border is defined by the Tanzania-Kenya border from the northern terminus of Lake Natron to the northeast corner of Serengeti NP. The region's eastern border is the west shore of Lake Natron while the western extent of the study region is the eastern border of Serengeti NP. The southern extent of the region extends from Alashi Village near the park boundary eastward extending south of the Maloni Highlands to the southern end of Lake Natron. The region is a mosaic of natural communities, extensive grazing lands in the lowlands, and limited subsistence agriculture in the highlands. There are 16

Maasai communities that graze cattle and other livestock and raise subsistence crops. There are three protected areas adjacent to the study region with Ngorongoro CA to the south, Serengeti NP (14,763 km^2) on the west, and Maasai Mara (1,368 km^2) to the north in southern Kenya. Much of the study region is included within the Loliondo GCA (4,000 km^2). The ecological zone is predominantly semi-arid savannah interspersed with open acacia woodlands. Distribution of rainfall is unpredictable and highly variable from year to year with rainfall amounts ranging from 450 to 850 mm/yr (Sinclair and Arcese, 1995).

The Manyara study region (5,500 km^2) is within the Monduli District of Arusha Region. The region's northern boundary extends from the southeast corner of Ngorongoro CA southeastward to the north of the Loosimingor Mountains to the Ardai Plains and the Arusha-Makuyuni Road. The eastern boundary extends south from the road to the southeast corner of Tarangire NP. Following the southern border of the park, the southern boundary of the region extends westward to the Bonga Forest. The western boundary extends north along the Dodoma Road to the southern tip of Lake Manyara, following the eastern lakeshore to the southeast corner of Ngorongoro CA and including the town of Mto wa Mbu. The region is a complex mosaic of diverse natural communities, grazing lands, irrigated agricultural areas and human communities. There are 14 communities in the study region, ranging from small traditional villages to the larger community of Mto wa Mbu (~ 6,000) There are three protected areas in or adjacent to the study region, including Tarangire NP (2,850 km^2), Lake Manyara NP (330 km^2), and Ngorongoro CA. The study region includes Burunge Wildlife Management Area (1300 km^2) and several game controlled areas (Sechambo 2001). The ecological zone is predominantly semi-arid savannah interspersed with open acacia woodlands. In drier areas, *Acacia* woodlands dominate along with *Commiphora* and *Acacia-Commiphora* woodlands. Annual rainfall averages 829 mm, varying from 645 mm (Tarangire) to 1306 mm (Ngorongoro) with most occurring in March-April and little in November-December (Sechambo 2001).

Methods

Elephant Collaring

Twenty-one elephants (7 bulls and 14 females) were fitted with satellite collars within the four study regions across northern Tanzania from September 2005 to August 2007. No more than one individual was collared within a herd. We also tried to choose herds that were widely separated from each other within an area to reduce the probability that herds were members of the same clan (Poole 1996). For family groups, we targeted an older adult female in the herd for collaring. Subadult and adult bulls were tagged in bull herds.

Six elephants were darted from the ground and 15 from a helicopter. Elephants were immobilized by a veterinarian using ethorphine hydrochloride (M99: C-vet UK) in darts fired from a modified .22-caliber rifle following the guidelines recommended by Thouless (1995). Once the elephant was immobilized and recumbent, it was fitted with telemetry unit; a blood sample taken; measures made of shoulder height, back length, tusk length, tusk basal circumference, and hind foot length and circumference; age estimated by size and head configuration following the guidelines of Thouless (1995). The effect of immobilizing drug was reversed using diprenorphine (M5050: C-vet UK).

Satellite Telemetry

We used GPS receiver collars on all elephants (African Wildlife Tracking, Pretoria, South Africa), and collared elephants were monitored for varying lengths of time, depending on collar performance (Table 2.1). The duty cycle of these units was variable. The first six units deployed in September 2005 were set to download one GPS fix in the morning (0500) and one at night (2300). After the first year, the duty cycle of these six units and three additional units (deployed January 2006) was changed to one fix during the day and two fixes at night. The duty cycle for the final 12 units deployed in November 2006 and August 2008 was two fixes during the day and 3 fixes at night. Fixes were downloaded via satellite through StarTrack (Australia), who transmit these data to Skygistics. The geographic accuracy of locations was 15 m for six collars we field-tested prior to deployment. All units were equipped with a VHF transmitter, allowing periodic tracking of the collared elephant and retrieval of the unit.

Home Range Estimation

We used the 100% minimum convex polygon (MCP100%) (Mohr, 1947) and 95% fixed-kernel (FK) (Worton 1989) methods to derive home range estimates for elephants. Despite its limitations (Powell 2000; Osborn 2004), we used the 100% MCP estimate to facilitate comparisons with other elephant home range studies. We chose to use the fixed kernel method rather than the adaptive kernel method because fixed kernel estimators typically are sensitive to multiple areas of concentrated use, and produce less area bias and better surface fit than adaptive kernel estimates (Seaman and Powel 1996; Seaman at al. 1999). Home ranges sizes were calculated using the Animal Movements Analyst Extension (AMAE ver.1.10: Hooge & Eichenlaub 1997) in Arc GIS software (Ver. 9

ESRI, Redlands, California). We used the auto-selected smoothing factor (H) and LSCV off options for calculating the kernel home range parameters.

Autocorrelation of elephant movements are long-term, temporally complicated, seasonally variable, and closely linked with rainfall events (Cushman et al. 2005). However, Otis and White (1999) argued that such autocorrelation is inconsequential if proper study design is applied (e.g. treating animals rather than locations as sample units). Further, Swihart and Slade (1997) argued that regular sampling intervals resulting in auto-correlated data will not invalidate many estimates of home range size so long as the study time frame is adequate. We calculated the wet and dry season ranges by year for 95% kernels, and the annual, wet and dry season ranges by year for the 100% MCP to compare to other studies. Further, we only calculated home ranges for elephants that were monitored for at least one annual cycle. We also calculated home ranges for elephants that were not tracked for an entire wet or dry season if there were >120 fixes for that partial tracking season. Although northern Tanzania typically has two rainy seasons with the long rains from March to May and the short rains from November to December, we delineated November - May as the wet season, corresponding to the period when vegetation was green and water is typically available in seasonal pans. We delineated June - October as the dry season, corresponding to low precipitation and low water availability in seasonal pans.

Statistical Analyses

Nonparametric tests were used to evaluate differences in home range sizes. Mann-Whitney *U*-tests were used to assess differences between average wet and dry season home ranges, and sex differences in home range sizes between seasons. Kruskal-Wallis

ANOVA tests were used to evaluate seasonal differences in home range sizes among the four regions. Statistical tests were conducted using Analyse-it (ver. 1.73: 2006).

Results

100% MCP Home Range Sizes

The annual and seasonal 100% MCP ranges for 21 elephants collared in northern Tanzania varied greatly for bulls (700 to 3,698 km^2) and females (191 to 2,590 km^2)(Table 2.2). Average 100% MCP wet ($\overline{X}$ =886 km^2) and dry ($\overline{X}$ =947 km^2) season ranges for bulls were similar (U=75, P=0.607), as were the wet ($\overline{X}$ =809 km^2) and dry season ($\overline{X}$ =759 km^2) ranges of females (U=348, P=0.332). There were also no differences between bulls and females for their wet season range (U=133, P=0.581) or dry season range (U=96, P=0.207).

Fixed Kernel Home Range Sizes

There was much variation in 95% fixed kernel home range sizes between bulls and females by season and between years (Table 2.3). The average wet season range for bulls (571 km^2) was 22% larger than for females (467 km^2) across all years (U=111, P=0.206). Similarly, the average dry season range for bulls (447 km^2) was 27% larger than for females (353 km^2) across all years (U=75, P=0.043). Although there were no statistical differences between years for bull wet season ranges (X^2=0.92, df=2, P=0.61), there was much variation in range sizes between years. For example, from Wet06 and Wet 07, bull T9 increased from 656 to 1,030 km^2 (57%), whereas T8 decreased from 518 to 340 km^2 (-34%). Similarly, there was no statistical difference between years for bull dry season ranges (X^2=0.61, P=0.738), but there was great variation. From Dry06 to Dry07, the range of bull T4 decreased 49% from 536 to 272 km^2, while T9 increased nearly six-fold from 146 to 981 km^2. Similar to bulls, there was no statistical difference between years for female wet (X^2=1.59, df=2, P=0.452) or dry (X^2=1.25, P=0.535) season ranges, but there was great variation between years for individual elephants. From Wet06 to Wet07, female T2 increased her range five-fold from 144 to 862 km^2, while the range of female T15 decreased from 1,093 to 682 km^2 (-38%) from Wet07 to Wet08.

There was much variation in 95% fixed kernel home range sizes between regions (Table 2.3). In the wet season, female ranges were largest in the Natron region ($\bar{X}$=780 km^2), intermediate size in West Kili ($\bar{X}$=438 km^2), and smallest in Loliondo ($\bar{X}$=243 km^2) and Manyara ($\bar{X}$=133 km^2) (H=13.8, df=3, P=0.003). In the dry season, female ranges were again largest in the Natron region ($\bar{X}$=916 km^2), but relatively small in the three other areas (Manyara $\bar{X}$=153 km^2; West Kili $\bar{X}$=138 km^2; Loliondo $\bar{X}$=81 km^2)(H=16.5, df=3, P<0.001). Bull ranges were typically much larger but inconsistent between the wet and dry seasons among the regions (Table 2.3). In the wet season, bull ranges were largest in West Kili ($\bar{X}$=688 km^2) and Loliondo ($\bar{X}$=564 km^2) regions and intermediate in Natron ($\bar{X}$=429 km^2) and Manyara ($\bar{X}$=367 km^2) regions (H=3.82, df=3, P=0.291). In the dry season, bull ranges were largest in Natron (T8 = 737 km^2) and Manyara (T19 = 654 km^2), and intermediate in Loliondo ($\bar{X}$=397 km^2) and West Kili ($\bar{X}$=389 km^2) (H=2.36, df=3, P=0.50).

Discussion

100% MCP Home Range Sizes

Our annual100% MCP home range measures of elephants in northern Tanzania were highly variable, ranging from 191 to 3,698 km^2 (Figs. 2.1-2.21). This large variation in elephant home range sizes is commonly reported in other East African elephant telemetry studies. Thouless (1996) reported range sizes (100% MCP) for 20 radio-tagged female elephants varied from 102 to 5,527 km^2 in northern Kenya. Douglas-Hamilton et al. (2005) reported the home ranges (100% MCP) for 11 elephants with GPS collars between 11 and 5,520 km^2 in size within four regions in southern and central Kenya. Factors affecting this variation in elephant home range movements included variation in rainfall, human disturbance, poaching pressure, water availability, bush cover, length of tracking, and presence of fences (Thouless 1995, 1998; Douglas-Hamilton et al. 2005).

For elephants monitored in unfenced areas, Douglas-Hamilton et al. (2005:160) reported that elephants had distinct 'home' sectors linked by 'travel' corridors through unprotected areas. We observed such travel corridors in two of our study regions. In the Manyara region, two elephants (T17, T19) used a narrow corridor to move between Manyara Ranch (a private conservation area) and Tarangire NP. Similarly, two elephants (T15, T18) used a corridor to move between the West Kili and Natron study regions across the Namanga-Arusha Road. One other female elephant in West Kili (T21) consistently used the Kitendeni Corridor connecting the northern border of Kilimanjaro NP to the proposed Lemomo CA to the south of Amboseli NP. Although not a narrow corridor, frequent movements of seven elephants between West Kili and Amboseli NP through the Sinya Mine area highlight the critical importance of this area for supporting transboundary elephant movements in the West Kili region (Chpt. 3). Further, these West Kili elephants spent the vast majority of their time in unprotected areas ($\overline{X}$ =91.5%), and rarely ($\overline{X}$ =8.5%) occurred in protected areas within this study region. In Kenya, Douglas-Hamilton et al. (2005) reported that radio-collared elephants in unfenced areas spent between 10 and 98% of their time in unprotected areas.

Recognizing the limitations of using MCP estimates (Douglas-Hamilton et al. 2005), the average range sizes for females and bulls in our northern Tanzania study were intermediate compared to MCP home range sizes reported for other elephant home range studies conducted in East Africa (Table 2.4). The average annual home range size for our three bulls in West Kili in 2006 (1,138 km^2) and 2007 (1,939 km^2) were much larger than the ranges of the two bulls (M86: 210 km^2; M169: 140 km^2) Douglas-Hamilton (1998) collared in Amboseli NP, one of which ranged into West Kili. However, he monitored these two bulls for very short periods, 134 and 168 days respectively, compared to our 24-month monitoring period. Overall, our average bull range size (1,411 km^2) was 67% larger than the size of the single bull home range reported for Tsavo West NP, and within the range of bull home ranges reported for Tsavo East NP (Leuthold 1977). Similarly, our average annual home range size for females (1,117 km^2) was much larger than the ranges reported for Lake Manyara and Tsavo West NP; yet, smaller than home ranges reported in Tsavo East NP (-53%), and the two studies in Laikipia-Samburu (-51%, Thouless 1996; -67%, Douglas-Hamilton et al. 2005). Additionally, our average wet and dry season 100%MCP home ranges for our two Manyara female elephants were substantially smaller (-86% and -87%, respectively) than those reported by Galanti et al. (2005) for Tarangire NP (Table 2.4).

Sex, Seasonal and Regional Comparisons of Fixed Kernel Range Sizes

Similar to several previous home range studies (Stokke & du Toit 2002, Jackson & Erasmus 2005, Chase 2007), the home range sizes (95% fixed kernel) of bulls were typically larger than the home ranges of females in our study, but there was much variability between individual elephants (Table 2.3, Figs. 2.1-2.21). For example, two female elephants (T15, T18) had the largest home range sizes recorded of our 21 collared elephants, but these large ranges were due to their movements between the West Kili and Natron study regions. The larger size of home ranges during the wet season versus the dry season was also typical for both bulls and females (Table 2.3). The increased availability of water and reduced reliance on artificial water sources during the wet season typically allow elephants to range over larger areas (Dunham 1986, Ottichilo 1986, Lindeque & Lindeque 1991, de Villiers & Kok 1997, Osborn 2003, Jackson & Erasmus 2005, Chase 2007). Despite the overall larger average wet season ranges, nine of our collared elephants (3 bulls, 6 females) had larger ranges in the dry season than in their previous wet season. We suspect that the larger dry season ranges for both the bulls and females were associated with moving to artificial water sources and different woodland habitats. The difference was especially large for T15, a female elephant who shifted her range from the Natron to the West Kili region between the wet and dry seasons of 2008. Additionally, the three bulls that increased their dry season ranges were probably also following breeding herds in search of females in estrous.

The only subadult bull we collared (T9) had the largest home range size of all bull elephants; however, his range expansion occurred in 2007 during the second year of tracking. In this second year, he ranged much more widely in both the wet and dry seasons compared to 2006, and he expanded his dry season range from West Kili into the Natron study region. This bull was with his maternal herd in 2006 when he was collared. Our subsequent observations of this bull indicated that he left his maternal family group in 2007, possibly to establish associations with other bulls (Poole 1996) and conduct exploratory movements to other areas (Hoare 1997, Legget 2006).

The large differences in average home range sizes between study regions reflect varying strategies for obtaining food and water and avoiding humans. Although elephants typically had the smallest home range sizes in the Manyara and Loliondo regions, factors affecting these small range sizes differed between these two regions. In Manyara, both abundant food and water occur throughout the year within both of the protected areas (Tarangire NP and Manyara Ranch). Additionally, numerous human settlements surround much of Manyara Ranch and the northern and western borders of Tarangire NP. Thus, our collared elephants were primarily restricted to the protected areas, especially the females (T17, T20). Similarly, the range of the bull (T19) was also centered in the protected areas, but he dispersed more widely during the dry season, presumably in search of females in estrous. This bull also occurred more frequently in areas with agricultural fields, primarily during night time hours. There were two corridors used by these Manyara elephants (Chpt. 4). The bull T19 and female T20 both used the Jangwani Corridor linking Manyara Ranch and Lake Manyara NP, and T17 and T19 both used the Mswakini Chini Corridor to move between Manyara Ranch and Tarangire NP. Galanti et al. (2005) reported substantially larger average wet season (913 km^2) and dry season (642 km^2) home ranges for seven female elephants collared in Tarangire NP. In contrast to two of our Manyara elephants (1 bull, 1 female) that moved south from Manyara Ranch into the northern part of Tarangire NP, none of the female elephants collared in the park by Galanti et al. (2005) dispersed north into Manyara Ranch; however, the ranch was not established as a conservation area until 2002 two years after their study. Remarkably, two of their collared elephants (Kibonge, Maajabu) dispersed as far as 100 km southeast of the park, roaming over a 4,500 km^2 area. Four other of their collared elephants dispersed east of the park into the Lolkisale GCA.

In the Loliondo region, there are very few human settlements but abundant food and water resources for elephants, especially in the central and northern highland portions of the region. Rainfall is more abundant and consistent in these areas due to the climatic effects of Lake Victoria (Sinclair and Arcese, 1995). In addition to sparse human populations, the few communities are traditional Maasai pastoralists who grow few crops and benefit greatly from tourism income. Although there is limited human-elephant conflict in the region (A. Kikoti, unpubl. data), communities are more tolerant of elephants because of their limited agriculture and income derived from tour operators for wildlife viewing. Further, Serengeti NP is adjacent to the western border of this region, providing both habitat and anti-poaching protection. All five of our collared elephants in this region used the park, especially during the dry season and less frequently during the wet season. With consistent food and water available and sparse and tolerant human populations, elephant ranges are small in this region.

Elephant home range sizes were intermediate sized in the West Kili region where elephants must navigate a complex, largely unprotected mosaic of natural communities, human settlements with small agricultural fields, and large commercial farms. Rainfall is limited and inconsistent, especially at lower elevations where agriculture is small-scale and subsistent. However, rainfall is more abundant and consistent at higher elevations where the large commercial farms occur on the lower slopes of Mt. Kilimanjaro. Seven of the eight collared elephants in West Kili ranged in a wide arc stretching from West Kilimanjaro Ranch northward to Amboseli NP in southern Kenya, moving through the scattered woodlands and shrublands of the Oltupai Thicket in the south, Sinya Mine area on the Tanzania-Kenya border, and the Kitirua CA and proposed Lemomo CA south of Amboseli NP. There is relatively high human-elephant conflict in the region as elephants use artificial water sources in villages, and raid crop fields near villages and in the larger commercial farms further east. During the dry season, elephants are highly dependent on the artificial water sources in villages. Crop-raiding is highly seasonal (May-June) and primarily at night when elephants penetrate eastward through the villages to access the crop fields. When crops are not available during the dry season, elephants typically browsed in the woodlands and shrublands to the south, moving northward in the wet season to browse in the CAs south of Amboseli NP and to graze in the grasslands of Amboseli NP. Given the complex mosaic, unpredictable rainfall and resources, and high levels of human-elephant conflict, the elephants of West Kili are highly mobile utilizing seasonal resources and minimizing conflicts with people. Additionally, the movement of the subadult bull (T9) and westward dispersal of two females (T1, T3) towards the Natron region from West Kili indicates that some elephants may regularly move between the two regions.

Home range sizes were typically the largest in the Natron region where rainfall is very low and erratic. Human communities are small and scattered with very little agriculture due to the dry conditions. Consequently, elephants roam over relatively large areas during both the wet and dry seasons utilizing the woodlands, shrublands and grasslands along the Kiserian-Mriatata Ridge, especially on the western side where no human settlements are permitted by the local Maasai communities. Much of the human-elephant conflict occurs during the dry season when elephants utilize the water trapped behind small livestock impoundments, frequently destroying the earthen dams. Yet, this conflict typically occurs only when all other sources of water are depleted. Thus, although food resources are abundant in the Natron region, water is a serious limiting factor for elephants during the dry season. Without water sources provided by people, it is unlikely that elephants could occur in the Natron region during the dry season. The movement of two female elephants (T15, T18) and eastward dispersal by T10 towards West Kili suggest that some Natron elephants may regularly move between the two regions, potentially to access water during the dry season.

Conservation Implications

With 63% of the elephant range occurring outside of protected areas, rapidly growing rural human populations, increasing human-elephant conflicts, and increasing poaching pressure, increased attention needs to be focused on developing conservation strategies for elephant populations in the unprotected lands of Tanzania. Human settlements pose severe barriers to elephant movements and their expansion are increasingly restricting the dispersal of elephants to important habitats and into and out of protected areas. Thus, it is critical that these important habitats and conservation corridors be identified and protected from human development. Such measures will help to ensure movements of elephants across the landscape and reduce future potential human-elephant conflicts by keeping bomas and agricultural fields out of these important elephant habitats. Additionally, human-elephant conflict mitigation programs need to be implemented in communities where conflict is high. Such programs will reduce the number of conflicts; numbers of elephants killed as problem animals, and enhance community attitudes towards elephants. Finally, community-based anti-poaching programs need to be expanded throughout these unprotected lands where elephants occur.

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Table 2.1. Numbers of fixes and months used to estimate seasonal home range sizes by study region and sex for 21 elephants monitored in northern Tanzania, 2006-2008.

ID	Sex	Age	Study Region	Collar deployed	Collar Retrieved/ Failed	Mos. used for home range	Total fixes	2006		2007		2008	
								Wet	Dry	Wet	Dry	Wet	Dry
T1	M	35-40	West Kili	1-Sep-05	13-Mar-08	24	1730	539	376	423	392		
T4	M	35-40	West Kili	2-Sep-05	13-Mar-08	24	1772	547	423	414	388		
T9	M	18-20	West Kili	14-Jan-06	23-Nov-08	22	1621	493	447	401	280		
T2	F	20-25	West Kili	1-Sep-05	13-Mar-08	24	1789	551	435	410	393		
T3	F	20-25	West Kili	2-Sep-05	14-Mar-08	24	1683	530	393	387	373		
T5	F	20-25	West Kili	3-Sep-05	15-Mar-08	24	1945	527	508	457	453		
T6[f]	F	20-25	West Kili	4-Sep-05	15-Feb-07	12	1014	574	440				
T18	F	35-40	West Kili	16-Nov-06	2-Nov-08	23	1625			447	493	423	262
T21[f]	F	25-30	West Kili	6-Nov-06	8-Jul-08	19	1240			443	493	304	
T8f	M	30-35	Natron	15-Jan-06	6-Mar-07	14	1196	475	441	280			
T10[f]	F	24-30	Natron	16-Jan-06	3-Jun-07	17	1148	495	447	206			
T12	F	20-25	Natron	6-Nov-06	23-Nov-08	24	1779			442	496	442	399
T15	F	35-40	Natron	14-Nov-06	24-Nov-08	24	1719			438	472	423	386
T19[f]	M	35-40	Manyara	17-Nov-06	18-Jun-08	19	1383			447	495	441	
T17	F	25-30	Manyara	16-Nov-06	26-Nov-08	24	1488			412	408	414	254
T20[f]	F	30-35	Manyara	17-Nov-06	16-Feb-08	15	1056			447	448	161	
T16[f]	M	35-40	Loliondo	14-Nov-06	15-Jul-07	7	344			344			
T23	M	20-25	Loliondo	23-Aug-07	28-Nov-08	14	1045				238	424	383
T13	F	18-20	Loliondo	14-Nov-06	23-Nov-08	24	1691			430	476	403	382
T22	F	38-45	Loliondo	22-Aug-07	28-Nov-08	14	1028				243	412	373
T25	F	20-25	Loliondo	26-Apr-03	28-Nov-08	17	1043				215	432	396

M = male, F = female; [f] = unit failed

Table 2.2. Annual and seasonal 100% maximum convex polygon (100% MCP) home range sizes (km^2) for 21 elephants monitored in northern Tanzania from 2006-2008.

Sex	Elephant ID	Region	2006 Annual	2006 Wet	2006 Dry	2007 Annual	2007 Wet	2007 Dry	2008 Annual	2008 Wet	2008 Dry
Female	T2	West Kili	552	368	368	1,424	1,369	294			
	T3	West Kili	1,278	1,066	704	1,480	1,307	404			
	T5	West Kili	819	816	169	1,373	1,200	1,125			
	T6	West Kili	770	768	572						
	T21	West Kili				431	419	308		366	
	T10	Natron	1,562	762	1,406		845				
	T12	Natron				1,393	1,203	1,181	964	940	671
	T15	Natron				2,590	1,217	2,010	2,341	1,471	2,029
	T18	Natron				2,399	1,670	1,337	2,077	1,570	1,468
	T17	Manyara				360	297	266	389	351	274
	T20	Manyara				329	162	282		170	
	T13	Loliondo				191	181	108	2,470	699	2,405
	T22	Loliondo						61	883	847	158
	T25	Loliondo						198	425	173	415
$\bar{X}$			996	756	644	1,197	897	631	1,364	732	1,060
Bull	T1	West Kili	1,225	880	704	700	642	536			
	T4	West Kili	1,167	972	913	1,418	1,018	591			
	T9	West Kili	1,023	1,019	530	3,698	1,538	2,562			
	T8	Natron	1,618	781	1,393		487				
	T19	Manyara				1,676	964	1,675	1,103	494	241
	T16	Loliondo					1,193				
	T23	Loliondo						385	997	648	882
$\bar{X}$			1,258	913	885	1,873	974	1,150	1,050	571	562

Table 2.3. Seasonal 95% fixed kernel home range sizes (km^2) by season and year for 21 elephants monitored in northern Tanzania from 2006-2008.

Elephant ID	Study Region	Sex	2006		2007		2008	
			Wet	Dry	Wet	Dry	Wet	Dry
T1	West Kili	Male	453	180	357	219		
T4	West Kili	Male	756	536	874	272		
T9	West Kili	Male	656	146	1,030	981		
T2	West Kili	Female	144	74	862	118		
T3	West Kili	Female	259	119	635	225		
T5	West Kili	Female	275	51	766	177		
T6	West Kili	Femal	525	131				
T21	West Kili	Female			260	209	212	
T8	Natron	Male	518	737	340			
T10	Natron	Female	527	858	551			
T12	Natron	Female			683	820	418	301
T15	Natron	Female			1093	1000	682	1876
T18	Natron	Female			878	455	1411	1105
T16	Loliondo	Male			478	672		
T23	Loliondo	Male				217	651	302
T13	Loliondo	Female			88	72	159	203
T22	Loliondo	Female				56	622	85
T25	Loliondo	Female				35	105	33
T19	Manyara	Male			456	654	279	
T17	Manyara	Female			129	161	208	163
T20	Manyara	Female			113	135	81	

Table 2.4. Study area location, size (km^2), rainfall, and minimum convex polygon (MCP) home range sizes (km^2) by sex for African elephant telemetry studies in East Africa.

Location/Country	Study Area Size (km^2)	Rainfall (mm)	Female		Bull		Reference
			Mean (n)[a]	Range	Mean (n)	Range	
Lake Manyara NP, Tanzania	130	1,000	33 (2)	14 & 52			Douglas-Hamilton (1971)
Tarangire NP, Tanzania	35,000	600-650	NR (7)	477-7,648			Galanti et al. (2005)
Amboseli Ecosystem, Kenya	NR	341			175 (2)	140 & 210	Douglas-Hamilton et al. (2005)
Tsavo West NP, Kenya	25,000	550	409 (2)	369-448	843		Leuthold (1977)
Tsavo East NP, Kenya	25,000	550	2,380 (5)	1,009-2,975	1,183 (4)	516-1,756	Leuthold (1977)
Laikipia-Samburu, Kenya	15,000	400-750	2,291 (17)	102-5,527			Thouless (1996)
Laikipia-Samburu, Kenya	15,000	NR	3,380 (2)	1,240 & 5,520			Douglas-Hamilton et al. (2005)
This study	30,000	350-1,306	1,117 (14)	170-2,590	1,411 (7)	700-3,698	This study

[a] = number of elephants collared in study.
NR = not reported

Figure 2.1a. Overall home range (100% MCP), wet and dry season fixes for adult bull elephant (T1) in northern Tanzania, 2006 and 2007.

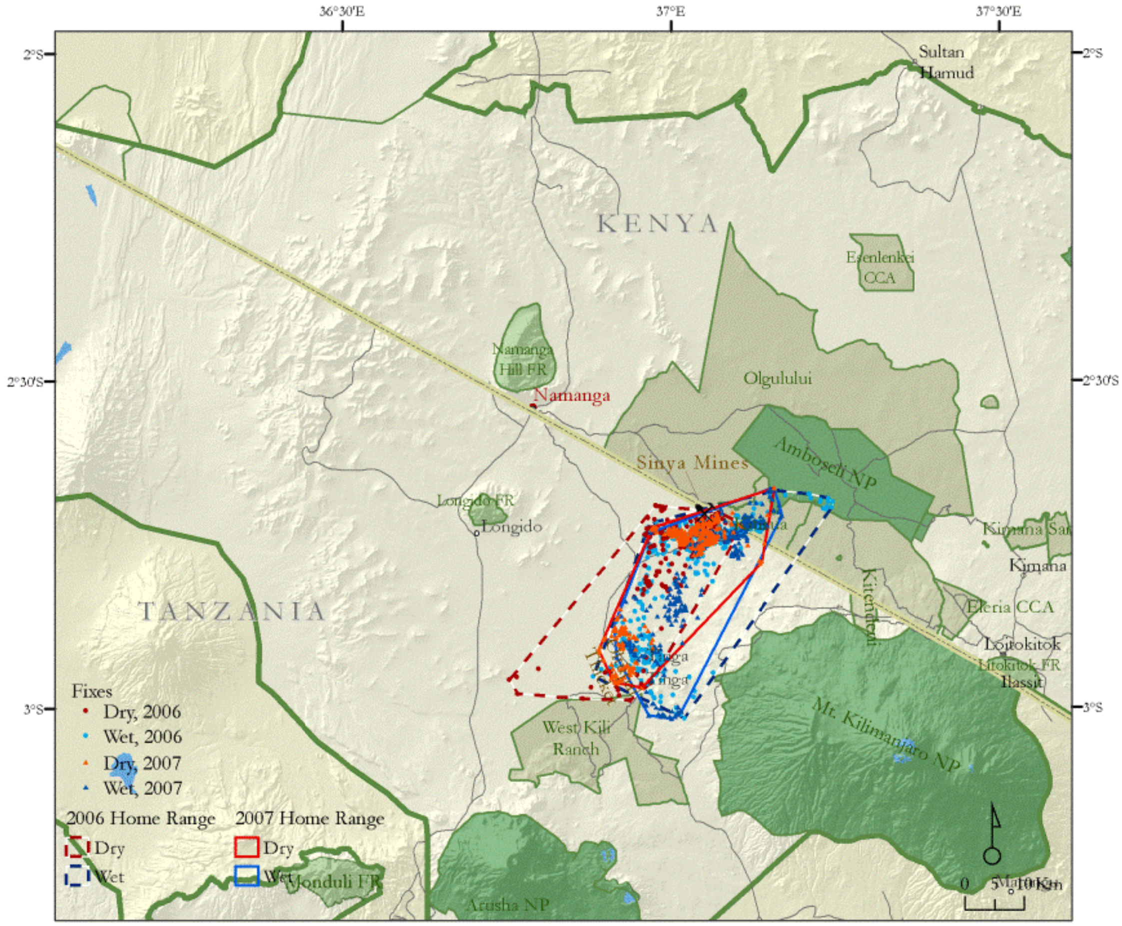


Figure 2.1b. Overall home range (95% FK), wet and dry season for adult bull elephant (T1) in northern Tanzania, 2006 and 2007.

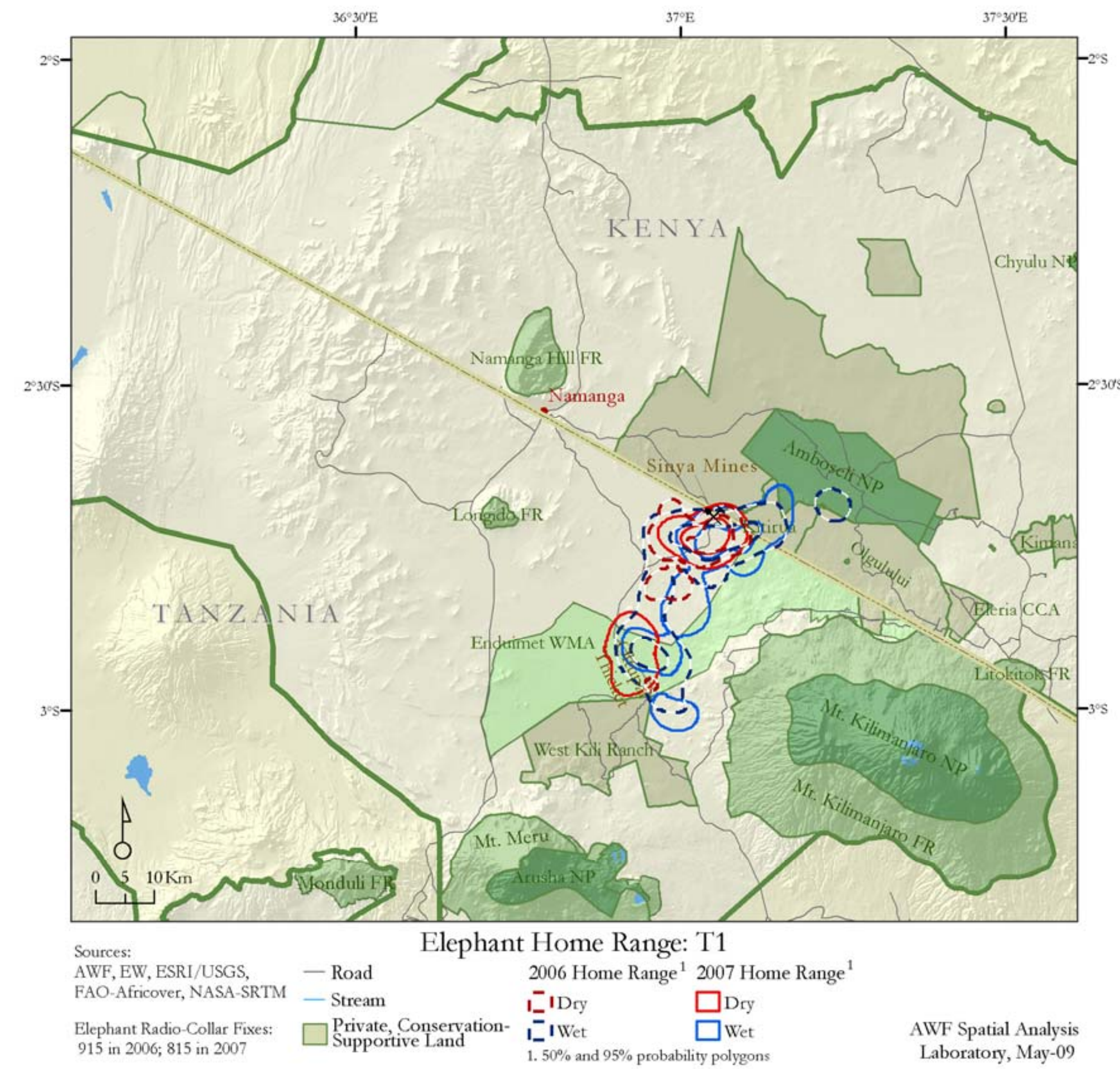


Figure 2.2a. Overall home range (100% MCP), wet and dry season fixes for adult female elephant (T2) in northern Tanzania, 2006 and 2007.

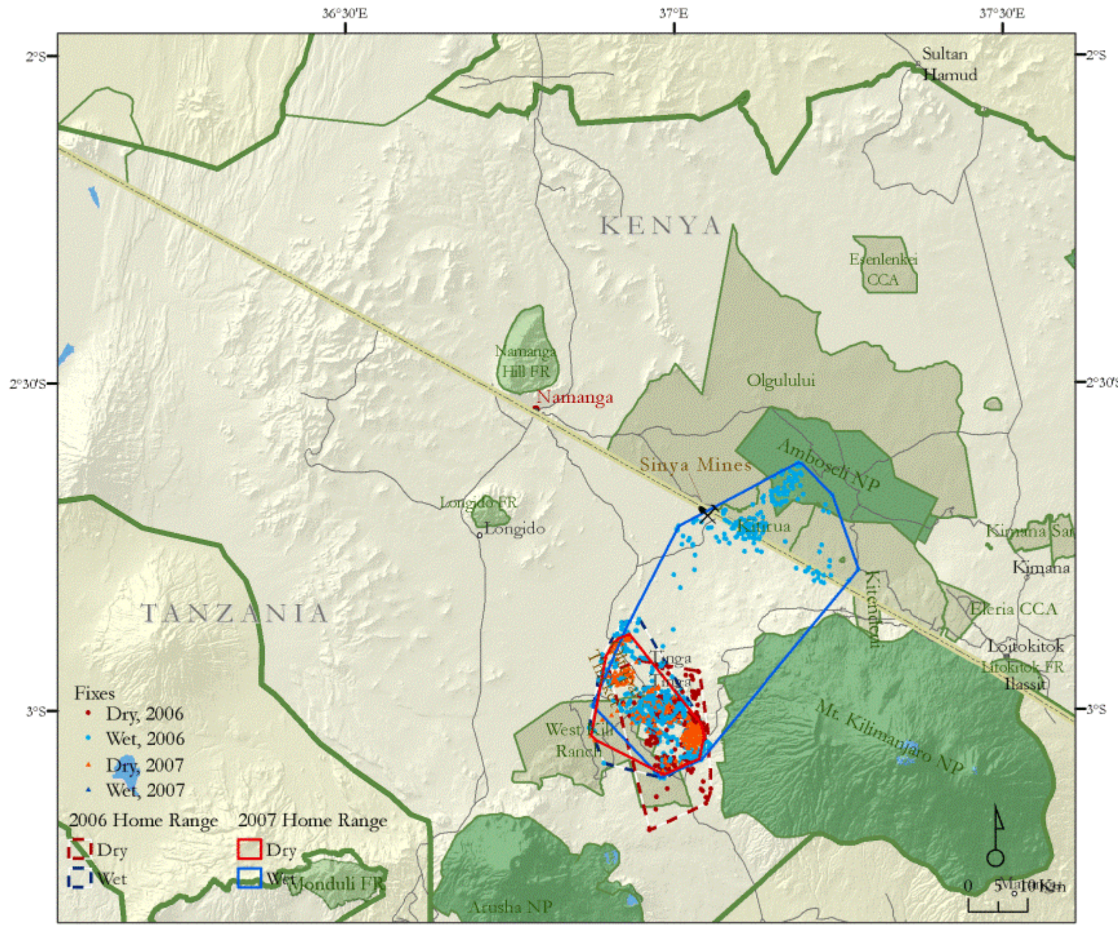


Figure 2.2b. Overall home range (95% FK), wet and dry season for adult female elephant (T2) in northern Tanzania, 2006 and 2007.

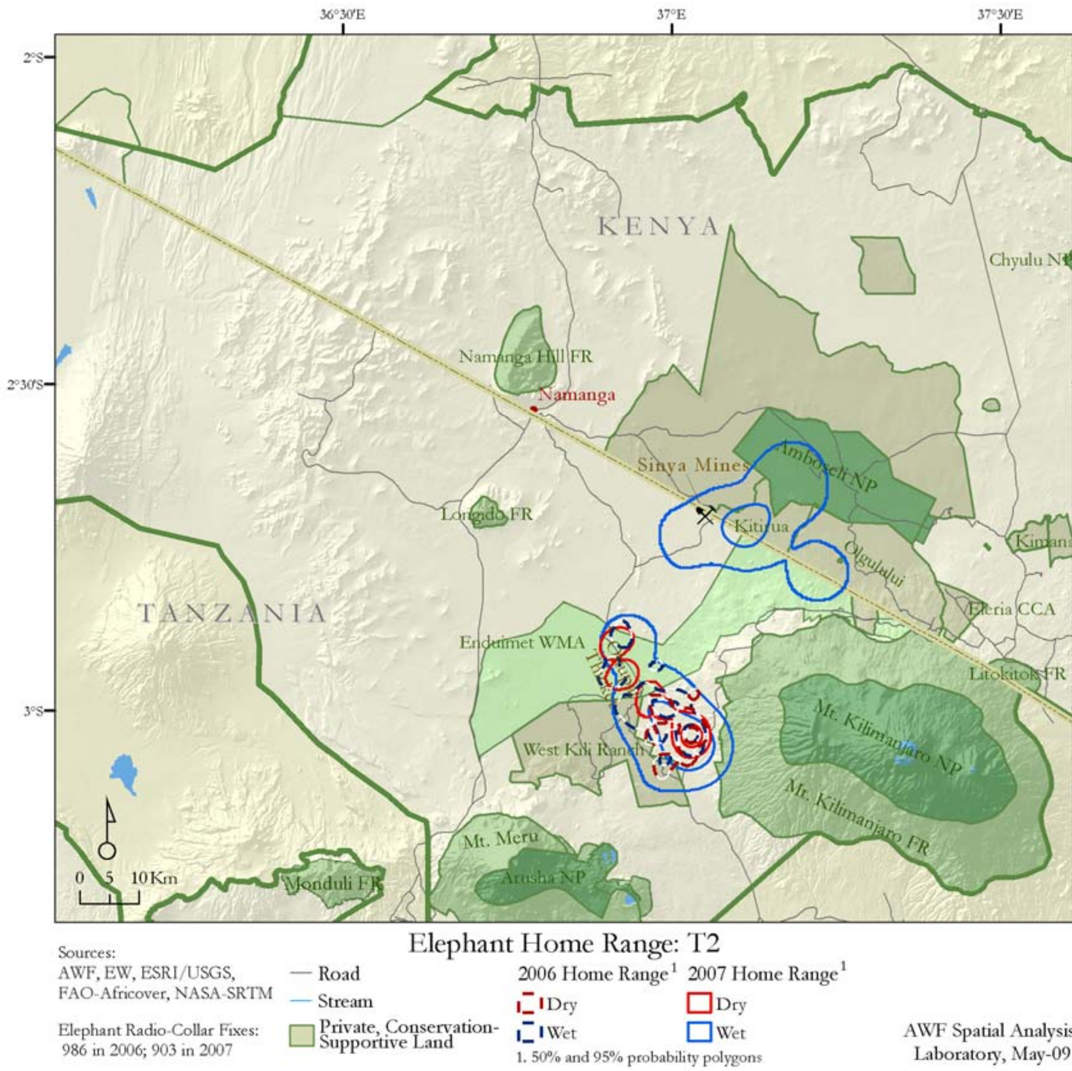


Figure 2.3a. Overall home range (100% MCP), wet and dry season fixes for adult female elephant (T3) in northern Tanzania, 2006 and 2007.

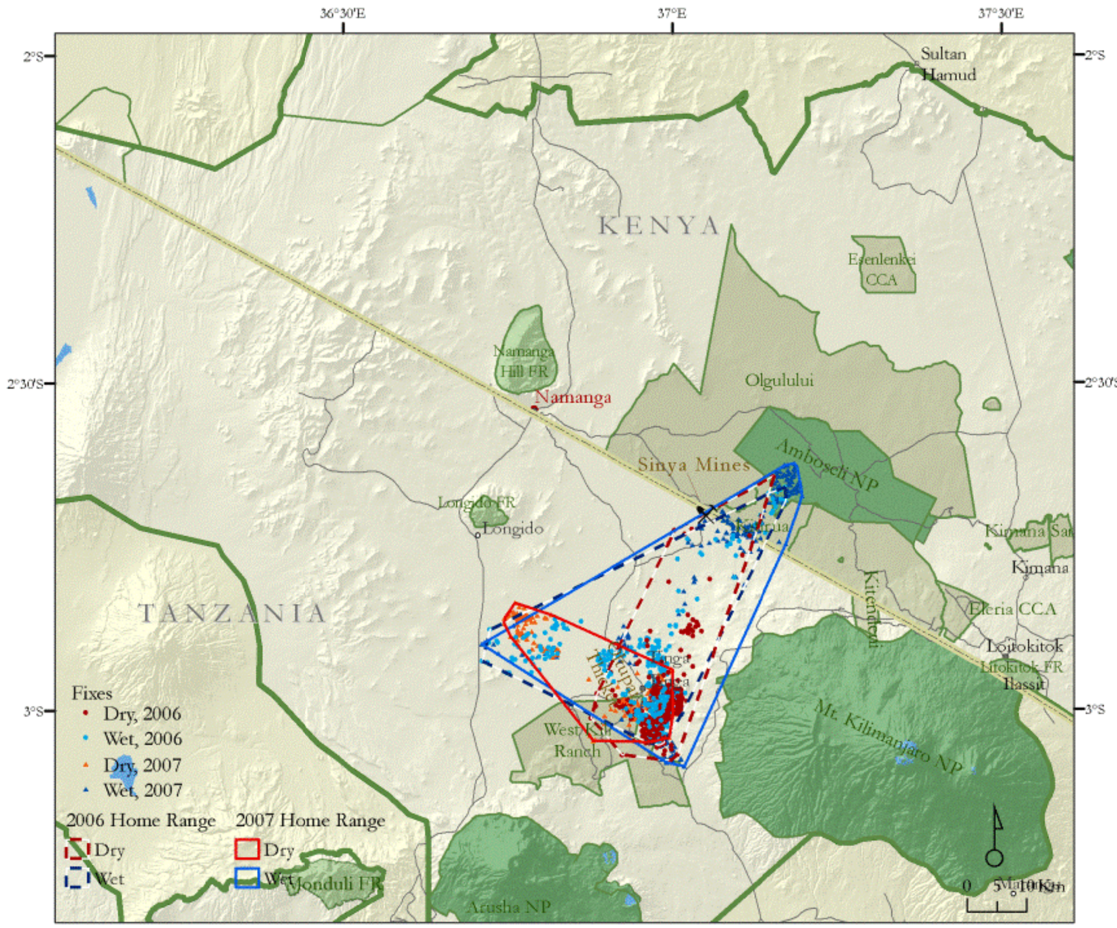


Figure 2.3b. Overall home range (95% FK), wet and dry season for adult female elephant (T3) in northern Tanzania, 2006 and 2007.

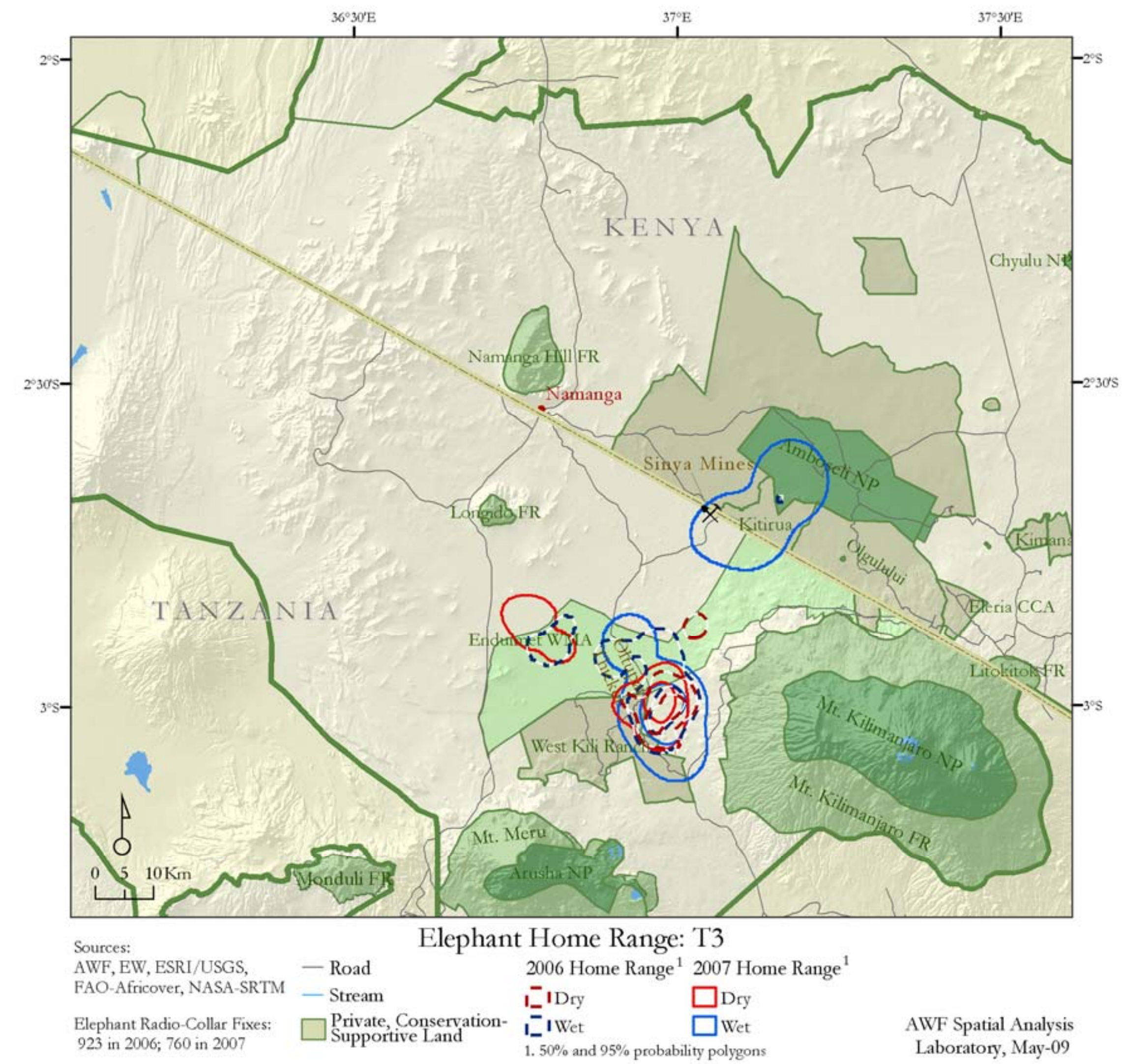


Figure 2.4a. Overall home range (100% MCP), wet and dry season fixes for adult bull elephant (T4) in northern Tanzania, 2006 and 2007.

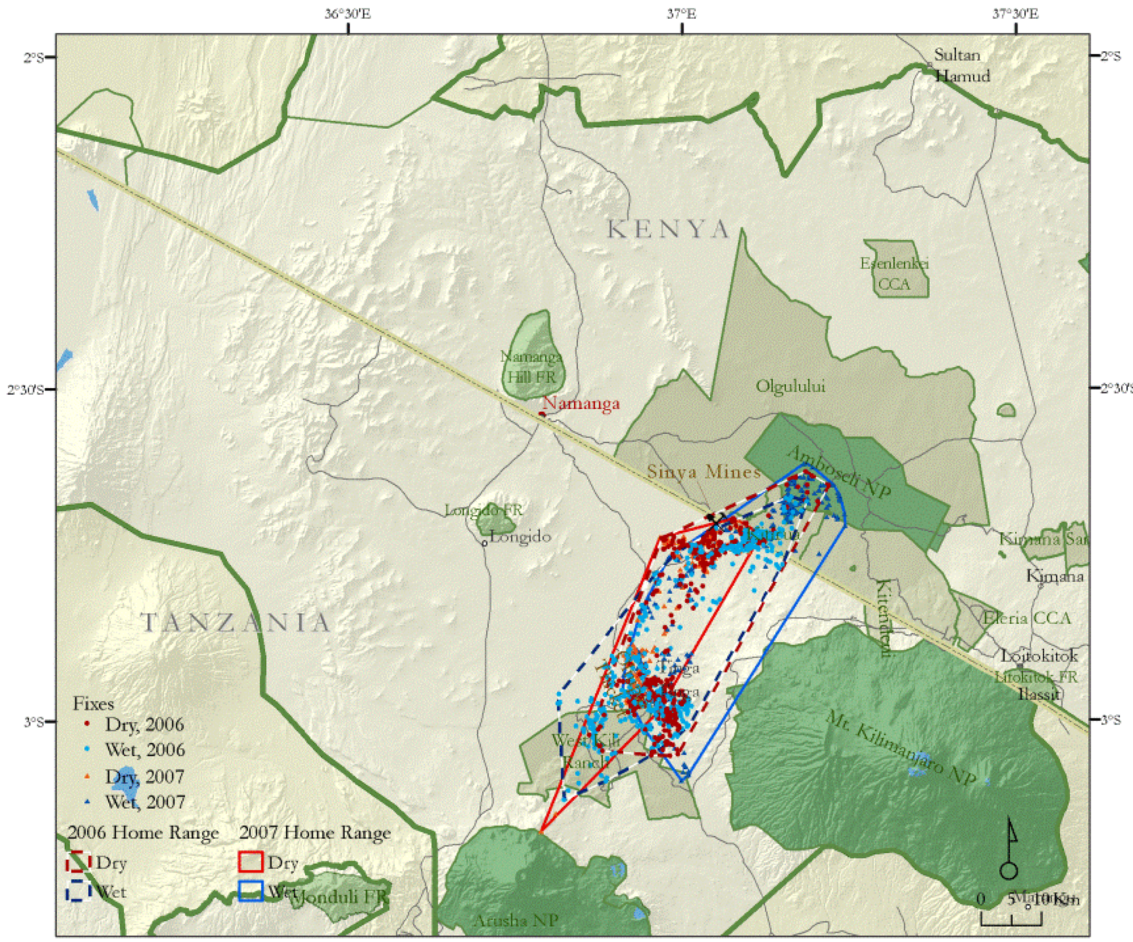


Figure 2.4b. Overall home range (95% FK), wet and dry season for adult bull elephant (T4) in northern Tanzania, 2006 and 2007.

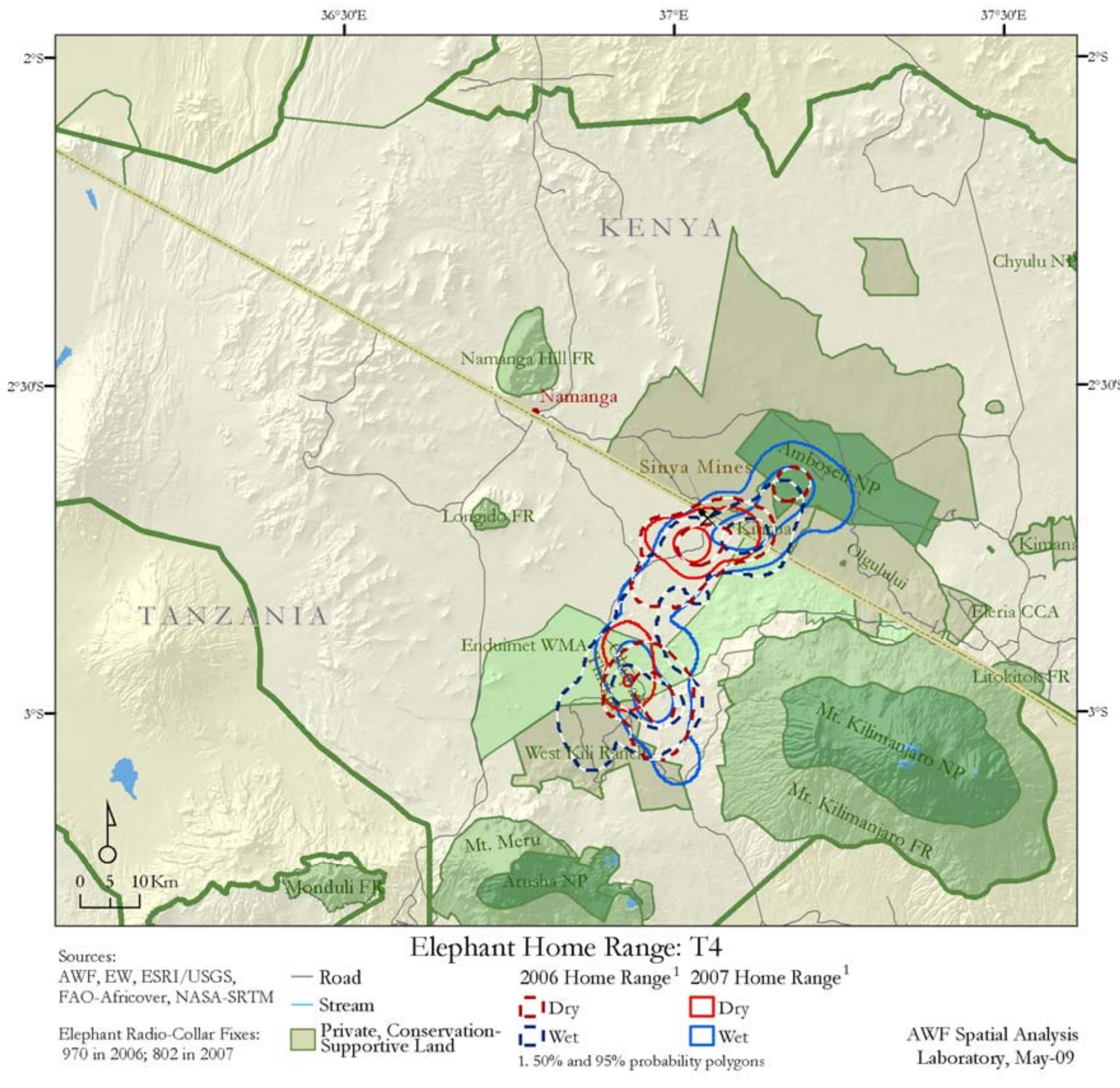


Figure 2.5a. Overall home range (100% MCP), wet and dry season fixes for adult female elephant (T5) in northern Tanzania, 2006 and 2007.

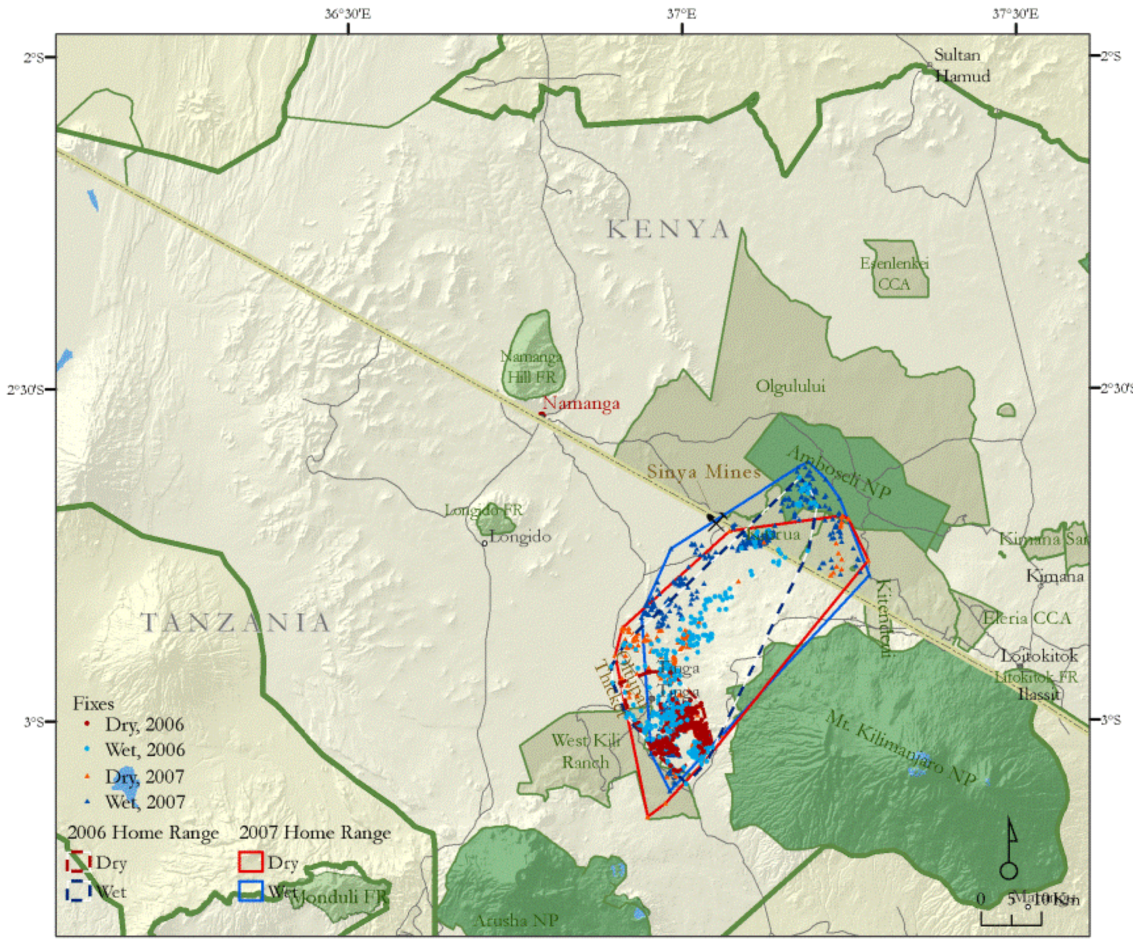


Figure 2.5b. Overall home range (95% FK), wet and dry season for adult female elephant (T5) in northern Tanzania, 2006 and 2007.

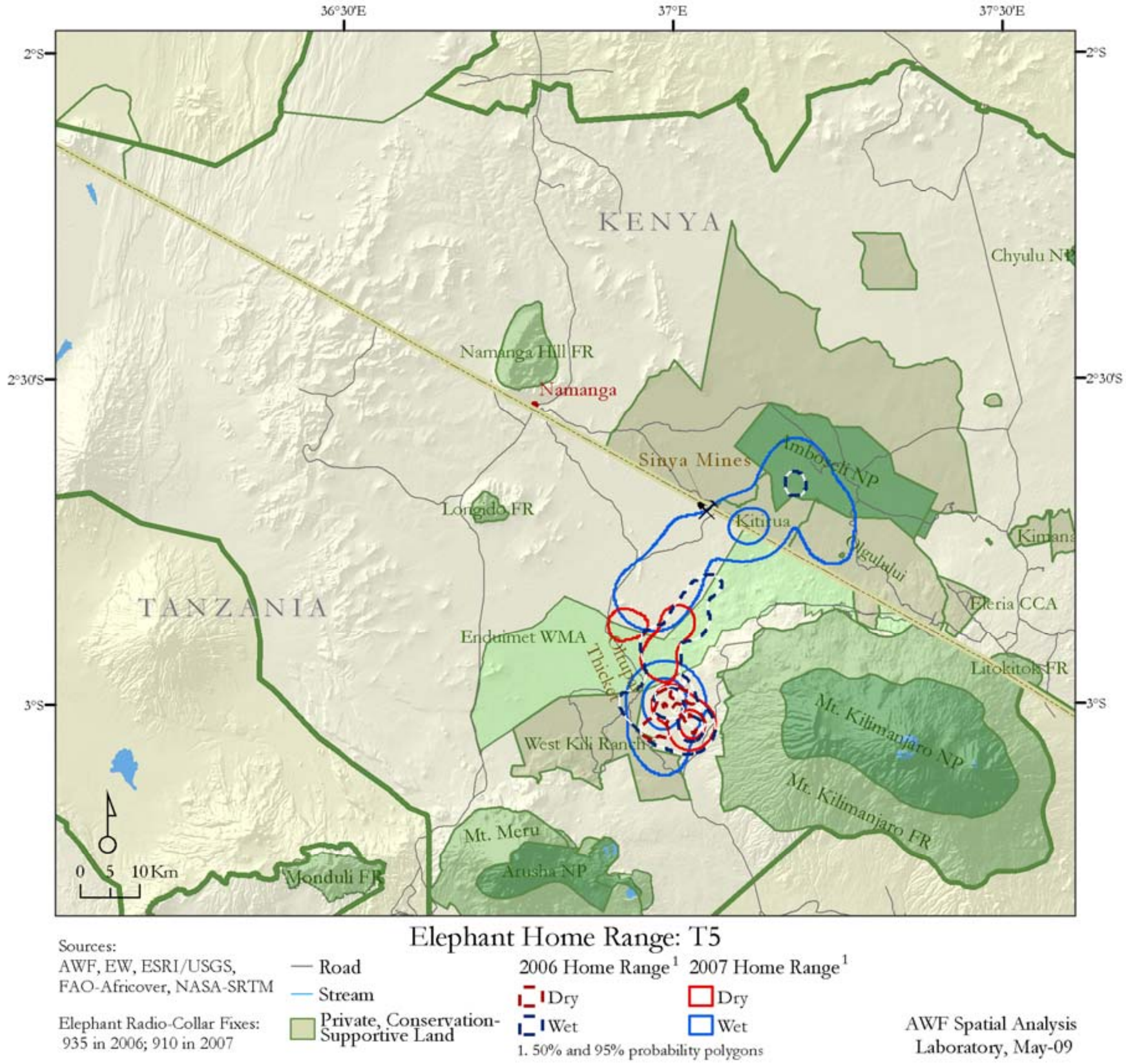


Figure 2.6a. Overall home range (100% MCP), wet and dry season fixes for adult female elephant (T6) in northern Tanzania, 2006 and 2007.

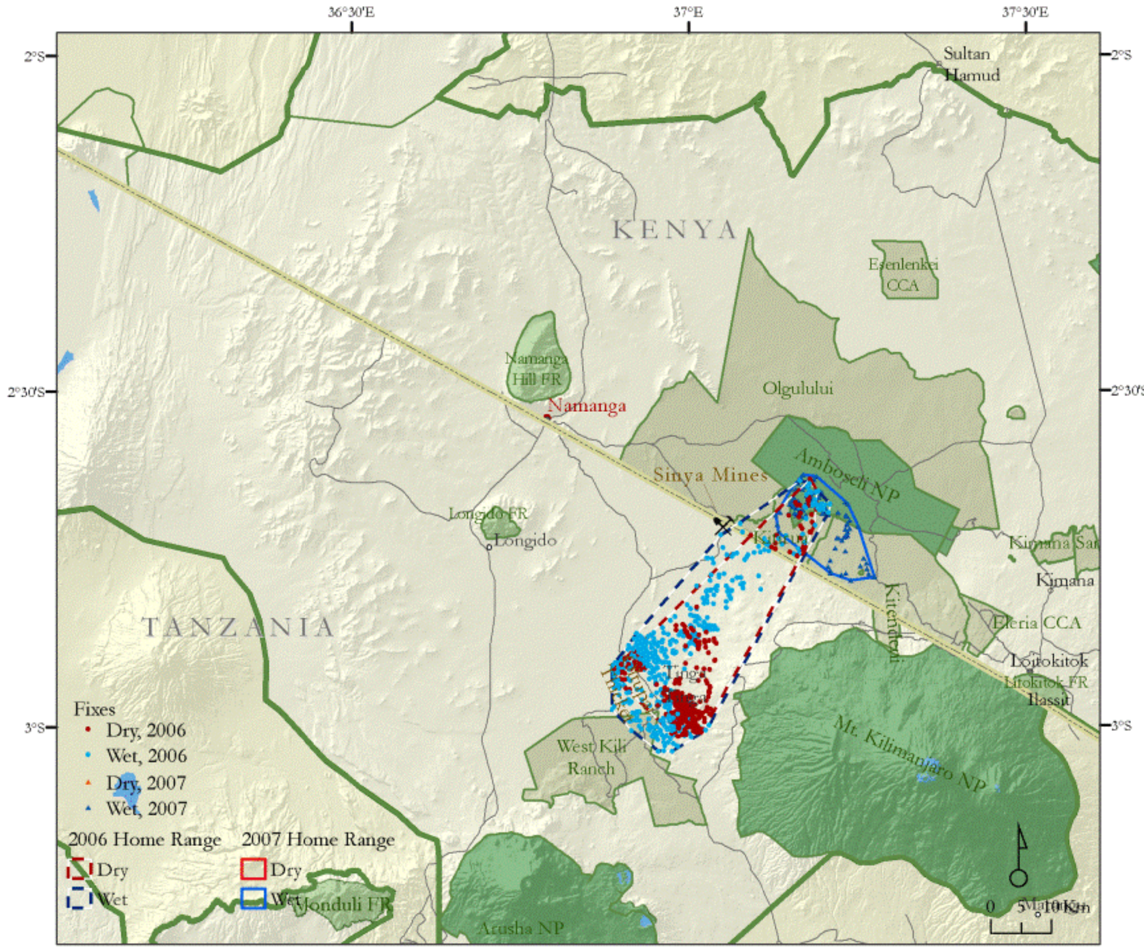


Figure 2.6b. Overall home range (95% FK), wet and dry season for adult female elephant (T6) in northern Tanzania, 2006 and 2007.

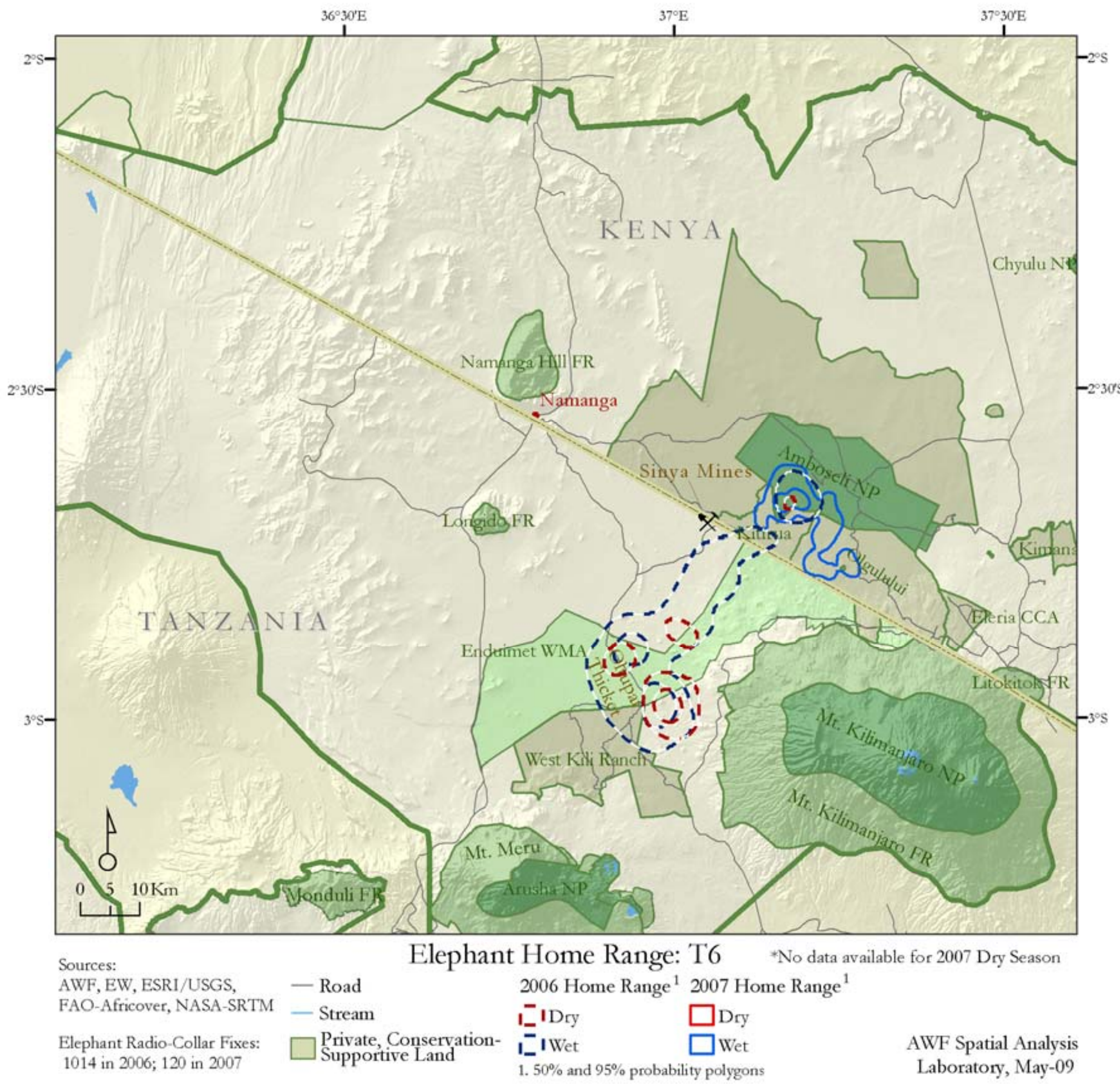


Figure 2.7a. Overall home range (100% MCP), wet and dry season fixes for adult bull elephant (T8) in northern Tanzania, 2006 and 2007.

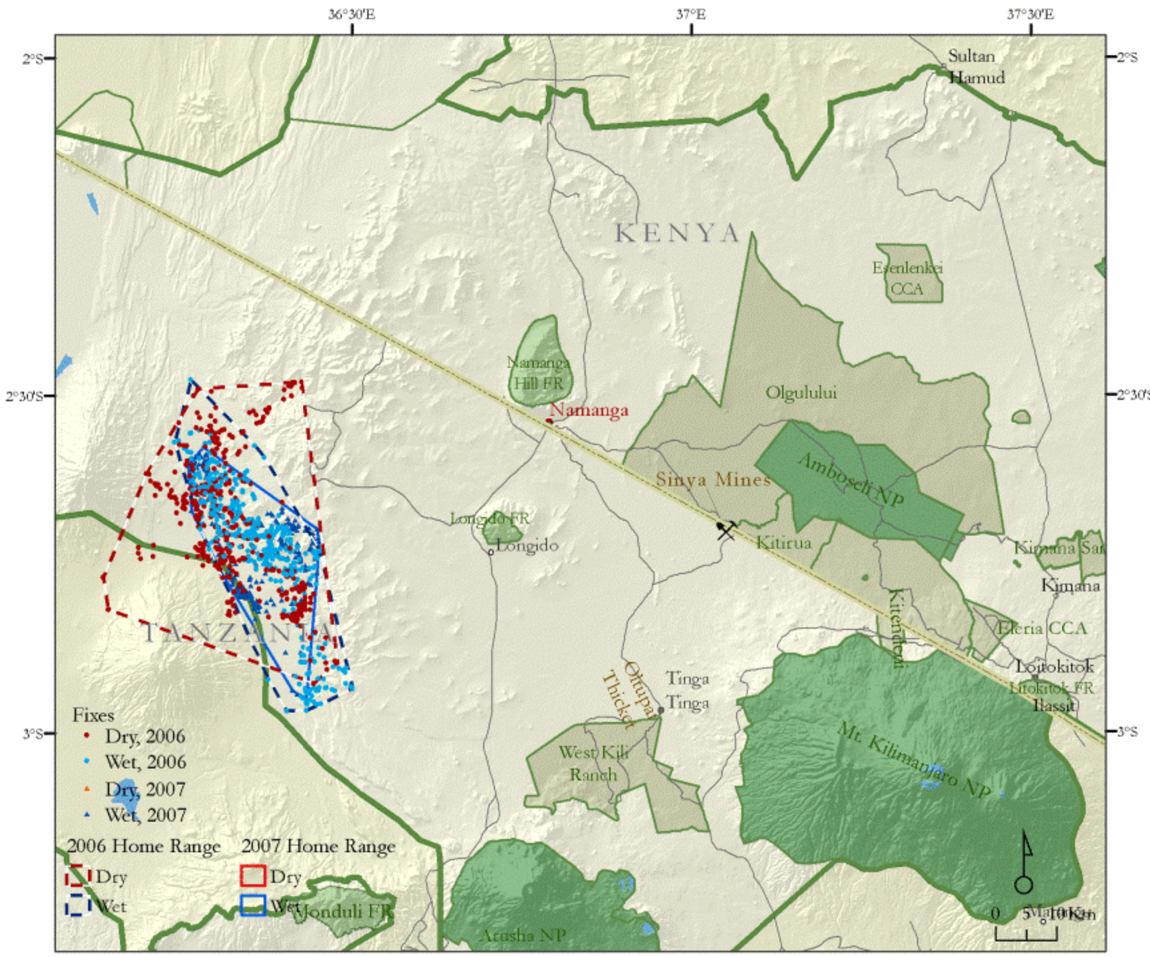


Figure 2.7b. Overall home range (95% FK), wet and dry season for adult bull elephant (T8) in northern Tanzania, 2006 and 2007.

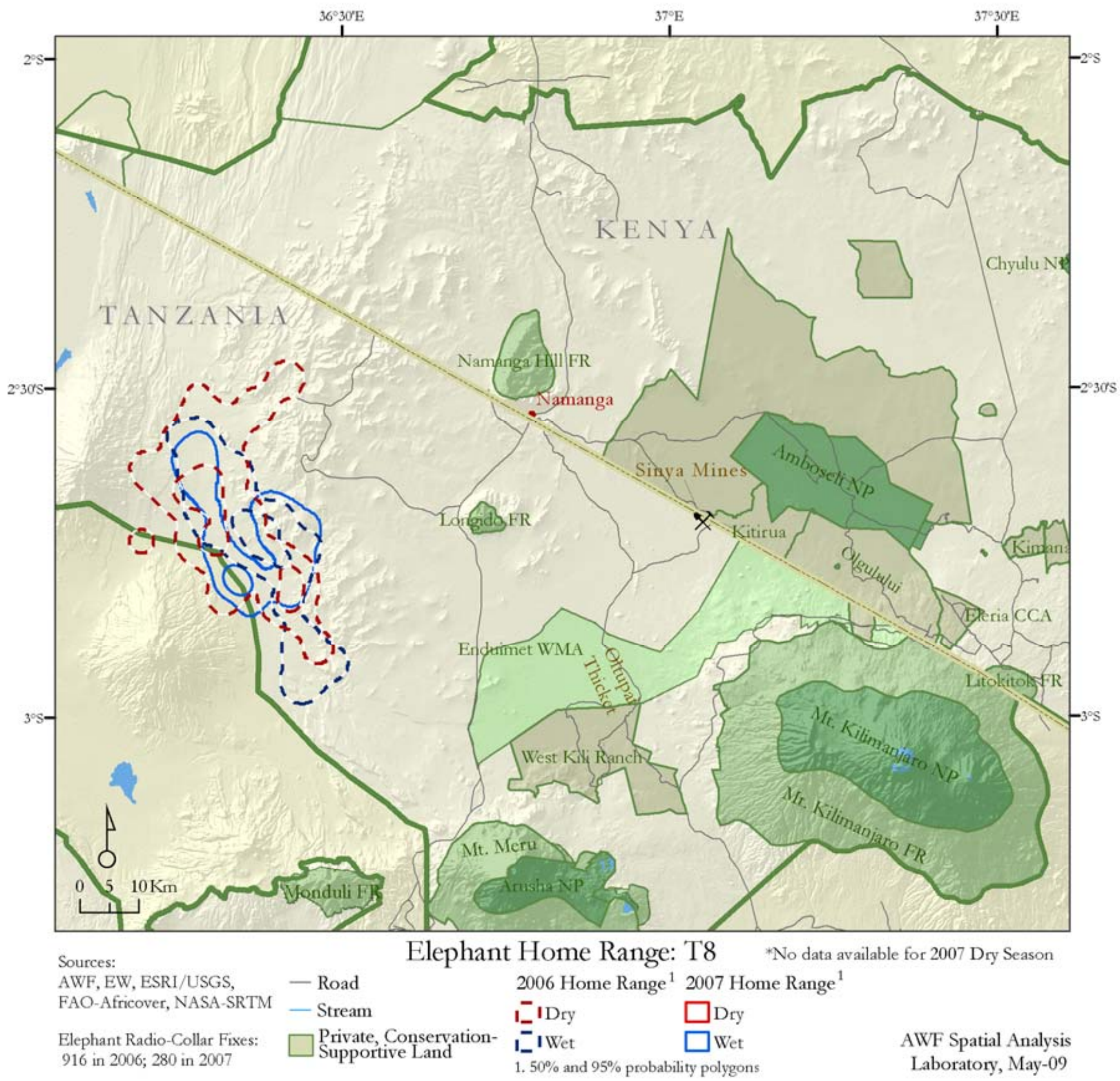


Figure 2.8a. Overall home range (100% MCP), wet and dry season fixes for subadult bull elephant (T9) in northern Tanzania, 2006 and 2007.

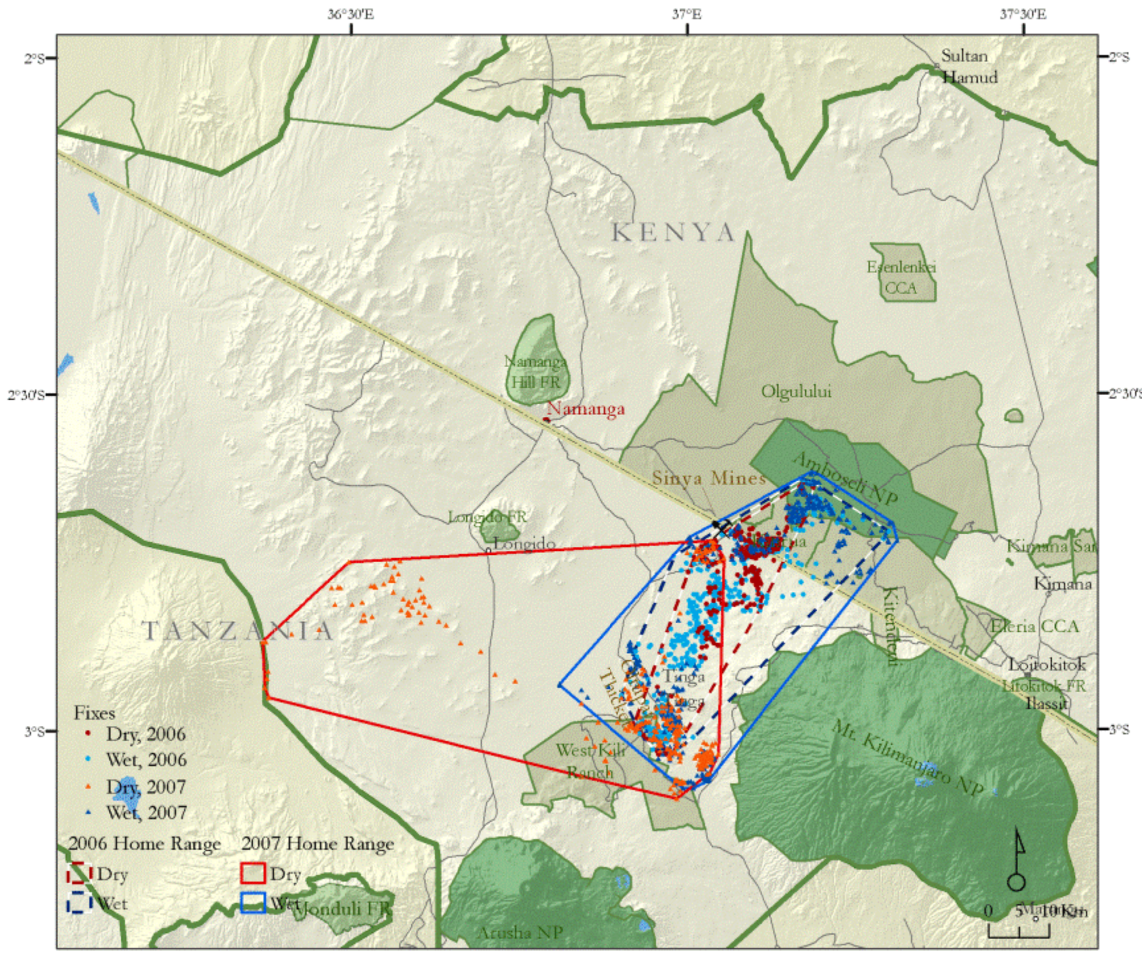


Figure 2.8b. Overall home range (95% FK), wet and dry season for subadult bull elephant (T9) in northern Tanzania, 2006 and 2007.

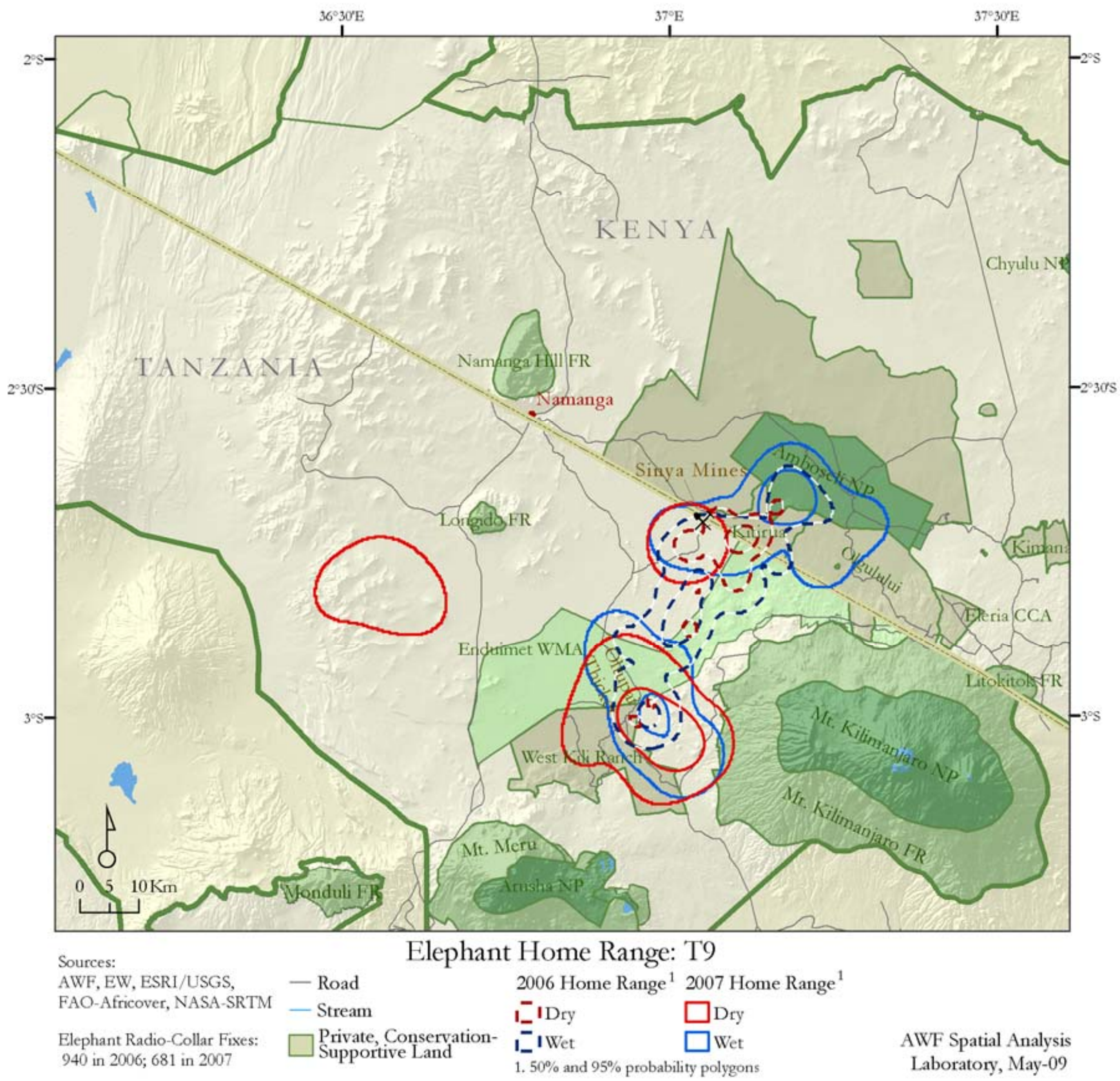


Figure 2.9a. Overall home range (100% MCP), wet and dry season fixes for adult female elephant (T10) in northern Tanzania, 2006 and 2007.

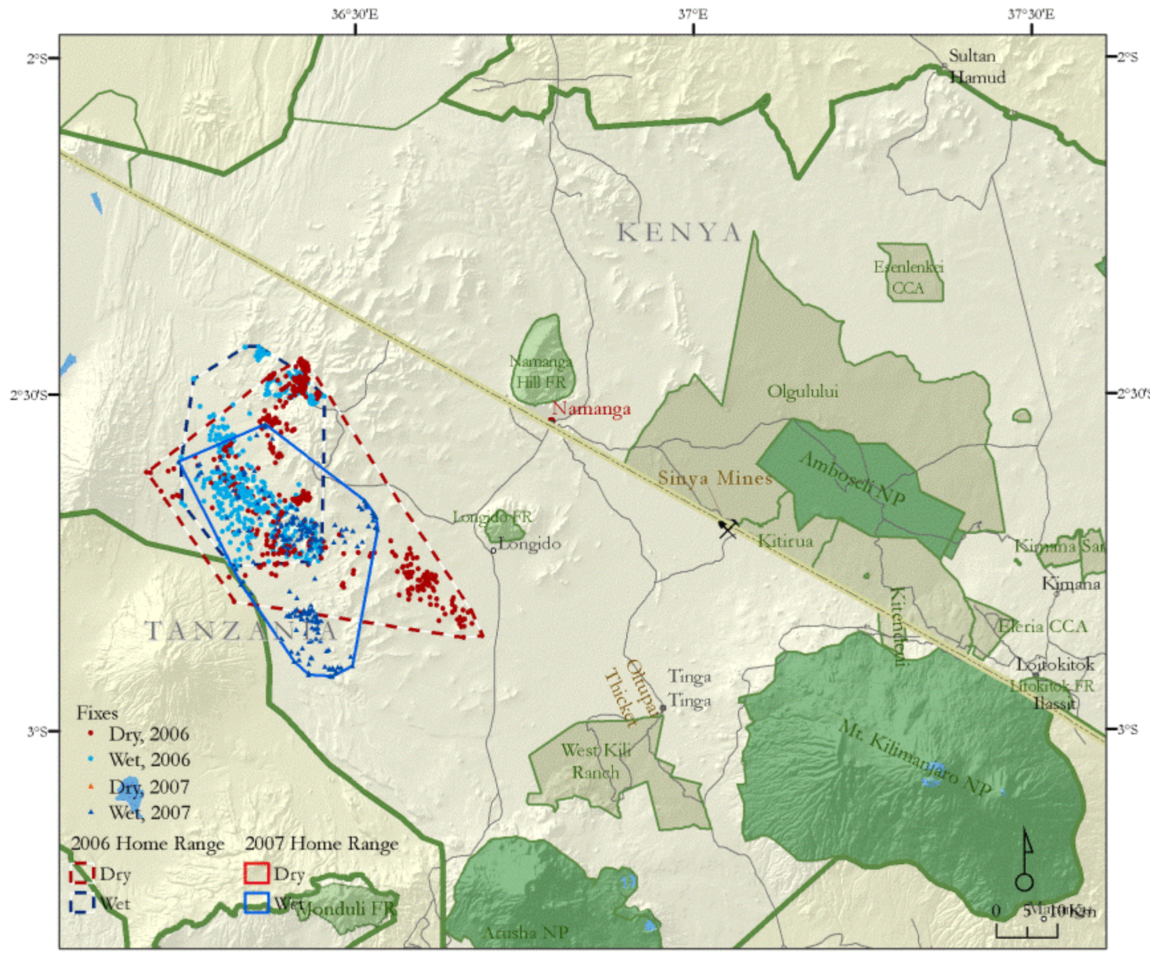


Figure 2.9b. Overall home range (95% FK), wet and dry season for adult female elephant (T10) in northern Tanzania, 2006 and 2007.

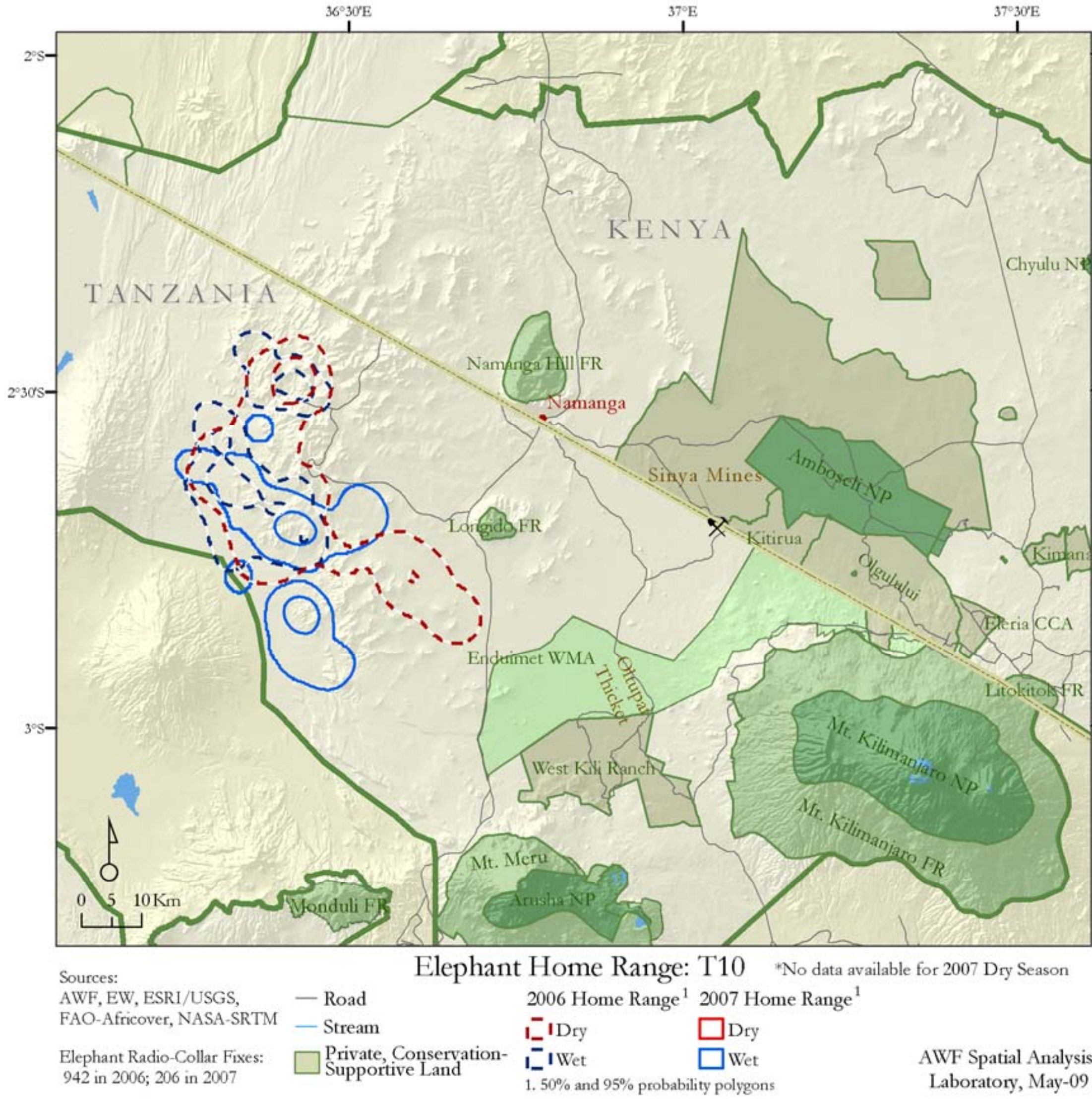


Figure 2.10a. Overall home range (100% MCP), wet and dry season fixes for adult female elephant (T12) in northern Tanzania, 2007 and 2008.

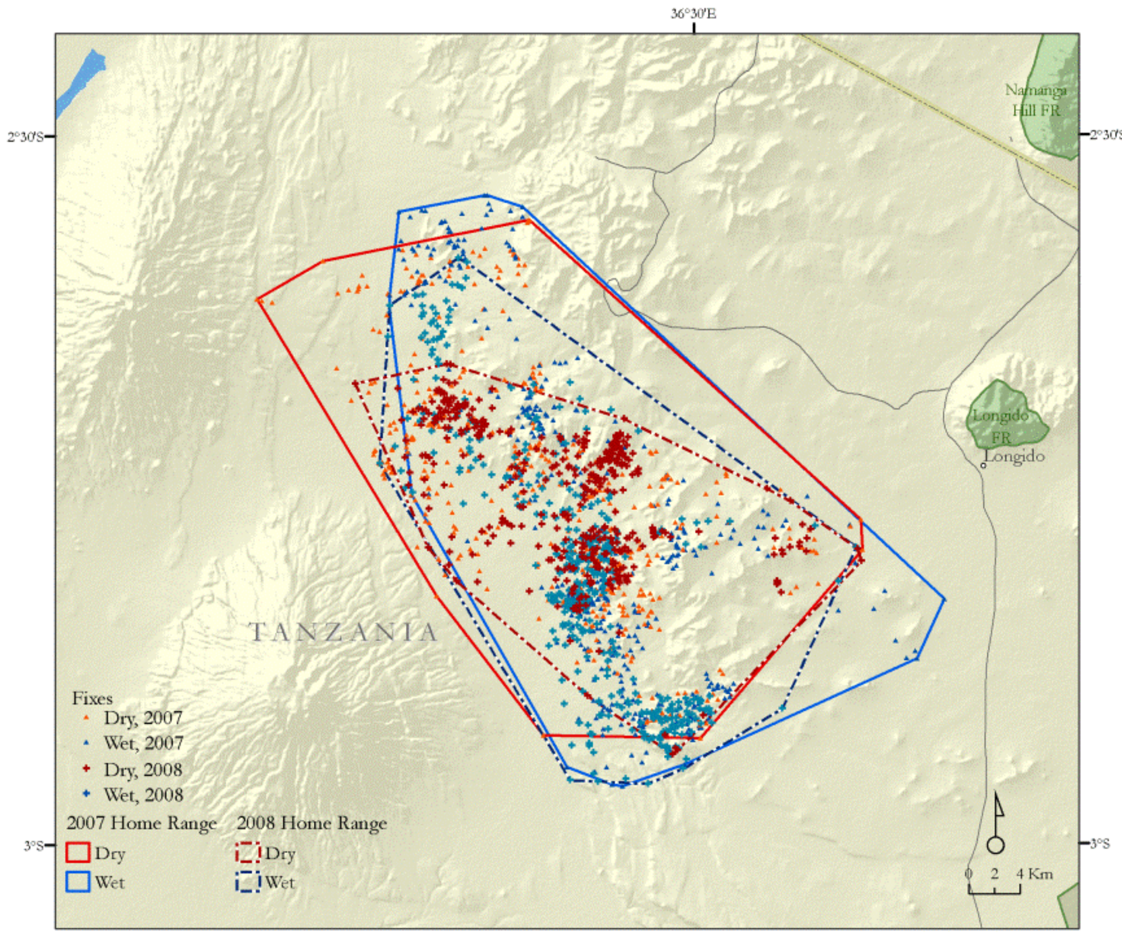


Figure 2.10b. Overall home range (95% FK), wet and dry season for adult female elephant (T12) in northern Tanzania, 2007 and 2008.

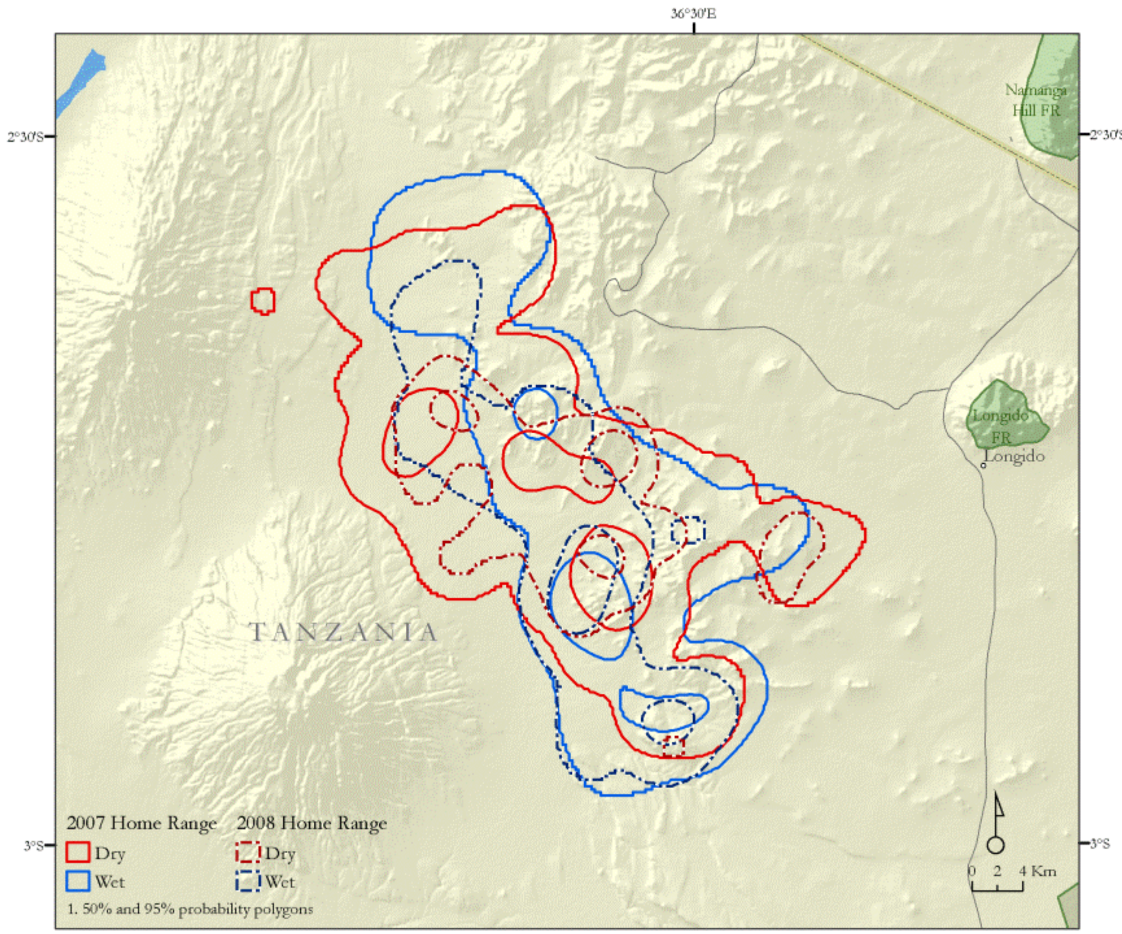


Figure 2.11a. Overall home range (100% MCP), wet and dry season fixes for adult female elephant (T13) in northern Tanzania, 2007 and 2008.

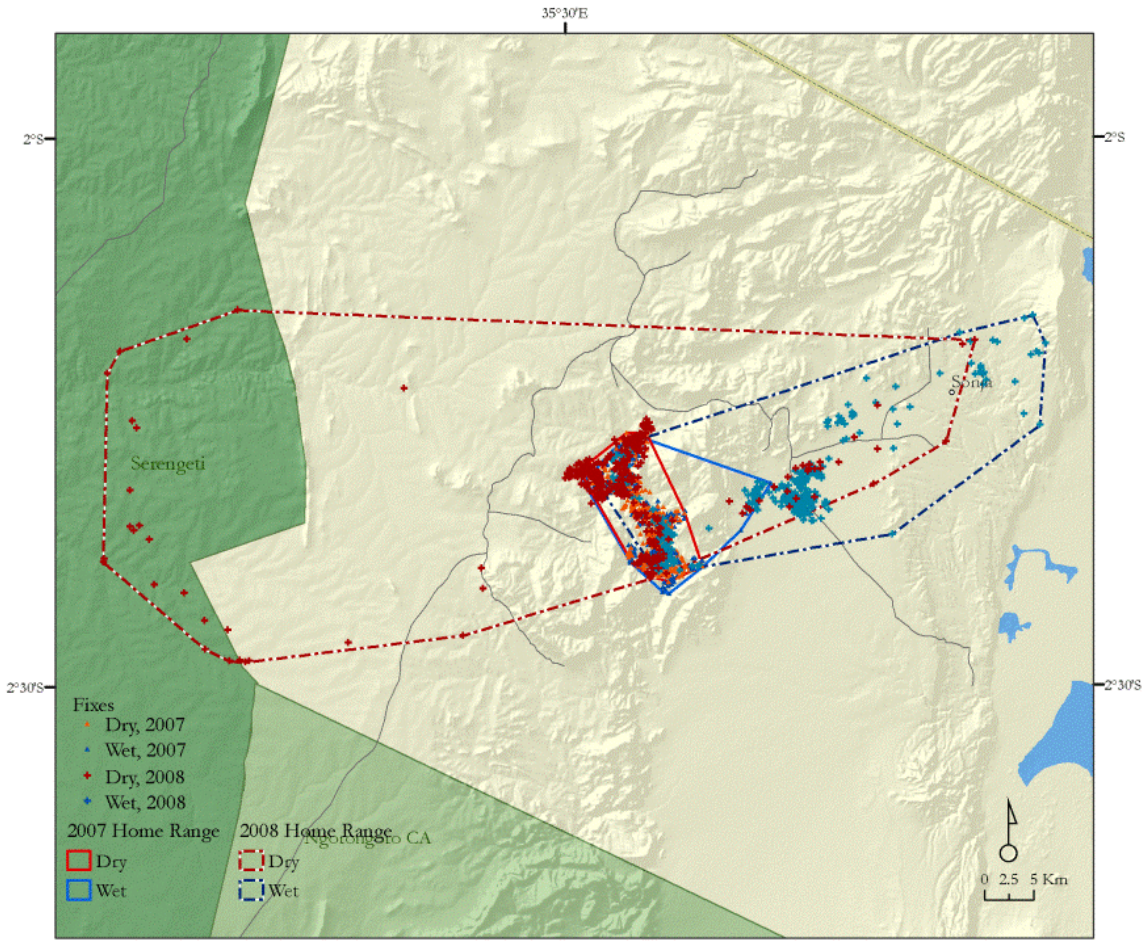


Figure 2.11b. Overall home range (95% FK), wet and dry season for adult female elephant (T13) in northern Tanzania, 2007 and 2008.

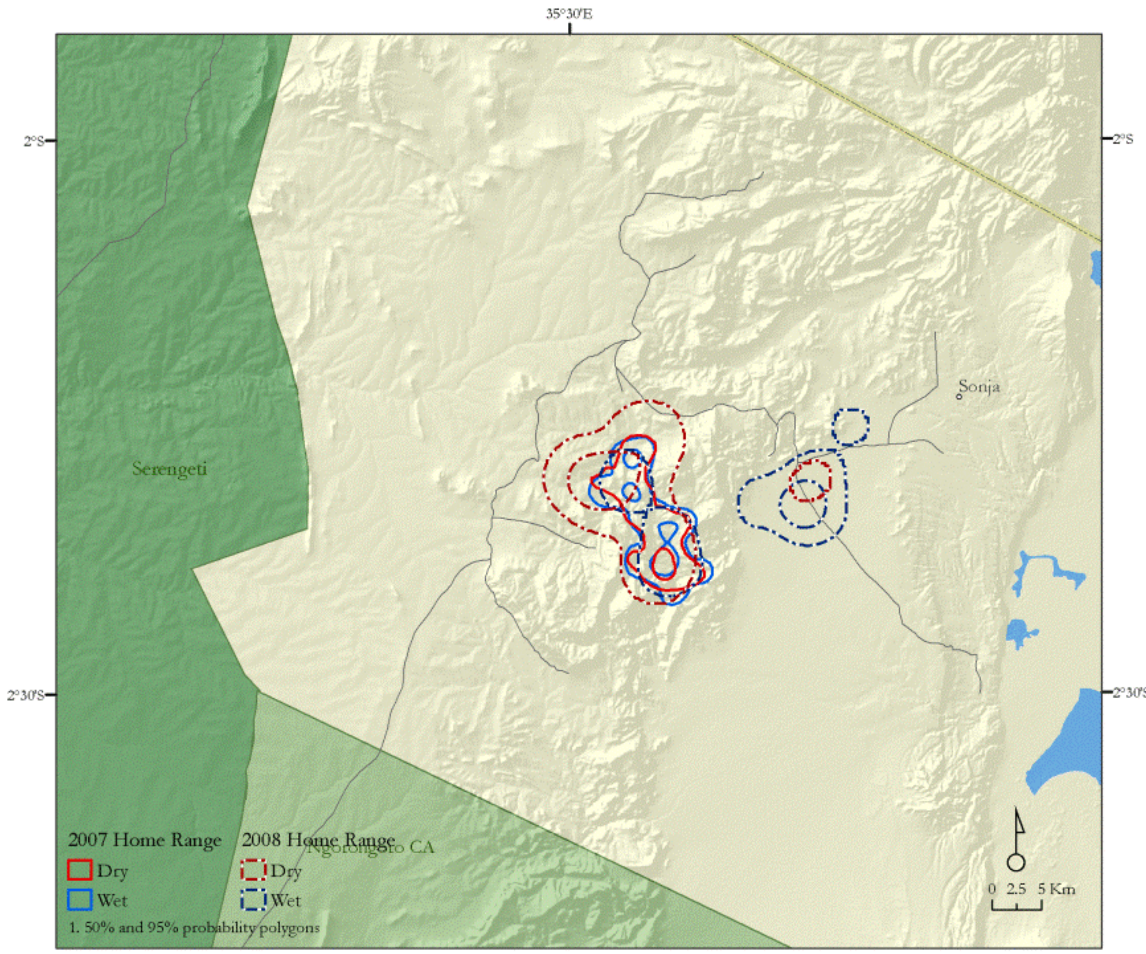


Figure 2.12a. Overall home range (100% MCP), wet and dry season fixes for adult female elephant (T15) in northern Tanzania, 2007 and 2008.

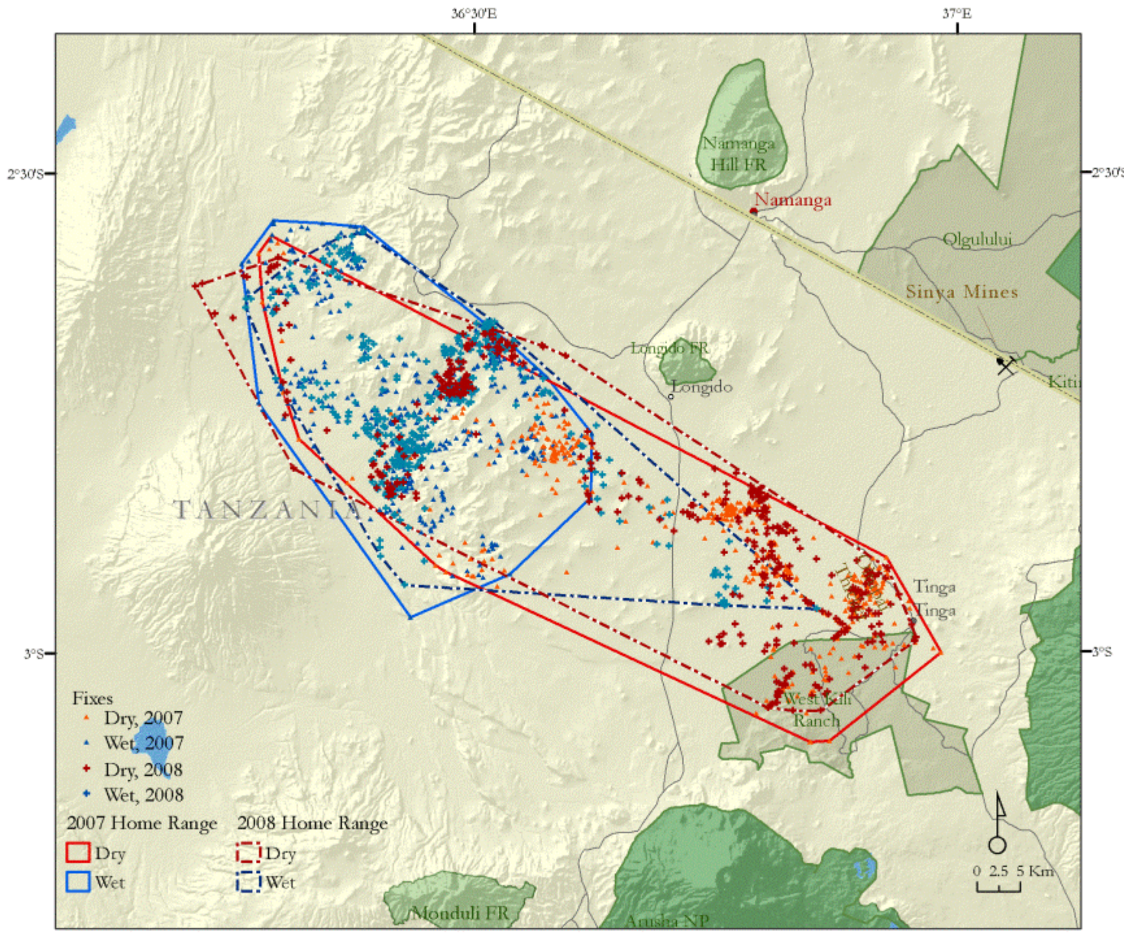


Figure 2.12b. Overall home range (95% FK), wet and dry season for adult female elephant (T15) in northern Tanzania, 2007 and 2008.

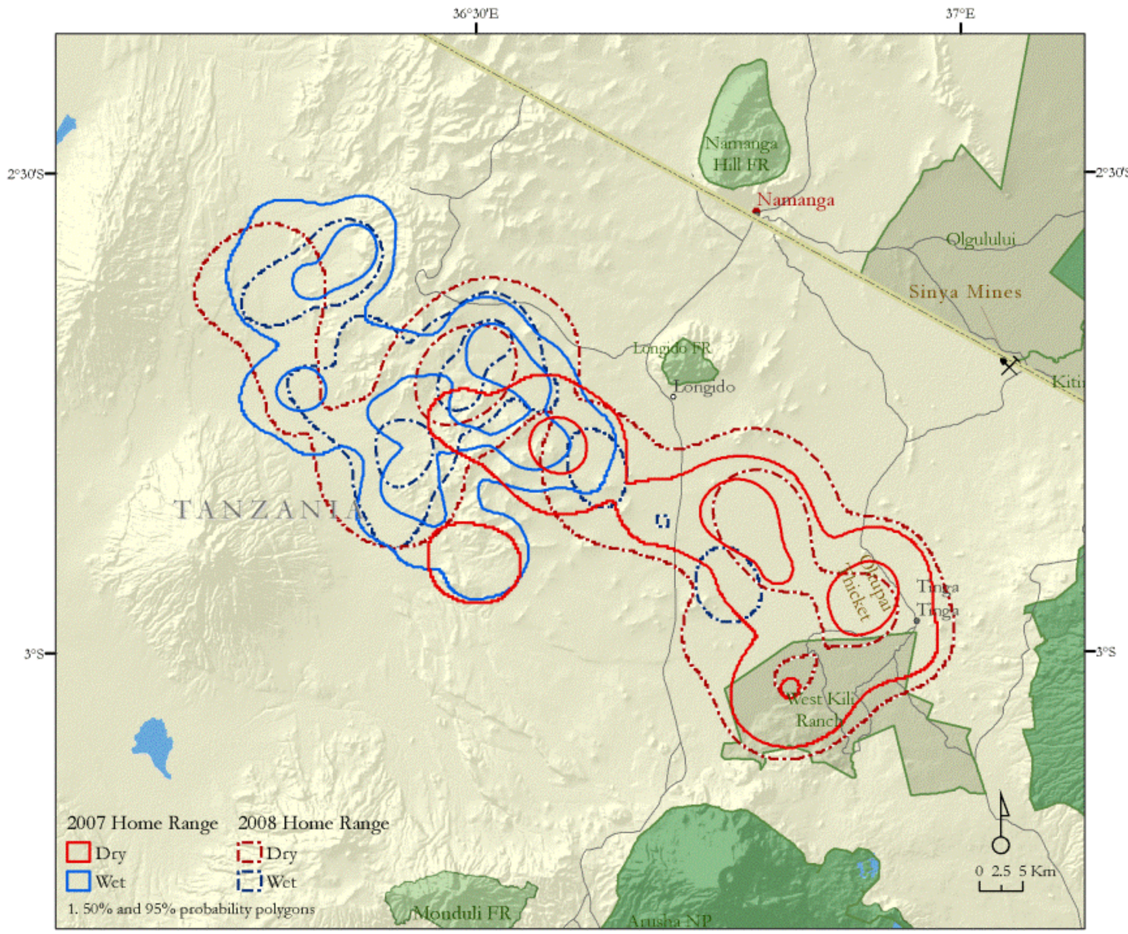


Figure 2.13a. Overall home range (100% MCP), wet and dry season fixes for adult bull elephant (T16) in northern Tanzania, 2007 and 2008.

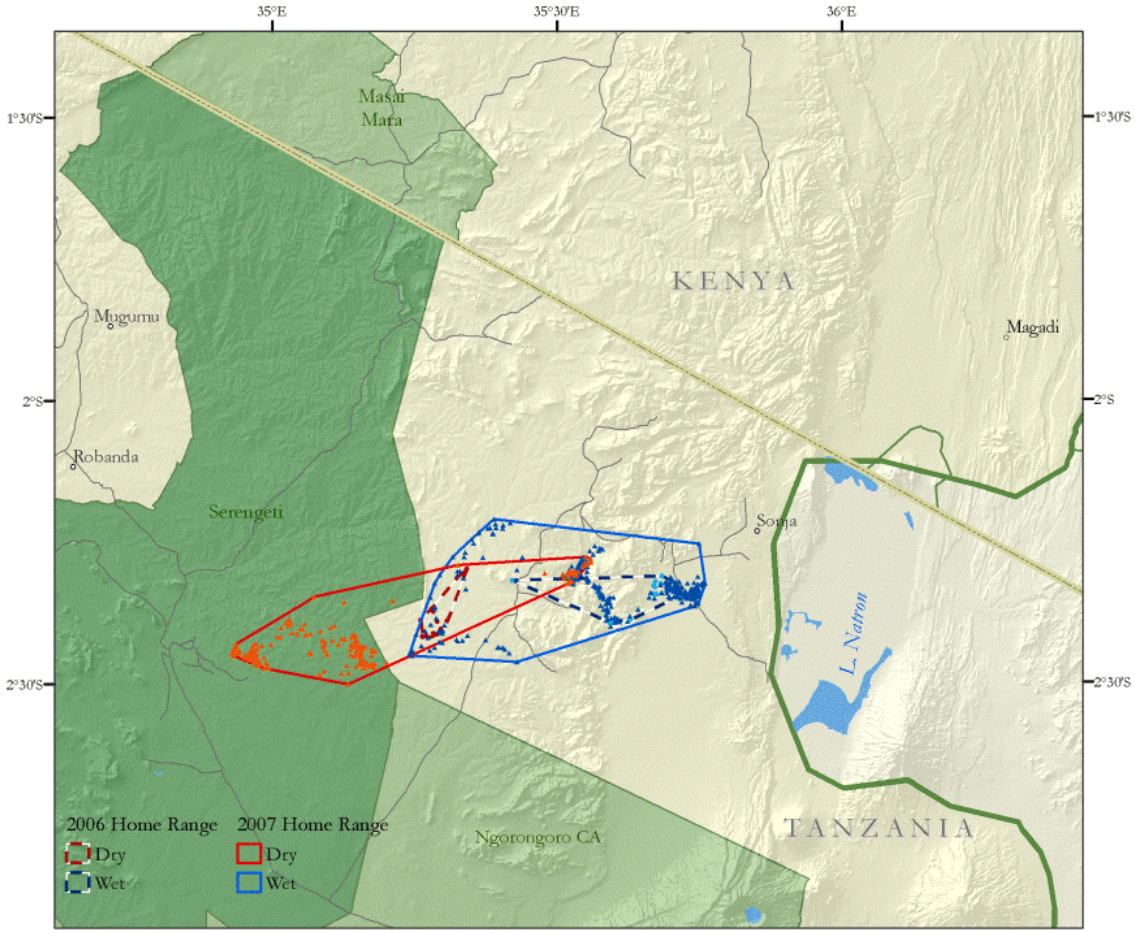


Figure 2.13b. Overall home range (95% FK), wet and dry season for adult bull elephant (T16) in northern Tanzania, 2007 and 2008.

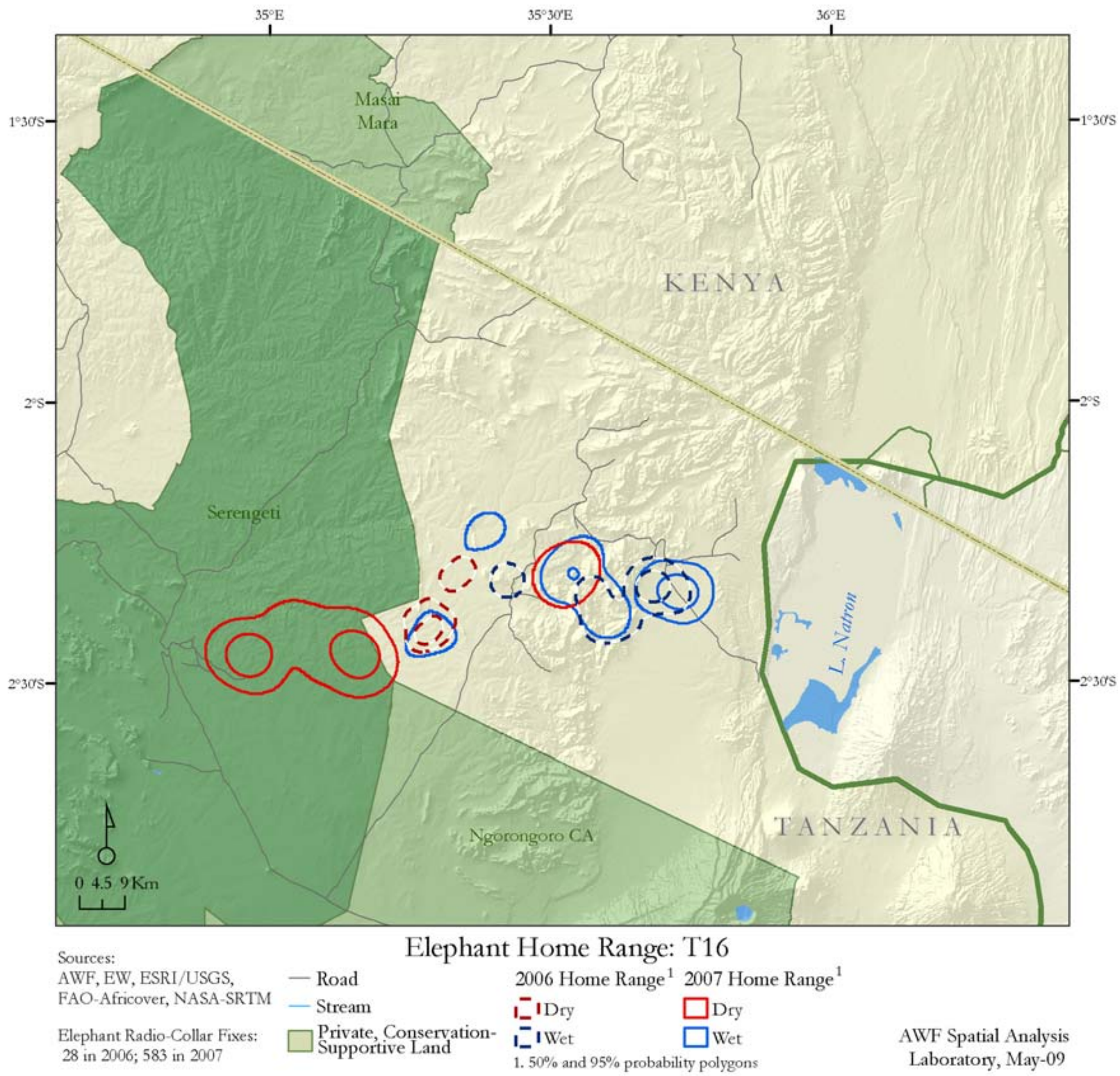


Figure 2.14a. Overall home range (100% MCP), wet and dry season fixes for adult female elephant (T17) in northern Tanzania, 2007 and 2008.

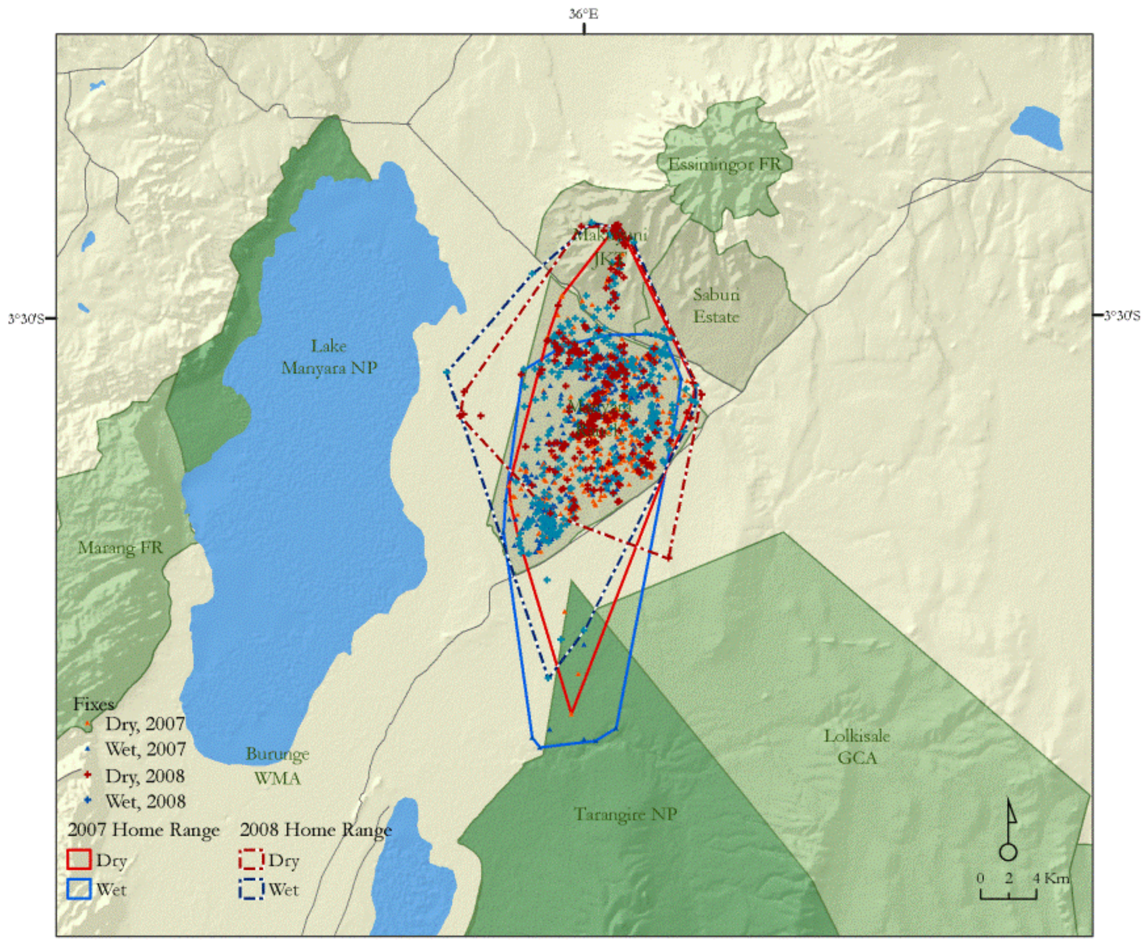


Figure 2.14b. Overall home range (95% FK), wet and dry season for adult female elephant (T17) in northern Tanzania, 2007 and 2008.

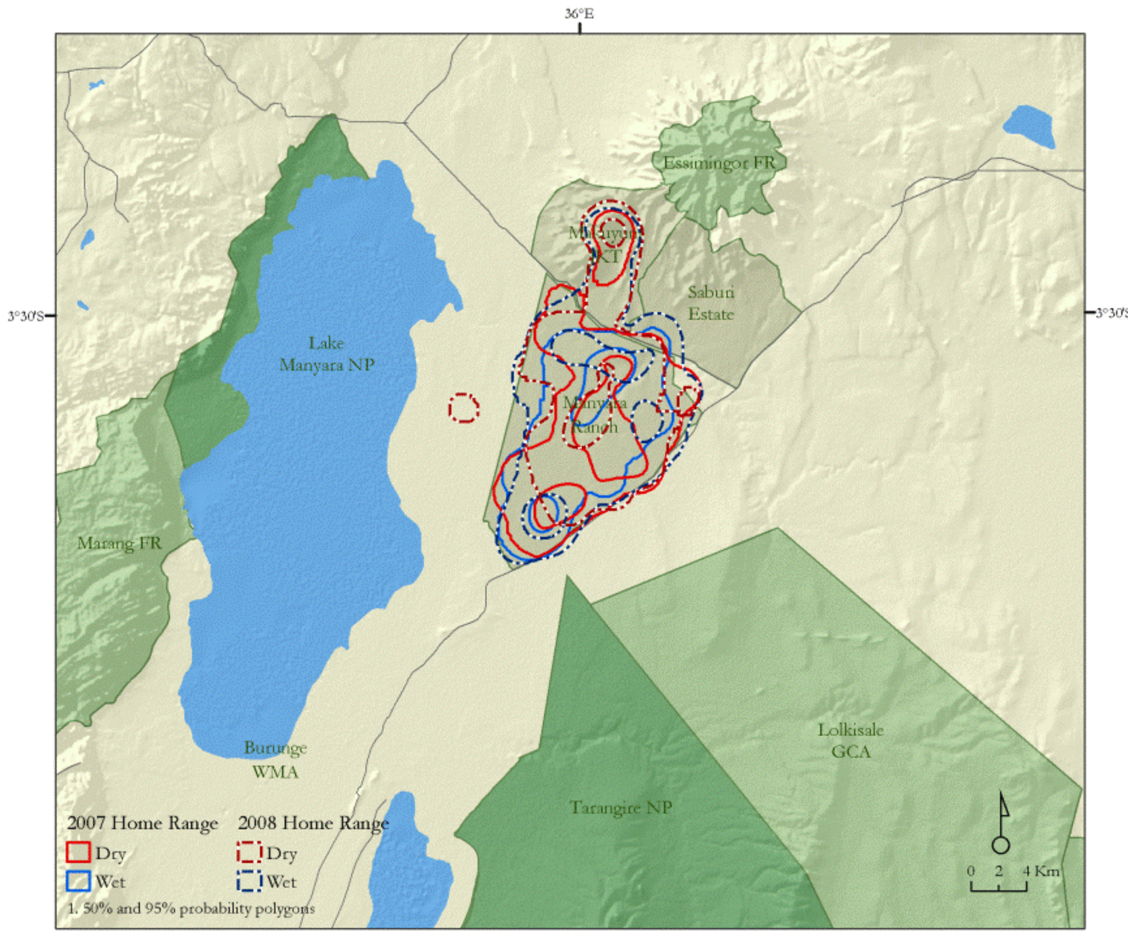


Figure 2.15a. Overall home range (100% MCP), wet and dry season fixes for adult female elephant (T18) in northern Tanzania, 2007 and 2008.

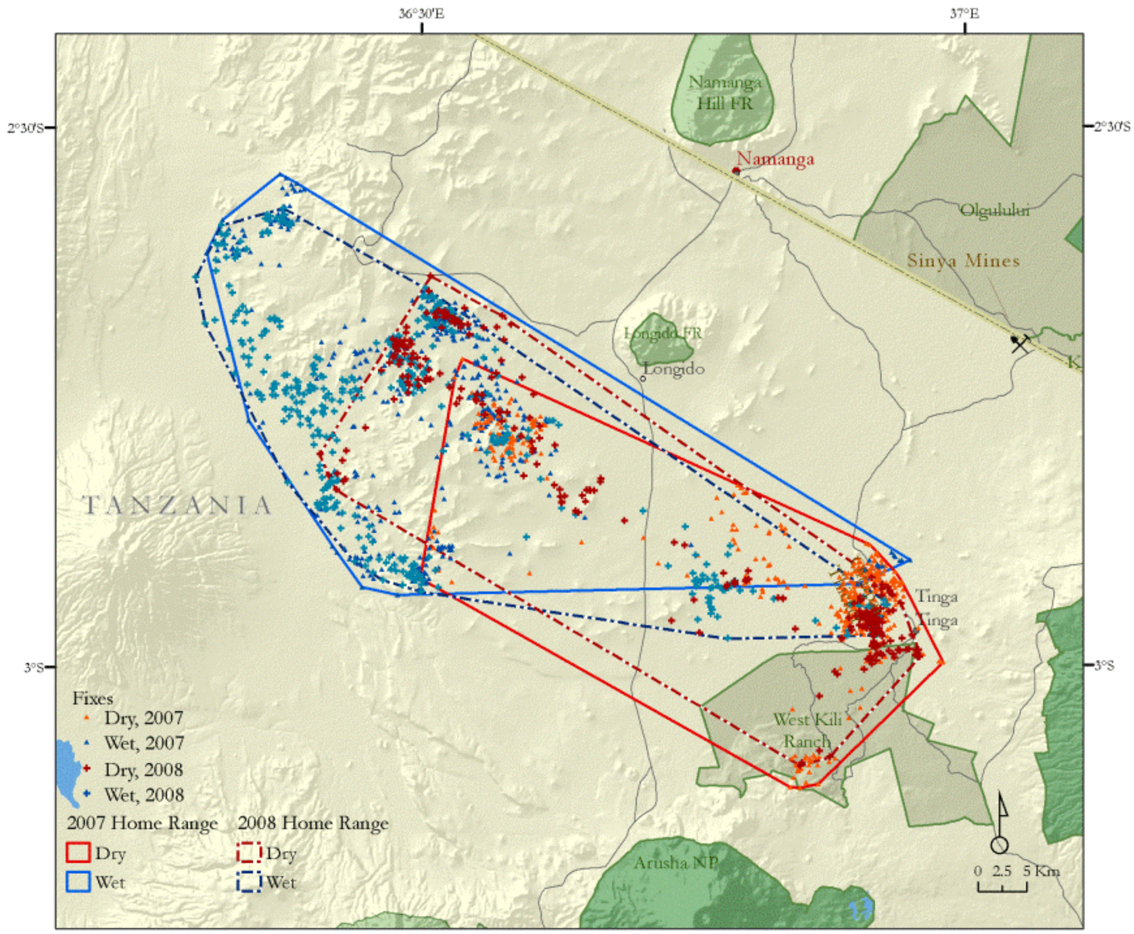


Figure 2.15b. Overall home range (95% FK), wet and dry season for adult female elephant bull (T18) in northern Tanzania, 2007 and 2008.

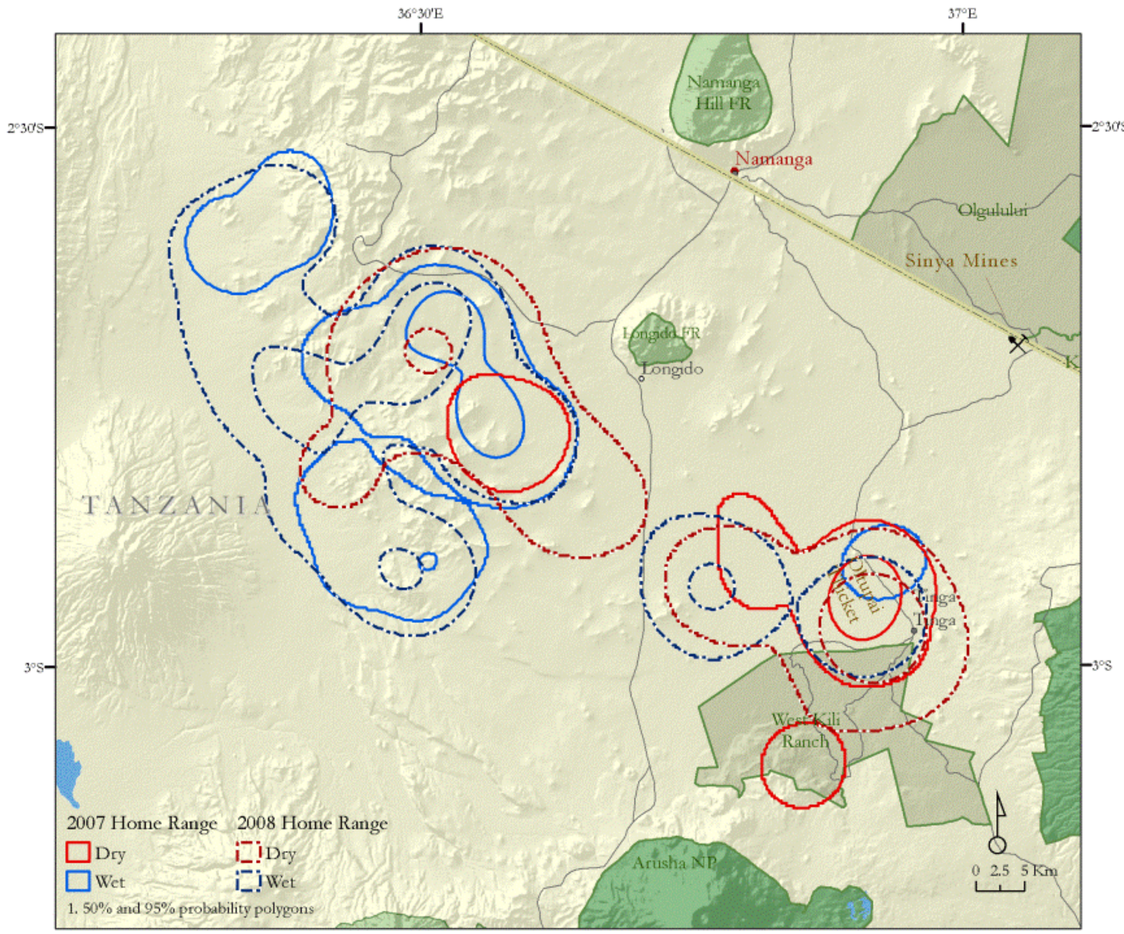


Figure 2.16a. Overall home range (100% MCP), wet and dry season fixes for adult bull elephant (T19) in northern Tanzania, 2007 and 2008.

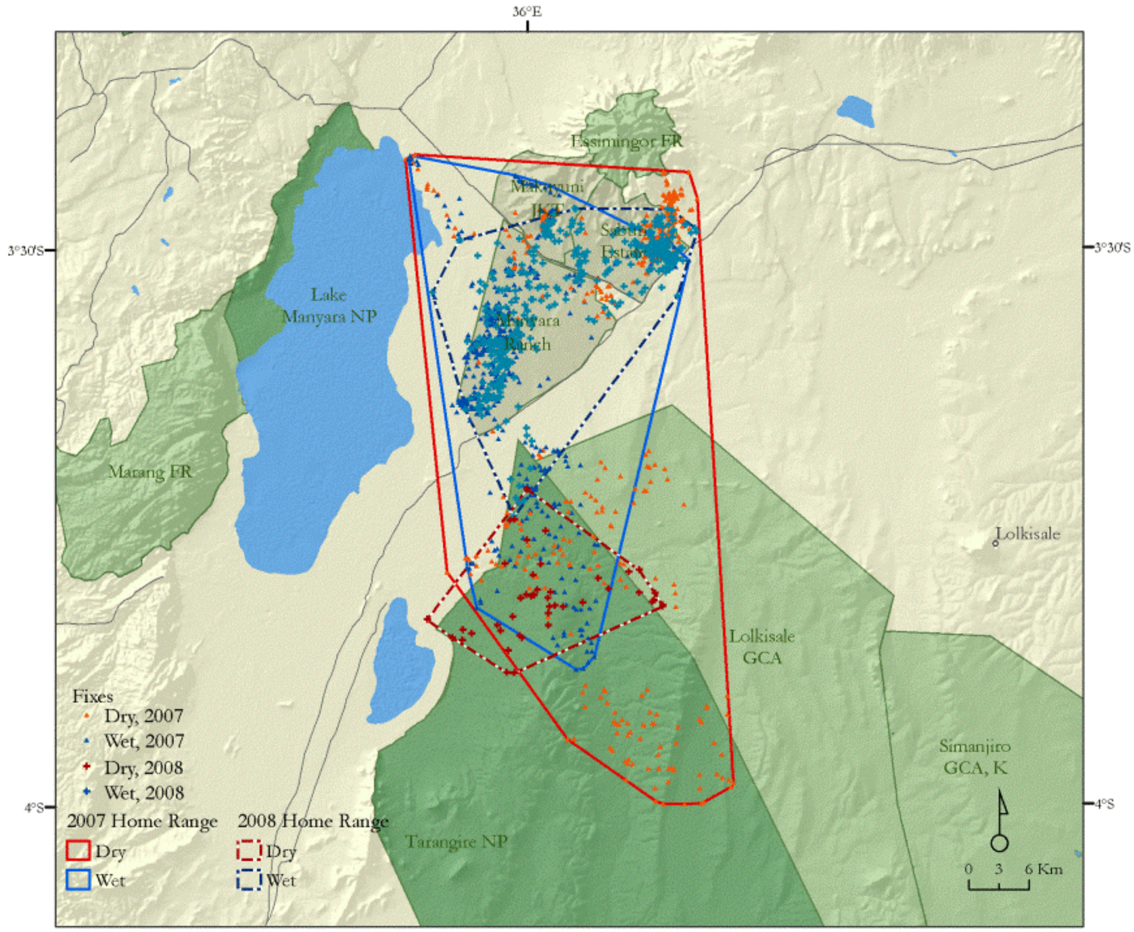


Figure 2.16b. Overall home range (95% FK), wet and dry season for adult bull elephant (T19) in northern Tanzania, 2007 and 2008.

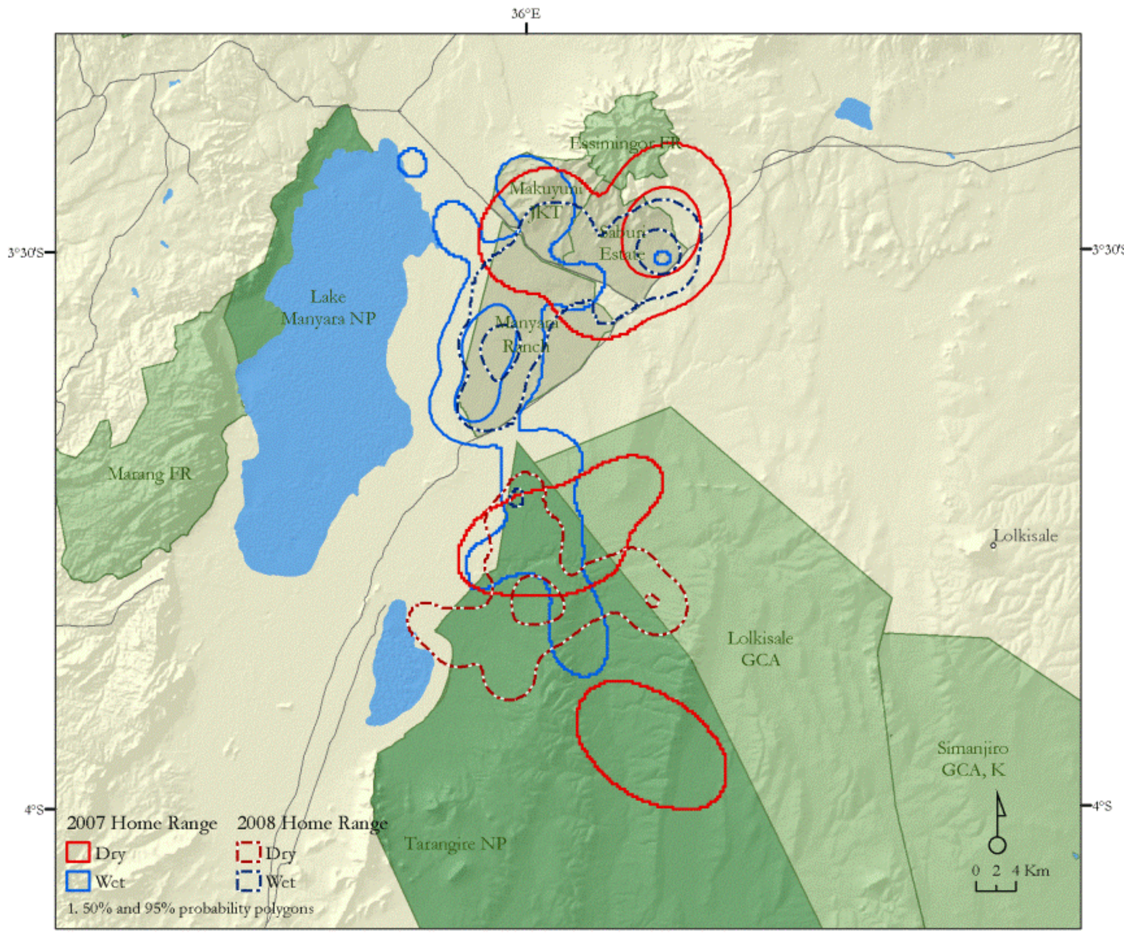


Figure 2.17a. Overall home range (100% MCP), wet and dry season fixes for adult female elephant (T20) in northern Tanzania, 2007 and 2008.

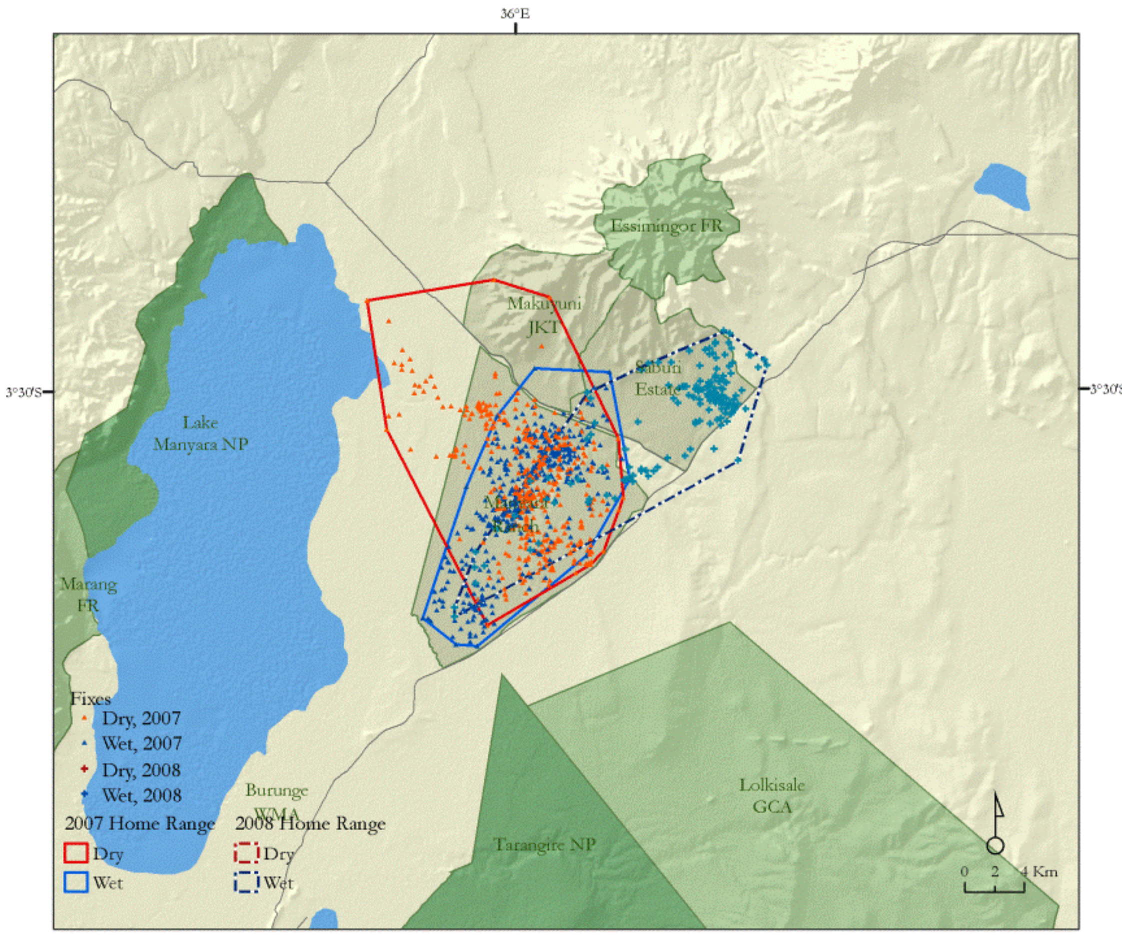


Figure 2.17b. Overall home range (95% FK), wet and dry season for adult female elephant (T20) in northern Tanzania, 2007 and 2008.

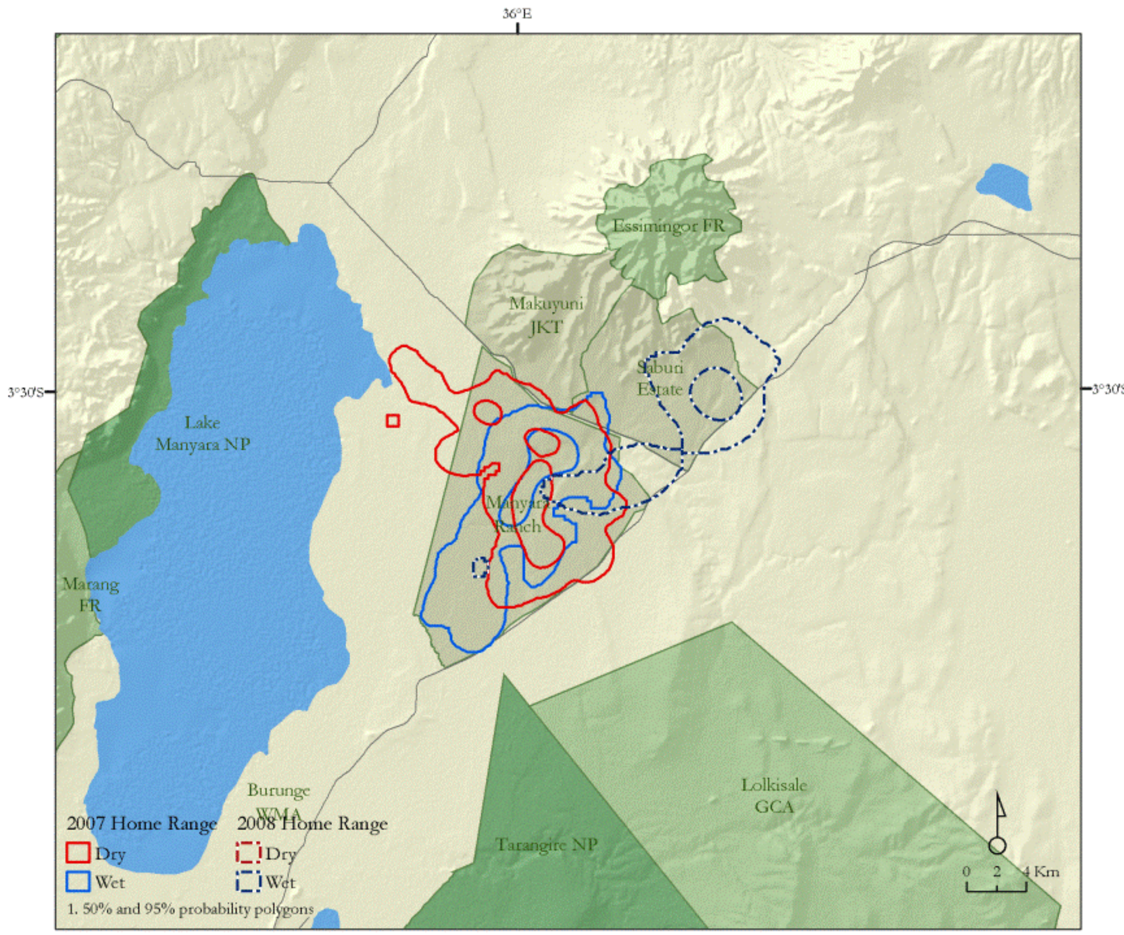


Figure 2.18a. Overall home range (100% MCP), wet and dry season fixes for adult female elephant (T21) in northern Tanzania, 2007 and 2008.

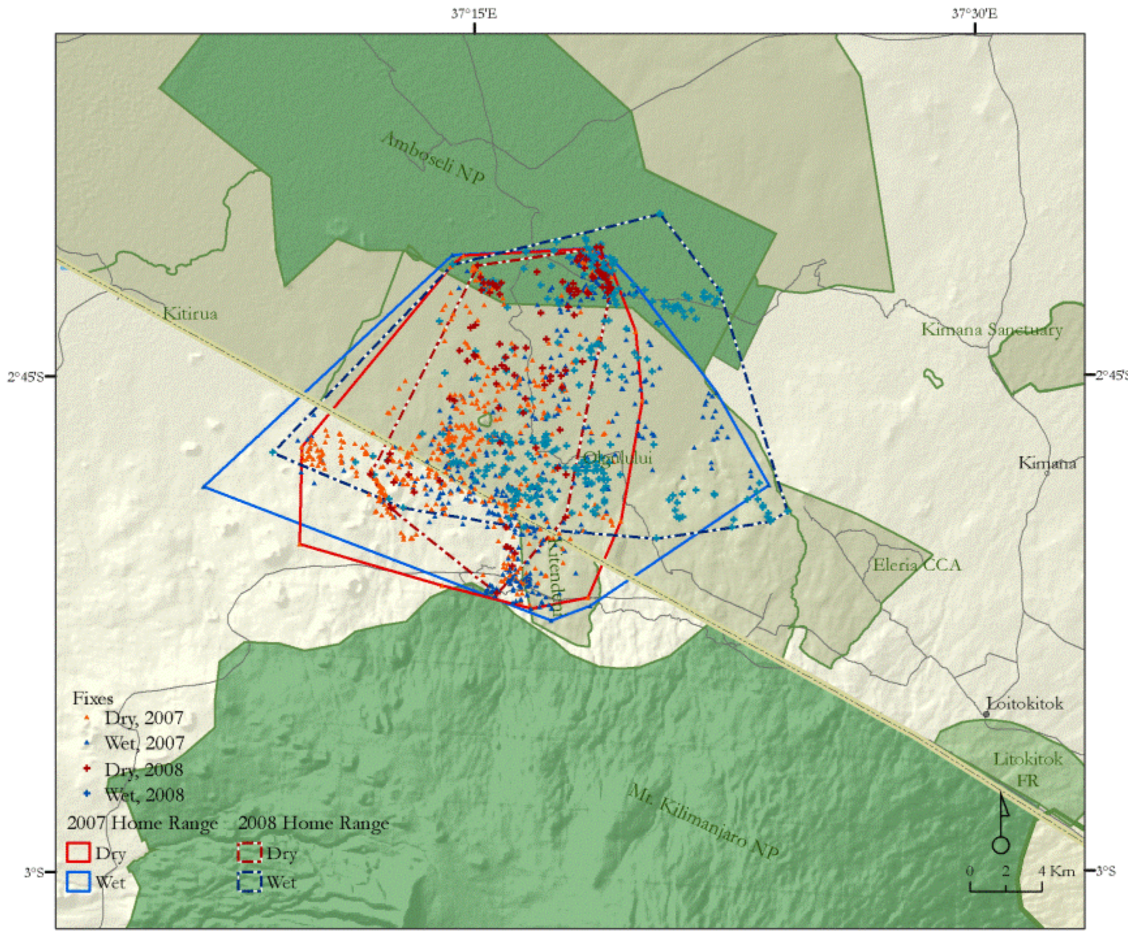


Figure 2.18b. Overall home range (95% FK), wet and dry season for adult female elephant (T21) in northern Tanzania, 2007 and 2008.

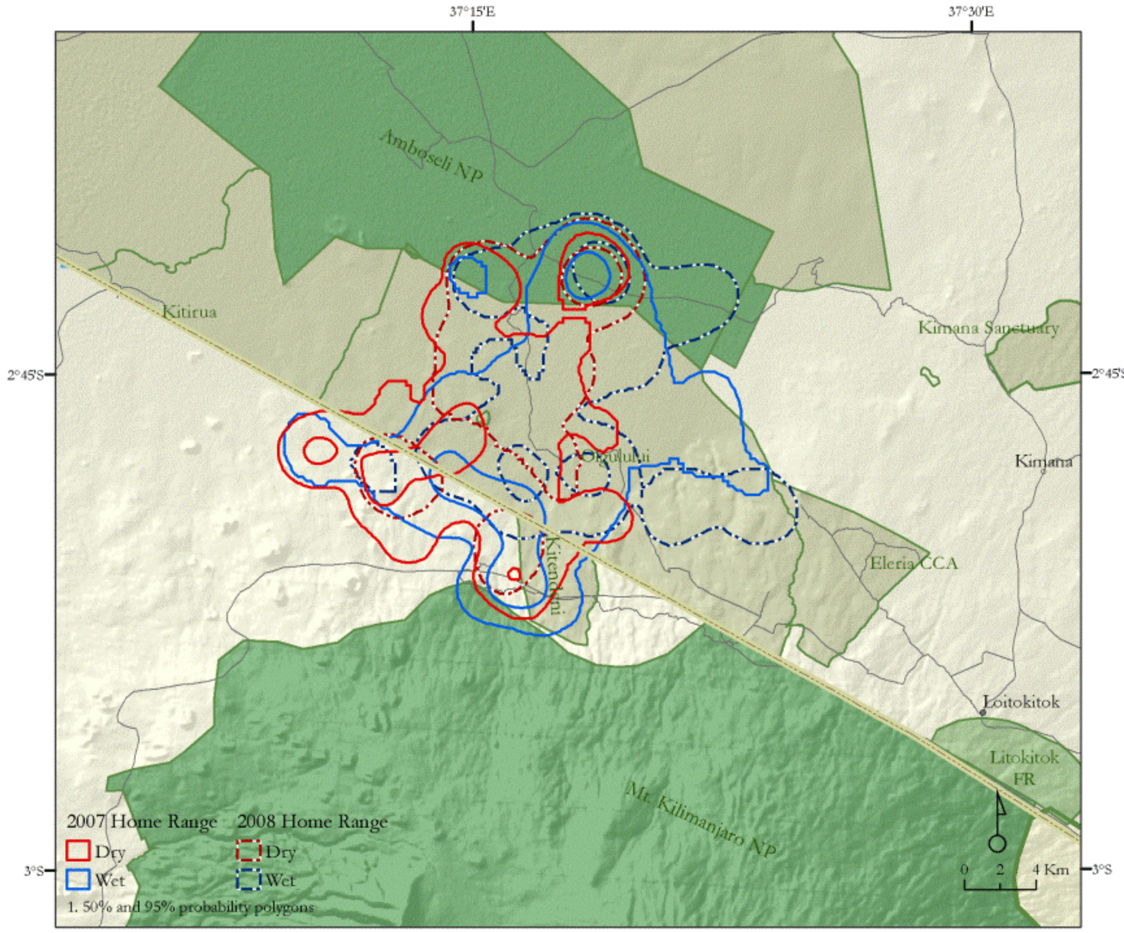


Figure 2.19a. Overall home range (100% MCP), wet and dry season fixes for adult female elephant (T22) in northern Tanzania, 2007 and 2008.

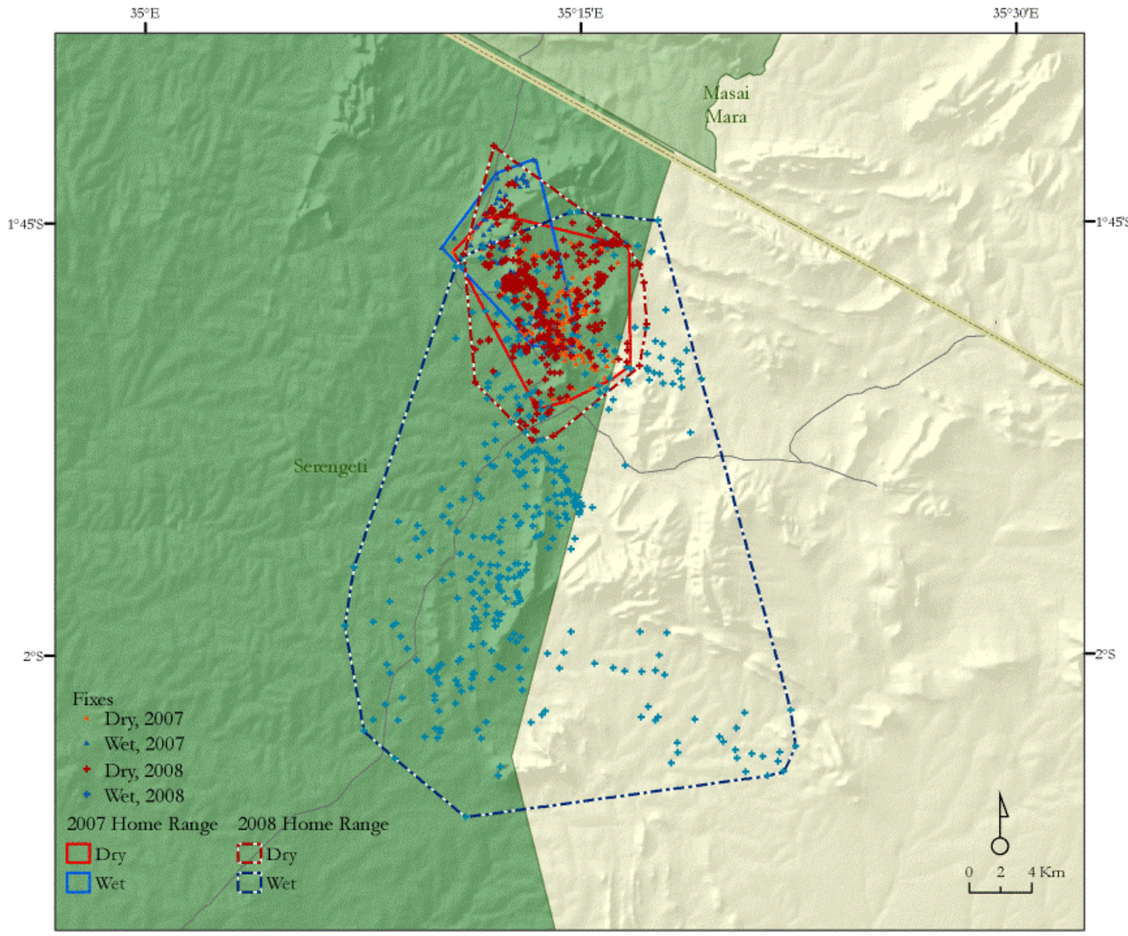


Figure 2.19b. Overall home range (95% FK), wet and dry season for adult female elephant (T22) in northern Tanzania, 2007 and 2008.

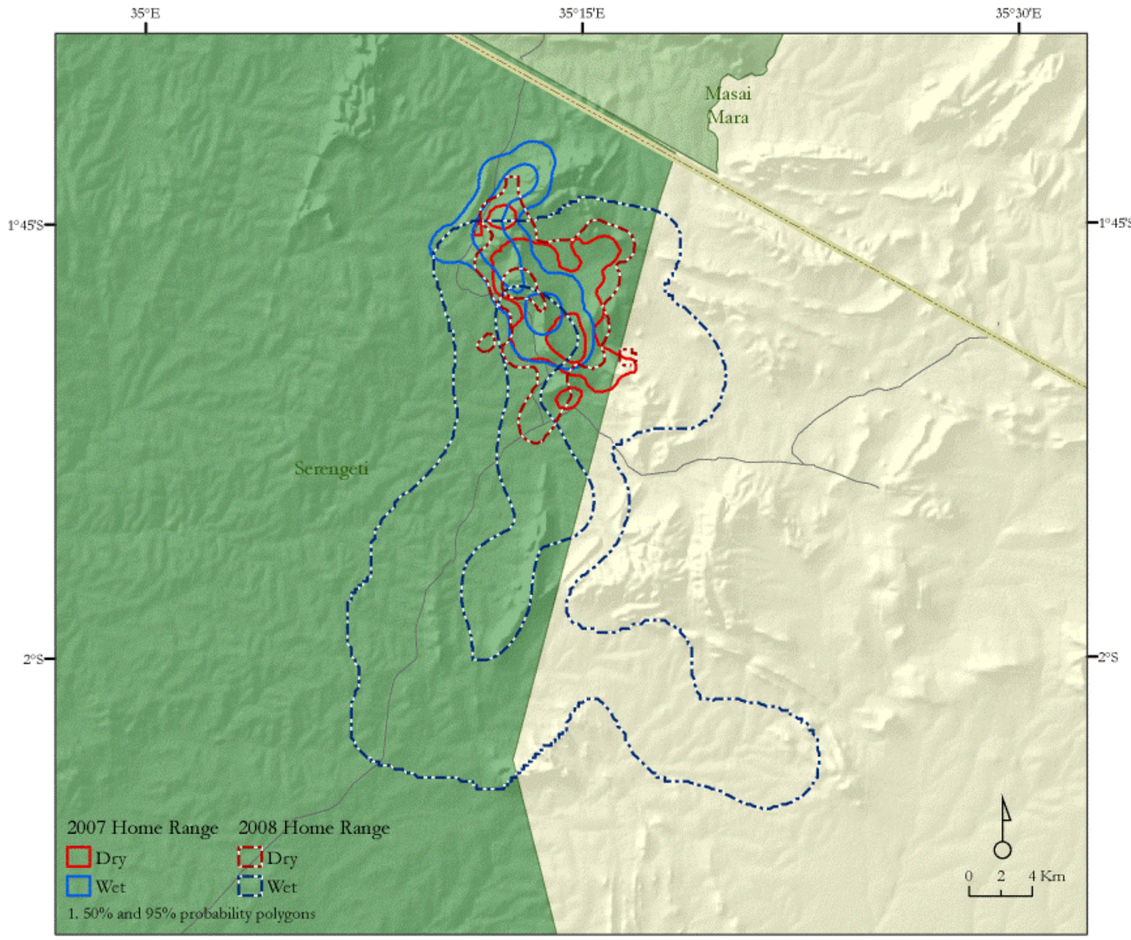


Figure 2.20a. Overall home range (100% MCP), wet and dry season fixes for adult bull elephant (T23) in northern Tanzania, 2007 and 2008.

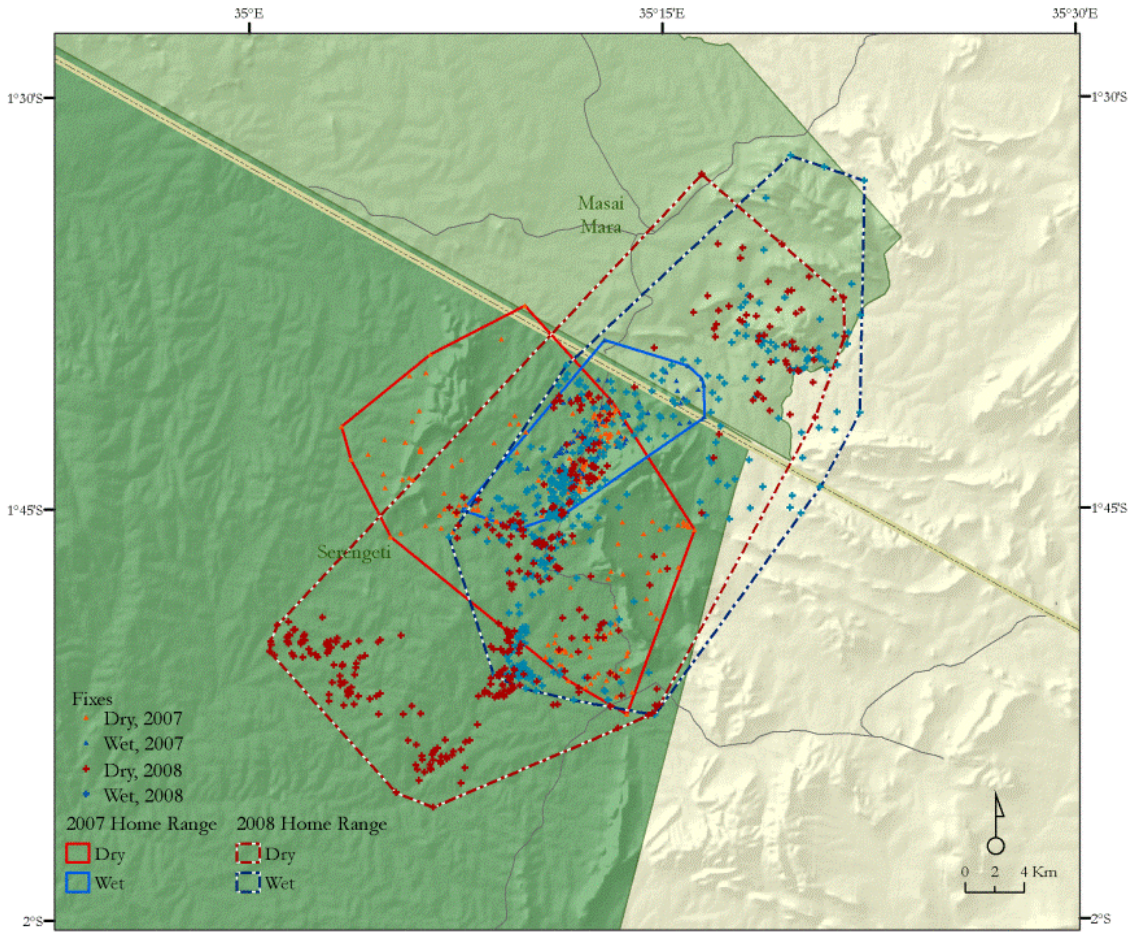


Figure 2.20b. Overall home range (95% FK), wet and dry season for adult bull elephant (T23) in northern Tanzania, 2007 and 2008.

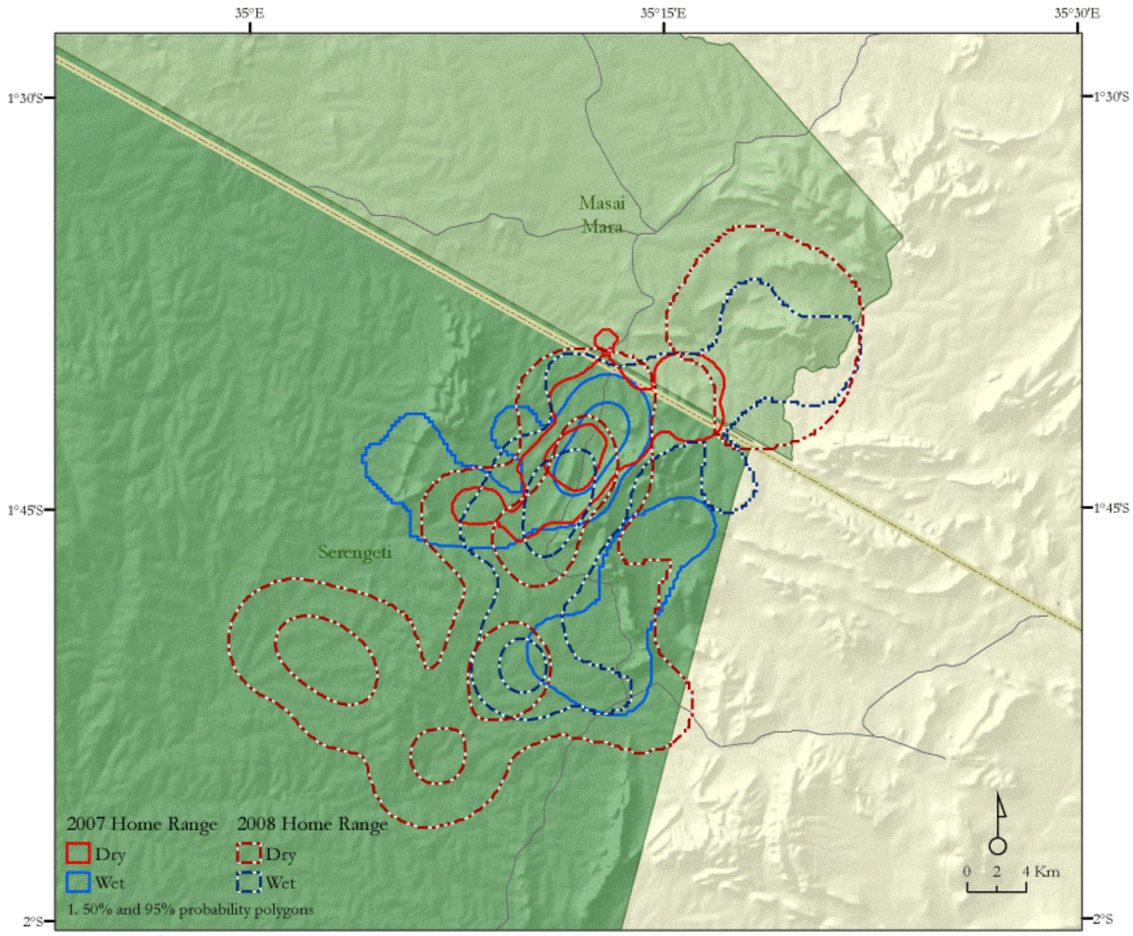


Figure 2.21a. Overall home range (100% MCP), wet and dry season fixes for adult female elephant (T25) in northern Tanzania, 2007 and 2008.

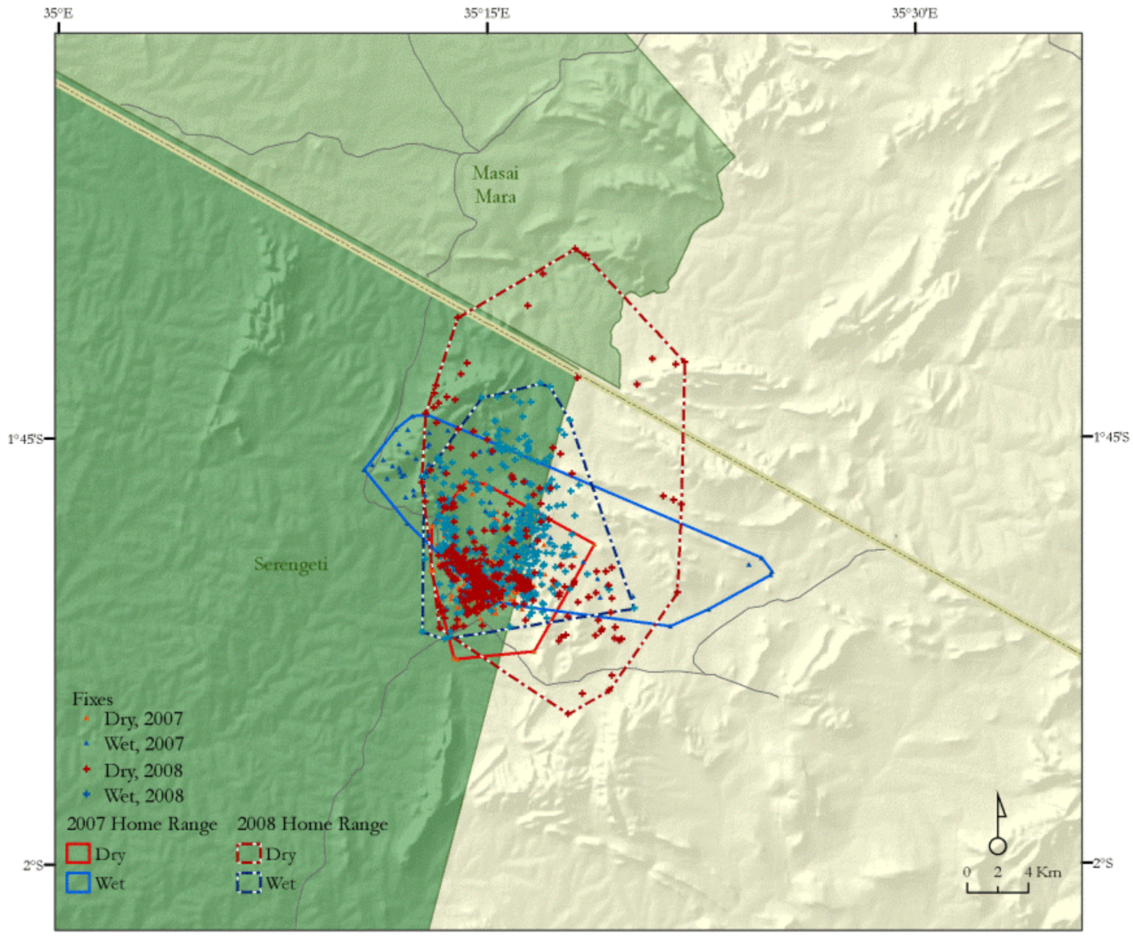
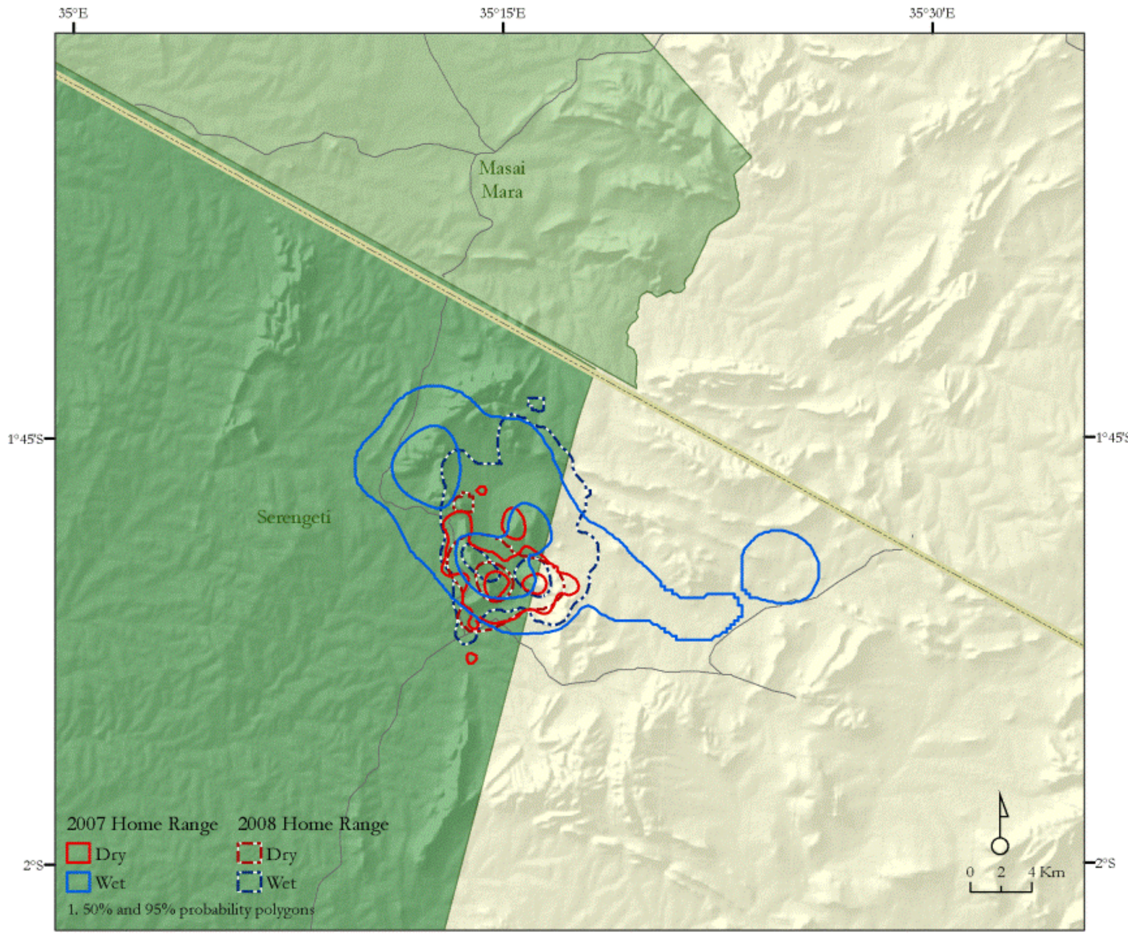


Figure 2.21b. Overall home range (95% FK), wet and dry season for adult elephant bull (T25) in northern Tanzania, 2007 and 2008.



CHAPTER III

TRANSBOUNDARY MOVEMENTS OF ELEPHANTS IN THE WEST KILIMANJARO REGION OF NORTHERN TANZANIA

Introduction

The elephants of Mt. Kilimanjaro have been considered distinct from those of the Amboseli elephant population in southern Kenya (C. Moss, pers. comm., cited in Western and Lindsay 1984) that rarely (Moss 2001), if ever (Afolayan 1975), disperse into southern Kenya. Similarly, it was believed there was little movement of Amboseli elephants to the forests of Kilimanjaro (Western and Lindsay 1984, Grimshaw and Foley 1991). Western and Lindsay (1984) reported that Amboseli elephants ranged over a 3,588-km^2 area primarily to the north and west of Amboseli NP and had a maximum dispersal distance of no more than 50 km during the wet season. However, in their aerial surveys and radio-tracking study, Western and Lindsay [1984:233 (fig. 1)] indicated that Amboseli elephants also ranged across the Kenya-Tanzania border to the south and west of Amboseli NP. Douglas-Hamilton et al. (2005) reported on the movements of two bull elephants tagged with GPS collars in Amboseli NP. Both bulls ranged widely outside of the park, spending 60% and 90% respectively, of their time outside of protected areas. One of these tagged elephants dispersed south, crossing the Kenya-Tanzania border to the Longido Game Controlled Area. Kikoti (2002) reported that 70 of the 100 elephants he photographed in West Kilimanjaro matched the photographs of recognizable Amboseli elephants in the Amboseli Elephant Research Project database. Further, he reported that elephants regularly used a 6-km-wide vegetation corridor to move between the forest border of Kilimanjaro NP and the Kenya-Tanzania border, and he suggested that some elephants may be moving far beyond West Kilimanjaro. However, the movement patterns of elephants in West Kilimanjaro are unknown. Further, elephants moving across the West Kilimanjaro landscape must cope with a complex mosaic of natural communities, agricultural fields, grazing lands, and human settlements; thus, there is a significant potential for human-elephant conflicts. With increasing human populations and loss of natural habitats in the region, this potential for conflict will increase. Thus, the goals of this project were to determine 1) extent of transboundary movements, 2) use of protected and unprotected areas, and 3) important habitats for elephants in the West Kilimanjaro region of northern Tanzania and Amboseli Basin of southern Kenya. Such information is critical for assessing the importance of immigration/emigration in the dynamics of this regional elephant population, establishing regional conservation corridors, and developing regional conservation plans for the elephants of West Kilimanjaro.

Study Area

West Kilimanjaro (West Kili) (3,068 km^2) is within the Longido, Arumeru and Siha districts of Arusha and Kilimanjaro region of northern Tanzania (Fig. 3.1). The northern extent of the region is the Tanzania-Kenya border from near the border town of Namanga southeastward to Irkaswa Village. The eastern border extends around the northern and western flanks of Mt. Kilimanjaro defined by the boundary of Kilimanjaro National Park (NP) extending southward to near the community of Sanya Juu. The southern extent of this study region extends west from Sanya Juu to the northeast corner of Arusha NP, continuing along the northern park border to the Arusha-Nairobi Road that also defines the western extent of the study region. The region is a complex mosaic of diverse natural communities, extensive grazing lands, and large agricultural fields at lower elevations on Mt. Kilimanjaro and Meru. There are traditional, agro-pastoral Maasai communities (n=12) that graze cattle and other livestock and raise subsistence crops. In addition, there are five other moderately-sized agricultural communities in the region. There are several protected areas in the study region, including Kilimanjaro NP (1,665 km^2) on the eastern boundary, Arusha NP (137 km^2) to the south, and Amboseli NP (390 km^2) in southern Kenya, 20 km north of the Tanzania-Kenya border. Additionally, there are two private conservation areas, West Kilimanjaro Ranch (303 km^2) and Endarakwai Ranch (44 km^2), and the Longido Game Controlled Area (1,700 km^2) that provide important habitats for wildlife. Although variable with elevation (1,230 to 1,600 m), the predominate ecological zone is semi-arid savannah (Pratt et al. 1966) interspersed with woodlands, and there are extensive agricultural fields along the lower, western flank of Mt. Kilimanjaro and lowland forests within the boundary of Kilimanjaro NP. Distribution of rainfall is unpredictable, especially at lower elevations, and highly variable from year to year. Rainfall amounts average 350 mm/yr in semi-arid lower elevations (KWS records, 1988) and 890 mm/yr in agricultural areas at lower elevations on Mt. Kilimanjaro (Rey and Das 1996). Although northern Tanzania typically has two rainy seasons with the long rains from March to May and the short rains from November to December, we delineated November to May (7 mos) as the wet season, corresponding to the period when vegetation was green and water is typically available in seasonal pans. We delineated June to October (5 mos) as the dry season, corresponding to low precipitation and low water availability in seasonal pans.

Methods

Eight elephants (3 bulls and 5 females) were fitted with satellite collars in West Kilimanjaro in September 2005 (n=6), January 2006 (n=1) and November 2006 (n=1)(Table 3.1). No more than one individual was collared within a herd. We also tried to choose herds that were widely separated from each other within an area to reduce the probability that herds were members of the same clan (Poole 1996). For family groups, we targeted a middle-aged adult female in the herd for collaring. One subadult (18-20 yrs old) and two adult bulls (35-40 yrs old) were tagged in bull herds.

Six elephants darted from the ground and two darted from a helicopter were immobilized by a veterinarian using ethorphine hydrochloride (M99: C-vet UK) in darts fired from a modified .22-caliber rifle following the guidelines recommended by Thouless (1995). Once the elephant was immobilized and recumbent, it was fitted with a satellite telemetry unit; a blood sample taken; measures made of shoulder height, back length, tusk length, tusk basal circumference, and hind foot length and circumference; age estimated by size and head configuration; and health status evaluated. The effect of immobilizing drug was reversed using diprenorphine (M5050: C-vet UK).

We used GPS receiver collars on all elephants (African Wildlife Tracking, Pretoria, South Africa), and collared elephants were monitored for varying lengths of time, depending on collar performance (Table 3.1). The duty cycle of units was set to download three GPS fixes per day, one every eight hours (~0200, ~1000, ~1700 hrs). However, beginning November 2007 (wet season of 2008), the duty cycle of units T1-6 was reduced to two fixes per month to conserve battery life pending removal of collars. The geographic accuracy of locations was 15 m for six collars we field-tested prior to deployment. All units were equipped with a VHF transmitter, allowing periodic tracking of the collared elephant and retrieval of the unit.

Numbers of transboundary movements across the Tanzania-Kenya border were calculated using ARCGIS software using the elephant path files and field calculator to determine border crossing frequencies by season and year. Numbers of transboundary crossings were weighted by number of months tracked in each season. The seasonal and annual occurrences of elephants in protected versus unprotected areas were determined by plotting the number of fixes that occurred within each land use category. We considered fixes in Amboseli, Arusha, and Kilimanjaro NPs as occurring in protected areas, while all other fixes were considered occurring in unprotected areas. Following the procedures reported by Douglas-Hamilton et al. (2005), we identified important habitats by constructing a 250-m grid over the study area and calculating the frequency that elephant pathways crossed each grid square during the entire tracking period. Student t-tests were used to test for differences in transboundary crossings between sexes, wet and dry seasons, and time spent in protected and unprotected areas.

Results

Transboundary Movements

All eight elephants crossed the Tanzania-Kenya border during the monitoring period, but numbers of transboundary movements were highly variable between bulls and females and between seasons (Table 3.1). Overall, there was no difference in mean number of transboundary movements per season between bulls ($\overline{X}$ =3.36, SD=1.44, n=3) and females ($\overline{X}$ =2.28, SD=2.09, n=5)(t=0.86, df=6, P=0.423), but bulls crossed 47% more frequently than females. Both bulls and females crossed the border in both wet and dry seasons, but typically elephants crossed more frequently in the wet than the dry season, except for bull (T9) in 2006 and female (T21) in 2007 (Fig. 3.1). Excluding these two elephants, transboundary crossings in 2006 averaged 47% more during the wet season ($\overline{X}$ =1.95) versus the dry season ($\overline{X}$ =1.33)(t=0.587, df=10. P=0.57), and nearly five times more frequent during the wet season ($\overline{X}$ =4.33) than in the dry season ($\overline{X}$ =0.87) in 2007 (t=4.33, df=10, P<0.001).

Time in Protected and Unprotected Areas

Based upon 14,287 fixes from eight collared elephants, the vast majority of time was spent in unprotected ($\overline{X}$ =91.5%) versus protected ($\overline{X}$ =8.5%) areas (t=22.8, df=8, p<0.001) in the West Kilimanjaro region (Table 3.2). Amboseli NP was visited by all eight elephants and was the most utilized protected area ($\overline{X}$ =8%, range 2-24%). There were very few occurrences of elephants in either Arusha or Kilimanjaro NPs. In unprotected areas, elephants occurred most frequently (68%) in the "Other" category, lands with no official designation for land conservation. Of the mapped unprotected areas, the Enduitmet WMA (227km^2) was visited by 7 of the 8 collared elephants, accounting for 20% of all locations. Relatively little time (2.9%) was spent on West Kilimanjaro Ranch (303 km^2) and the narrow Kitendeni Corridor (~35km^2) that was only used by one (T21) of the collared elephants.

Important Elephant Habitats

The collared elephants of West Kilimanjaro ranged widely throughout the region; yet, three areas had unusually high elephant use (Fig. 3.1). Overall, the Oltupai Thicket is an important area for elephants, especially the southern portion southeast of the Tinga-Tiga Village. Areas adjacent to the thicket also provide important elephant habitat, including the northeast corner of the West Kilimanjaro Ranch, western portion of the Livestock Research Center, and the southwest corner of Endarakwai Ranch. Much of this area is mixed agriculture and grazing areas with few scattered large trees and secondary growth with a narrow riparian forested strip with yellow fever tree acacia (*Acacia zanthophloea*) along the intermittent Ngare Nairobi River. There is no livestock grazing on the Endarakwai Ranch. There are five artificial water sources, two in Tingatinga Village, and one each at Mbong'et, West Kili Ranch and Endarakwai Ranch. Seven of the GPS-collared elephants used this area extensively during both the dry and wet seasons. Although there is much human activity in this area during the day, elephants hide in the thickets and narrow riparian forest during the day dispersing out to water sources, foraging areas and agricultural fields at night.

The Sinya Mine area on the Tanzania-Kenya border is another important area for elephants (Fig 3.1). This area provides permanent water in four abandoned clay mines of which one is fresh and the other three are salty. The water sources are surrounded by concentrate rings of vegetation ranging from yellow fever tree acacia near the water sources, Sueda shrublands (*Sueda monoica*), open woodlands of *Acacia tortilis*, and *Acacia-Commiphora* woodlands furthest from the water sources. Seven of the GPS-collared elephants used the Sinya Mine area extensively during both the wet and dry seasons. The three bulls spent extensive periods of time at Sinya Mine during the dry season and less so during the wet season. The females typically used Sinya Mine as a transitory stop while moving between West Kilimanjaro and Amboseli NP. Although there are no human settlements at Sinya Mine, the water source with freshwater is used extensively during the day by Maasai cattle herds throughout the dry season.

The Kitirua Concession Area (CA) across the border in Kenya southwest of Amboseli NP is another important area for elephants (Fig. 3.1). This open area is dominated by elephant grass (*Sporoblus consimilis*); Sueda shrublands and Salvadora shrubs (*Salvadora persica*). There is a small stand of yellow acacia (*Acacia xanthophloea*) woodland at Nadosoito on the Kenyan side, but it is fenced to exclude wildlife. There are no water sources in this area, but it was used extensively by seven of the collared elephants moving from Sinya Mine to Amboseli NP. There are no permanent bomas in this travel corridor, but the area is used extensively for cattle grazing during the dry season.

The proposed Lemomo CA south of Amboseli is an important area for elephants linking Amboseli NP to the Kitendeni Corridor and Kilimanjaro NP (Fig. 3.1). The area is characterized by dense stands of *Acacia-Commiphora* woodlands in the southern portion of the CA, rocky grazing lands to the north, and a small area of elephant grass around Imarba Village on the eastern side of the CA. Five of the collared elephants used this area extensively, especially during the wet season, as well as during the dry season for T21. Although there are few human settlements throughout the area, there are many bomas, research camps, tourist lodges, community camp sites, and schools along the southern border of Amboseli NP. These settlements pose a major barrier to elephants moving in and out of Amboseli NP and contribute to high numbers of human-elephant conflicts. The dense *Acacia-Commiphora* woodlands in the southern portion of the conservation area restrict cattle grazing throughout the wet season and early dry season.

Discussion

The extensive transboundary movements of elephants between northern Tanzania and southern Kenya indicate that the elephant populations of West Kilimanjaro and Amboseli NP constitute a single transboundary population. These observations contrast with earlier researchers (Afolayan 1975, Western and Lindsay 1984, Grimshaw and Foley 1991, Moss 2001) who reported that the Amboseli elephant population was distinct and rarely, if ever, dispersed from southern Kenya into northern Tanzania. This apparent shift in elephant movement patterns may be related to several factors relating to resource availability and humans. First, Western (2006) documented long-term changes in vegetation communities in the Amboseli Basin between 1950 and 2002. He documented the contraction of woodlands from 30% to less than 10% of the area with replacement by Suaeda/Salvadora scrub and grasslands. Further, he also reported the thinning of the dense bushlands fringing the northern portion of the Amboseli basin and replacement by open bushlands, and that the permanent swamps increased > 3.5-fold in area within the basin. Western & Maitumo (2004) and Western (2006) attributed these losses of woodlands and expansion of grasslands and scrublands to elephants. Western (2006) reported that this large and continuing loss in habitat diversity throughout the basin caused a sharp decline in browsing ungulates and a number of species extinctions (Western 1989). In contrast, West Kilimanjaro is dominated (65%) by thickets and shrubs (Kikoti 2003), providing abundant browse habitat for elephants and other wildlife. Further, in 2000 electric fences were constructed east of Amboseli NP to enclose irrigated, cultivated areas at Namelok (24 km of fence) and Kimana (38 km of fence) to reduce crop-raiding by elephants (Kioko et al. 2008). These fences in combination with the extensive agricultural lands of Impiron farms and human settlements pose barriers to elephant movements eastward from Amboseli NP to the Chyula Hills and Tsavo West NP. Consequently, increasing numbers of elephants from Amboseli NP may disperse southward into Tanzania.

In contrast to Western and Lindsey (1984) who reported that movements of elephants into Amboseli was primarily due to water availability during the dry season, most of our collared elephants had higher frequencies of transboundary movements into Amboseli during the wet season, a period when water is typically widely distributed across the region. The increased availability of grasslands in Amboseli reported by Western (2006) and the high utilization of grasses by elephants during the wet season 70-80%, (Kingdom, 1979) may partially explain these frequent movements to Amboseli by our GPS-collared elephants. Further, there may be less human disturbance of elephants by Maasai herders in Amboseli during the wet season because water is more widely distributed throughout the Amboseli Basin, thereby reducing the need to water cattle at the swamps within Amboseli NP. Additionally, human disturbance may increase in West Kilimanjaro during the wet season when many Maasai move their cattle herds from the Amboseli Basin into West Kilimanjaro. The shallow, well-drained soils in West Kilimanjaro (Kikoti 2003) reduce the incidence of cattle hoof-related diseases associated with the poorly drained soils in the Amboseli basin (Maasai elders, pers. com.).

Despite the preponderance of transboundary elephant movements into the Amboseli Basin during the wet season, some elephants, especially the bulls, had frequent short trips to Amboseli NP during the dry season. This contrasts with the five collared female elephants that rarely crossed into Kenya during the dry season. We suggest that those visits might have been related to finding mates and essential minerals.

The extensive occurrence of GPS-collared bulls and females outside of protected areas (91.5%) underscores the critical importance of unprotected lands in supporting the elephant population in northern Tanzania and southern Kenya. Similarly, Douglas-Hamilton et al. (2005) reported that two elephants collared in Amboseli NP spent 60 and 90% of their time in unprotected areas in southern Kenya and northern Tanzania. With only 37% of elephant range within protected areas in Tanzania (Blanc et al. 2007), unprotected lands play a critical role in sustaining Tanzania's elephant population.

Conservation Implications

Human settlements are expanding in many of these unprotected areas in West Kilimanjaro and Amboseli Basin, resulting in increasing numbers of bomas, agricultural fields, loss of woodlands and potential for human-elephant conflicts. Thus, more effective management of unprotected lands for elephants is needed to sustain elephants in the region. Although the acquisition and management of the West Kilimanjaro Ranch, Endarakwai Ranch and Enduimeti WMA for conservation has protected important elephant habitats, anti-poaching efforts need to be expanded on these areas and coordinated with anti-poaching efforts throughout the region. Further, the Livestock Research Center needs to be secured and managed for conservation to enhance protection of the Oltupai Thicket for elephants. The Research Center provides important woodlands for cover and feeding and an important link with Siha Farms to east, providing access to the western side of Kilimanjaro NP. Additional efforts are needed to reduce the illegal charcoal production occurring in the Oltupai Thicket, a critically important foraging and cover habitat for West Kili elephants. Securing the Kisimiri Corridor is another critical conservation measure needed. This corridor is a narrow (~1 km wide) valley providing the only remaining linkage between West Kilimanjaro Ranch and Arusha NP. Further, conserving this corridor will also reduce the potential of future human-elephant conflicts.

The Sinya Mine and adjacent Kitirua CA in southern Kenya constitute the most important link between West Kilimanjaro and Amboseli NP. There is a critical need to establish a ranger post on the Kenyan side near Nadosoito Hill to facilitate regular anti-poaching patrols by the Amboseli-Tsavo Game Scouts Association. Further, these anti-poaching efforts need to be coordinated across the border with the Hifadhi Network in Tanzania.

Elephant use of the proposed Lemomo CA and connecting Kitendeni Corridor is the primary linkage between the southeastern corner of Amboseli NP and the northern border of Kilimanjaro NP. Although the Kitendeni Corridor is secure as the first conservation corridor in Tanzania (Chpt 5), human activities in southern Kenya around Imalba and Muludule villages and along the southern border of Amboseli NP severely restrict elephant movements. Land use regulations need to be developed by the Olgulului Group Ranch to prohibit bomas from expanding into the two remaining pathways currently used by elephants. Working in collaboration with the lodges and their tourist operations, the community can encourage development away from these critical elephant pathways. Additionally, expanded protection for these pathways could be achieved by the Group Ranch gazetting them as conservation corridors for wildlife and cattle grazing. This was accomplished for the Kitendeni Corridor by two Maasai communities in northern Tanzania (Chpt 5). There is also a critical need to establish a ranger post on the

Kenyan side near Lemomo Hill to facilitate regular anti-poaching patrols by the Amboseli-Tsavo Game Scouts Association. These patrols would also need to reduce illegal charcoal production occurring at Misigiyo Village. Further, these anti-poaching efforts need to be coordinated across the border with the Hifadhi Network in Tanzania.

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Table 3.1. Sex, age, months tracked and numbers of transboundary crossings by year and season for eight GPS-collared elephants in the West Kilimanjaro region of northern Tanzania and Amboseli Basin of southern Kenya.

						2005	2006		2007		2008	
ID	Sex[1]	Age	Date collar deployed	Date collar removed/ failed	Mos Tracked	Dry ()[2]	Wet	Dry	Wet	Dry	Wet	Dry
T1	B	35-40	1-Sep-05	13-Mar-08	31	2 (2)	24 (7)	14 (5)	30 (7)	10 (5)	2 (4.5)	
T4	B	35-40	2-Sep-05	13-Mar-08	31	2 (2)	34 (7)	22 (5)	24 (7)	14 (5)	0 (4.5)	
T9	B	18-20	14-Jan-06	13-Mar-08	26		11 (4.5)	94 (5)	17 (7)	0 (5)	6 (4.5)	
T2	F	20-25	1-Sep-05	13-Mar-08	31	0 (2)	0 (7)	0 (5)	40 (7)	0 (5)	0 (4.5)	
T3	F	20-25	2-Sep-05	14-Mar-08	31	0 (2)	6 (7)	2 (5)	34 (7)	0 (5)	6 (4.5)	
T5	F	20-25	3-Sep-05	15-Mar-08	31	0 (2)	9 (7)	0 (5)	37 (7)	2 (5)	8 (4.5)	
T6	F	20-25	4-Sep-05	15-Feb-07	30	11 (2)	9 (7)	2 (5)	0 (4.5)			
T21	F	25-30	6-Nov-06	8-Jul-08	20				52 (6.25)	76 (5)	9 (7)	0 (2)

[1] - B = bull, F = female

[2] – number of months tracked during that season

Table 3.2. Percent time spent in protected and unprotected lands by eight GPS-collared elephants in the West Kilimanjaro region of northern Tanzania and Amboseli Basin of southern Kenya.

		Protected Areas (IUCN Cat II)							Unprotected Areas								
		Amboseli NP		Arusha NP		Kilimanjaro NP			Enduimeti WMA		W.Killi Ranch		Kitendeni		Other		
ID	Total fixes	No. of fixes	%	No. of fixes	%	No. of fixes	%	% Time in Protected Area	No. of fixes	%	No. of fixes	%	No. of fixes	%	No. of fixes	%	% Time in Un-protecte d Areas
T1	1956	32	2	0	0	0	0	2	417	21	3	0.1	0	0	1504	77	98
T2	2040	55	2	0	0	0	0	2	343	17	140	7	0	0	1502	74	98
T3	1935	93	5	0	0	0	0	5	387	20	100	5	0	0	1355	70	95
T4	2023	136	7	1	0.1	0	0	7	591	29	122	6	0	0	1173	58	93
T5	2131	95	5	0	0	0	0	5	262	12	42	2	0	0	1732	81	95
T6	1327	141	11	0	0	0	0	11	454	34	25	2	0	0	707	53	89
T9	1816	216	12	0	0	0	0	12	454	25	25	1	0	0	1121	62	88
T21	1059	254	24	0	0	4	0.4	24	0	0	0	0	70	7	731	69	76

Figure 3.1 West Kilimanjaro region of northern Tanzania and Amboseli Basin of southern Kenya showing international border, protected areas, communities and important elephant habitats.

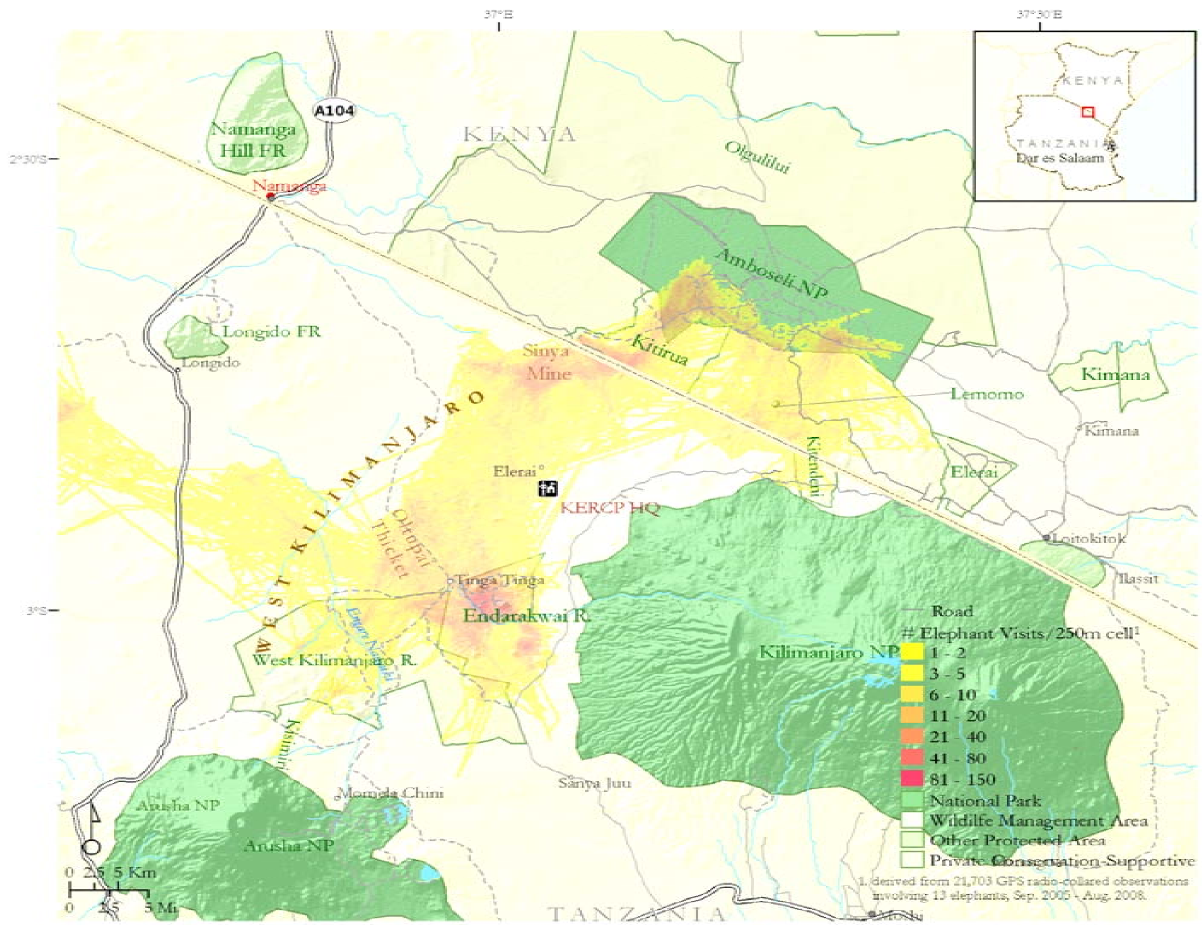
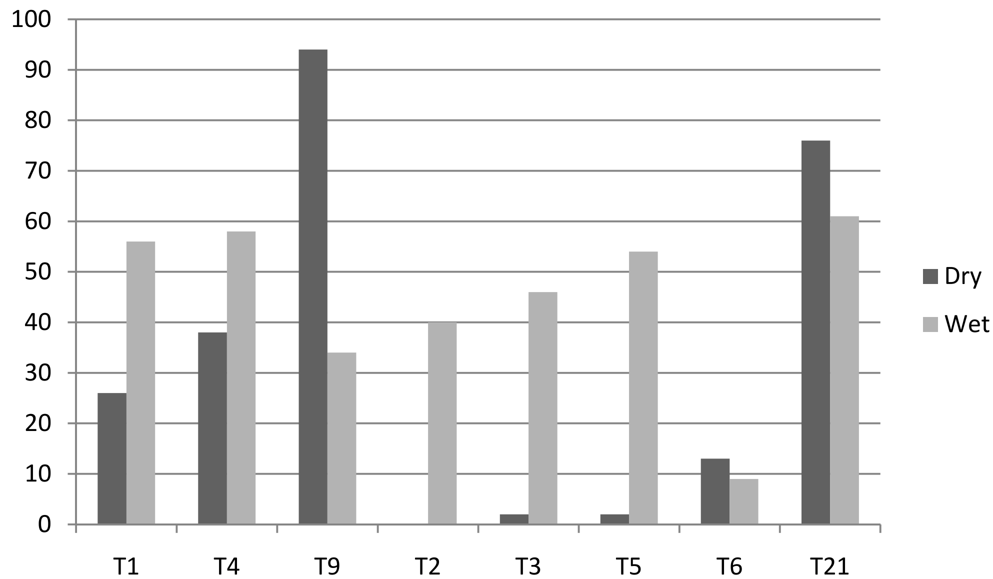


Figure 3.2. Numbers of dry and wet season transboundary crossings by elephant in the West Kilimanjaro region of northern Tanzania and Amboseli Basin of southern Kenya 2005 – 2008.



CHAPTER IV

WHERE ARE THE CONSERVATION CORRIDORS FOR ELEPHANTS IN NORTHERN TANZANIA?

Introduction

Thirty years ago, Soule et al. (1979) expressed concern about extinctions of large mammals in East African parks as human settlements increased around protected areas. Newmark (1996) attributed the loss of six diurnal mammals from four of the smallest parks in northern Tanzania to the isolation of these parks by human settlements, farms, and restriction of traditional migration routes. Establishing wildlife conservation corridors to link these protected areas was recommended to facilitate animal movements and to reduce wildlife-human conflicts (Borner 1985; Mwalyosi 1991; Newmark 1993, 1996; Kamenya 2000; Mpanduji et al 2002; Hofer et al. 2004).

With recent estimates in excess of 140,000 elephants (MNRT 2008) and a large and growing rural human population (26,487,000; National Bureau of Statistics Tanzania 2002), increasing habitat loss, fragmentation and human-elephant conflicts threaten Tanzania’s elephant populations. Elephant conservation is an especially serious concern outside of protected areas where 63% of the elephant range occurs (Blanc et al. 2007). Protection of movement corridors was recommended for linking protected areas and reducing human-elephant conflicts in Zimbabwe (Osborn & Parker, 2003), Kenya (Douglas-Hamilton *et al*., 2005) and Tanzania (Mwalyosi, 1991; Hofer *et al*., 2004), and as a potential option for reducing elephant densities in over-abundant elephant populations (Balfour *et al*., 2007; van Aarde and Jackson, 2007). Yet, to date (2009) only one conservation corridor has been established in Tanzania, the Kitendeni Corridor linking Kilimanjaro National Park (NP) in northern Tanzania with the Amboseli Plains south of Amboseli NP in southern Kenya (Kikoti Chpt. 5). Thus, the purpose of this study was to use the movements of 21 elephants with GPS collars reported by Kikoti (Chpt. 2) to identify the corridors they used to move within and between four study regions in northern Tanzania. Additionally, we provide information on the status of these corridors and conservation measures needed. We hope that this report provides the necessary information needed to establish additional wildlife conservation corridors in northern Tanzania.

Study Area

Although the study was conducted over a large area (~21,000 km^2) in northern Tanzania, our primary focus was on elephants in the unprotected lands between the four national parks of Kilimanjaro, Arusha, Serengeti, Tarangire, Lake Manyara, and the Ngorongoro Conservation Area. We collared elephants in four study regions (West Kilimanjaro, Natron, Loliondo, and Manyara-Tarangire) (Fig. 4.1). Overall, the study area is a complex landscape mosaic, including small- to moderate-sized human communities, extensive communal grazing lands, small- to large-scale agricultural lands, hunting concessions, and several types of conservation lands (national parks, conservation areas, game controlled areas, and wildlife management areas). In 2002, the human population in the study area was estimated at 214,190 (National Bureau of Statistics Tanzania 2002). Typically, there are two rainy seasons with the long rains from March to May and the short rains in November and December, but rainfall amounts vary much over the four study regions.

The West Kilimanjaro (West Kili) study region (3,067 km^2) is a complex mosaic of diverse natural communities, extensive grazing lands, and large agricultural fields at lower elevations on Mt. Kilimanjaro. There are traditional, agro-pastoral Maasai communities (n=12) that graze cattle and other livestock and raise subsistence crops. In addition, there are five other medium-sized agricultural communities in the region. Several protected areas border the study region, including Kilimanjaro NP (1,665 km^2) on the eastern boundary, Arusha NP (137 km^2) to the south, and Amboseli NP (390 km^2) in southern Kenya, 20 km north of the Tanzania-Kenya border. Although variable with elevation (1,230 to 1,600 m), the predominate ecological zone is semi-arid savannah (Pratt et al. 1966) interspersed with woodlands, and there are extensive agricultural fields along the lower, western flank of Mt. Kilimanjaro and lowland forests within the boundary of Kilimanjaro NP. Distribution of rainfall is unpredictable, especially at lower elevations, and highly variable from year to year. Rainfall amounts average 341 mm/yr in semi-arid lower elevations (Moss 2001) and 890 mm/yr in agricultural areas at lower elevations on Mt. Kilimanjaro (Rey and Das 1996).

The Natron study region (7,500 km^2), west of the West Kili region, is a mosaic of diverse natural communities and extensive grazing lands. There are 15 traditional Maasai communities that graze cattle and other livestock and raise subsistence crops. The entire region is included within the Natron GCA and the northern portion of the Monduli GCA where wildlife is managed primarily for hunting. The ecological zone is predominantly semi-arid savannah interspersed with open acacia woodlands (*Acacia-Commiphora*), especially on the western side of the Kiserian-Mriata Ridge. Distribution of rainfall is unpredictable and highly variable from year to year with rainfall amounts typically ≤ 350 mm/yr.

The Loliondo study region (5,000 km^2) is west of the Natron region. The region is a mosaic of natural communities, extensive grazing lands in the lowlands, and limited subsistence agriculture in the highlands. There are 16 Maasai communities that graze cattle and other livestock and raise subsistence crops. Three protected areas border the study region with Ngorongoro CA to the south, Serengeti NP (14,763 km^2) on the west, and Maasai Mara (1,368 km^2) to the north in southern Kenya. Much of the study region is included within the Loliondo GCA (4,000 km^2). The ecological zone is predominantly semi-arid savannah interspersed with open acacia woodlands. Distribution of rainfall is unpredictable and highly variable from year to year with rainfall amounts ranging from 450 to 850 mm/yr (Sinclair and Arcese, 1995).

The Manyara-Tarangire study region (5,500 km^2) is a complex mosaic of diverse natural communities, grazing lands, irrigated agricultural areas and human communities. There are 14 communities in the study region, ranging from small traditional villages to the larger community of Mto wa Mbu (~ 6,000) There are three protected areas in or adjacent to the study region, including Tarangire NP (2,850 km^2), Lake Manyara NP (330 km^2), and Ngorongoro CA (8,288 km^2). The ecological zone is predominantly semi-arid savannah interspersed with open acacia woodlands. In drier areas, *Acacia* woodlands dominate along with *Commiphora* and *Acacia-Commiphora* woodlands. Annual rainfall averages 829 mm, varying from 645 mm (Tarangire) to 1,306 mm (Ngorongoro) with most occurring in March-April and little in November-December (Sechambo 2001).

Methods

The movements of 21 elephants (7 bulls and 14 females) fitted with GPS collars were monitored within the four study regions from September 2005 to August 2007 (see Kikoti Chpt. 2 for details). No more than one individual was collared within a herd. For family groups, we targeted a middle-aged adult female in the herd for collaring. All bulls tagged were adults, except for one subadult. Collared elephants were monitored for 12 to 24 months, depending on collar performance (see Kikoti Chpt. 2 for Table 2.1). The duty cycle of these units was variable. The first six units deployed in September 2005 were set to download one GPS fix in the morning (0500) and one at night (2300). After the first year, the duty cycle of these six units and three additional units (deployed January 2006) was changed to one fix during the day and two fixes at night. The duty cycle for the final 12 units deployed in November 2006 and August 2008 was two fixes during the day and 3 fixes at night. The geographic accuracy of locations was 15 m for six collars we field-tested prior to deployment. Although the home ranges of these 21 elephants were reported by Kikoti (Chpt. 2), this report focuses primarily on the locations of specific movement corridors elephants used to move within and between the study regions. We used the corridor and linkage definitions of Beier et al. (2008:837) as our criteria for designation. They defined a *corridor* as "a swath of land intended to allow passage by a particular wildlife species between 2 or more wildland areas", whereas *linkage* was used "to denote connective land intended to promote movement of multiple focal species or propagation of ecosystem processes".

Results

Based upon the movements of 15 of the 21 GPS-collared elephants in northern Tanzania, we identified eight areas that we consider important for wildlife conservation corridors/linkages for elephants (Fig. 4.1). All but one of these corridors (Tanganyet) connected one or more protected areas with important elephant habitats, or in the case of Sinya Mine provided a critical linkage habitat. Each corridor/linkage is described below by study region, including its use by our GPS-collared elephants, our assessment of its viability and known threats, and conservation actions needed.

West Kilimanjaro Region

Kisimiri Corridor

Description & Use – This ~15-km long corridor links the southern end of West Kilimanjaro Ranch, a private conservation area owned by the African Wildlife Foundation, with Arusha NP. The corridor is about 5 km wide at the ranch, crosses the old Ngarenanyukie–Arusha Road, narrowing to < 1 km-width at the border with Arusha NP. There is a steep river valley at the mouth of the corridor where it enters the park. The corridor also traverses the Kisimiri Village for 2 km along the river valley with extensive human settlements and agricultural fields on each side of the valley. There is sparse woodland cover in much of the southern extent of the valley, with scattered woodlands north of the Ngarenanyukie–Arusha Road.

On different occasions, three of our collared elephants (T4 a 35-40 year old bull, and T15 and T18 similar-aged adult females) moved south out of the ranch into the corridor. T4 traversed the entire corridor quickly during the night, entering Arusha NP where he remained for only one day before returning to West Kilimanjaro Ranch. On several occasions, T 15 and T18 moved into the corridor from the ranch during the day, only moving 5 km south of the ranch to a small stand of yellow fever trees (*Acacia zanthophloea*) with a small spring. Neither of these females remained in the corridor for more than 1 day during their visits.

Although not collared, we observed 17 elephants move into the corridor from the forests of Mt. Meru in 2006. These elephants passed through Kisimiri Village around 0830 hrs, but villagers tried to force them back to the mountain. The herd retreated about 100 m and stopped. Within 30 min, two females charged back at the people, killing one person. This herd then continued moving through the corridor to West Kilimanjaro Ranch. Cape buffaloes also use the corridor. A herd of 30 buffalo left Arusha NP, injured a man in the Kisimiri Village, and continued into the West Kili region to the west of the ranch.

Two other female elephants (T2, T5) moved south from West Kilimanjaro Ranch towards Momella Lakes in Arusha NP. However, they dispersed only about halfway to the park (~8 km) to near Kalansi Village before returning north again to the ranch. Extensive agricultural areas and human settlements of the village probably prevented these elephants from continuing further south to the park. Both of these elephants moved into this area during the night and retreated north with the early morning light. Historically, we suspect that this was a corridor for elephants moving south into Arusha NP, but the extensive human settlements in the area now pose a barrier, and there are few conservation opportunities for this pathway.

Conservation Potential - The Kisimiri Corridor is used frequently but cautiously by elephants and other wildlife to move between the West Kili region and Arusha NP. With the narrowness of the corridor exiting the park and much human disturbance, animals move rapidly through this section of the corridor. There are at least six shacks in the corridor near the road, and the woodland trees are being cut for charcoal production. While there is a willingness by the four local communities to protect the corridor for conservation, costs will be high to relocate people already settled in the corridor. This is the only corridor remaining for wildlife to disperse out of Arusha NP, a small park (552 km^2) surrounded by 40 communities. Thus, the Kisimiri Corridor is a critical link for wildlife moving between the park and the West Kili region.

Sinya Mine Linkage

Description and Use – The Sinya Mine area on the Tanzania-Kenya border is a critical transboundary linkage for elephants and other wildlife moving between the West Kili region and Amboseli Basin in southern Kenya, including Amboseli NP. Three main pools in this area provide year-round water for elephants and Maasai cattle herds. The *Acacia zanthophloea/Sueda monoica* woodlands in the area are used extensively by elephants. The width of the primary corridor varies from 3 - 5 km; however, an approximate 50 km^2 area around the pools is used extensively. Although there are no human settlements at Sinya Mine, the one freshwater water pool is used extensively by Maasai cattle herds during the day throughout the dry season. There are no permanent Maasai bomas within the primary corridor and temporary, seasonal bomas (*loonjoos*) are few (3 huts/km^2)(A. Kikoti, unpubl. data).

Seven of our GPS-collared elephants used the Sinya Mine area extensively during both the wet and dry seasons (Kikoti Chpt 3). The three bulls spent extensive periods of time at Sinya Mine during the dry season and less so during the wet season. The females typically used Sinya Mine as a transitory stop while moving between West Kili and Amboseli NP. Females primarily used the pools at night when there was no disturbance from the Maasai and their herds. They retreated into the adjacent woodlands during the day. In contrast, the bulls used the pools during the day despite the presence of Maasai and their herds. At night, these bulls would range widely, up to 30 km away to raid crop fields. A variety of other wildlife (wildebeests, zebras and Thompson's gazelles) move through the Sinya Mine area to calving grounds at Mbuga Tatu (Nasuandet), Ngasurai Plain and West Kilimanjaro Ranch. They also return to the pools at Sinya Mine during the dry season in June. The Sinya Mine area is a critical area for linking the elephant habitats of the West Kili region (Kilimanjaro Ranch, Ndarakwai Ranch, Oltupai Thicket, Enduimet WMA) with the Kitirua CA and Amboseli NP in southern Kenya.

Conservation Potential – The Sinya Mine linkage is used extensively by elephants and other wildlife to move between West Kili and the Amboseli Basin. With these wildlife concentrations, several safari companies proposed building lodges within the primary corridor. However, these developments were prohibited to date, but the threat is continuing. Given the open terrain and good accessibility, poaching is also a threat. However, the regular patrols of the Hifadhi Network in Tanzania minimize the numbers of wildlife killed. However, there is a critical need to establish a ranger post on the Kenyan side near Nadosoito Hill to facilitate regular anti-poaching patrols by the Amboseli-Tsavo Game Scouts Association. Further, these anti-poaching efforts need to be coordinated across the border with the Hifadhi Network in Tanzania.

Simba River Corridor

Description and Use – The Simba River flows westward from the west side of Mt. Kilimanjaro. At higher elevations (1,650 m), the river is perennial with extensive pine plantations on both sides. At lower elevations, there are narrow, dense riparian forests bordered by large- and small-scale agricultural fields. At the lowest elevations (1,220 m) the river becomes seasonal and transitions to sub surface flow near the Ngasurai Plain. The riparian forests along the river adjacent to the agricultural fields provide refuge for elephants during the day from farmers; yet, ready access to fields at night for crop-raiding.

Nine of our collared elephants occurred frequently in the croplands to the north and south of the Simba River during wet and dry seasons. Similarly, the shrublands northeast of Tingatinga Village also provided cover for elephants during the day. The Simba River provides an important riparian corridor used by elephants linking the shrublands of the West Kilimanjaro Ranch, Livestock Research Center, and Ndarakwai Private Farm to the large agricultural areas to the east on the western slope of Mt. Kilimanjaro.

Conservation Potential – The Simba River Corridor is very narrow, typically restricted to the riparian forest that is typically < 100 m wide. Further, the crop fields and huts adjacent to the river restrict elephant movements away from this narrow corridor. Riparian vegetation is disappearing rapidly for fuel wood, and there is no enforcement of the watershed regulations by the Ministry of Water or the Forestry Department. Thus, the riparian forests and essential cover for elephants declines.

Considering that many of the huts along the river are there illegally, there is good potential for the people to be relocated by the government, and compensation would be minimal. Removal of these settlements in combination with better watershed management would conserve the riparian forests and provide additional water resources to wildlife and villages downstream.

<u>Siha Corridor</u>

Description and Use – The corridor begins at the northeast corner of the West Kilimanjaro Ranch extending through the Livestock Research Center running north of the West Kilimanjaro Airstrip and south of the cell phone towers. The Siha Farm borders the Livestock Research Center on the east and Kilimanjaro NP on the west. Both the Livestock Research Center and the Siha Farm are critical links in this corridor providing important foraging habitats for elephants.

Currently, the Livestock Research Center has an active lab research program, but there are few livestock and the Center property is underutilized. Similarly, Siha Farm is not operational and was tendered for sale by the Tanzanian government in 2007. Both of these properties need to be secured and managed for conservation to maintain the connectivity with Kilimanjaro NP.

The Siha Corridor was used extensively for foraging by six of our collared elephants in West Kili, and all elephants dispersed as far as the park boundary. The Siha Farm was used primarily at night due to human activities and absence of tress for cover. This corridor provides the shortest pathway between West Kili and Kilimanjaro NP; however, the steep slopes in the adjacent park lands restrict elephant movements much beyond the forest edge.

Conservation Potential – Loss of woodlands due to charcoal production is the major threat to the Livestock Research Center property. Conservation management of this property could be accomplished through a co-management agreement between the adjacent West Kilimanjaro Ranch and the Tanzania Ministry of Livestock. In the short term, patrols by Hifadhi Network and Kilimanjaro Ranch scouts could reduce the loss of woodlands to illegal charcoal production. Further, the boundaries of the Center need to be demarcated to enforce land management objectives. The Siha Farm needs to be purchased from the government by a conservation organization, such as the African Wildlife Foundation. Once the property is secure, farming will be prohibited and re-growth of the natural vegetation will occur. Further, the small school built in 2007 will need to be relocated near to the village outside of areas used by elephants. It is critical that this property be purchased from the government and secured for conservation.

Kitendeni Corridor

Description and Use – Grimshaw and Foley (1990) first proposed that Kitendeni was an important corridor for elephants moving between Amboseli NP and the northern border of Kilimanjaro NP. Subsequently, Kikoti (2002) confirmed the extensive use of this 5-km wide corridor by elephants and worked with local communities to designate it as Tanzania's first wildlife corridor in 2002 (Kikoti Chpt. 5). The corridor is located within two Maasai villages, Kitendeni to the west and Irkaswa to the east. The corridor is 6.6 km in length and 5 km wide. Numerous bomas (~ 20) are immediately adjacent to the corridor along about half the length of the eastern border in Irkaswa Village, and ~35 bomas outside the corridor ($\leq$ 1 km) on the Kitendeni side.

One of our collared female elephants (T21) extensively used this corridor to move between the northern side of Mt. Kilimanjaro NP and southern Kenya and into Amboseli NP. Much of her wet and dry season ranges occurred in the proposed Lemomo Conservation Area to the south of Amboseli NP. She spent relatively little time in either of the adjacent protected areas.

Conservation Potential – Since its establishment in 2002, there has been strong support for the corridor by both communities, and increasing use by elephants and other wildlife. An important component to the success of the corridor was developing a community-based anti-poaching unit as part of the Hifadhi Network that prevents wildlife poaching and illegal charcoal production.

Two anti-poaching posts were established, one on each side of the corridor to ensure its protection. The corridor has also played an important role in the community during drought periods, providing grazing for cattle. It also provides a sustainable source of firewood and medicinal plants for the local communities. As the first officially recognized wildlife conservation corridor in Tanzania, the Kitendeni Corridor provides a model for establishing other community-based corridors in Tanzania and other African elephant range states.

Natron Region

Tanganyet Corridor

Description and Use – Stretching for nearly 35 km, the Tanganyet Corridor links the Natron and West Kili regions extending from the Ngasurai Plains in the east to the base of the Kiserian-Mriatata Ridge in the west. In West Kili, the corridor begins as many elephant pathways in a broad 5 km-wide swath extending west out of the Oltupai Thicket in West Kili. Within 1 km of the Arusha-Nairobi Road, the corridor narrows to 3 km wide and the multiple paths coalesce into a single trail crossing the road. The corridor gradually expands in width west of the roadway to about 6 km at Telcom Hill. At this hill, one pathway leads northwest towards Oldonyo-Ndabashi hill and another continues westward to the Kiserian-Mriatata Ridge. The northward path is typically used during the dry season, providing access to artificial water sources used for livestock, with the elephants continuing onto the Kiserian Plateau. During the wet season, this pathway is avoided due to human settlements, and elephants continue westward to the ridge and access the plateau from the south. Within 500 m of the

Arusha-Nairobi Road, elephants typically move through the corridor quickly to cross the road. The Kiserian-Mriatata Ridge and Kiserian Plateau provide extensive *Acacia* spp. woodlands, shrublands and grasslands and there is minimal human activity in these areas.

Five of our collared elephants used this corridor. Three elephants (2 bulls, 1 female) entered the corridor from the eastern West Kili side. The bull (T9), a 20-year old bull, was collared in 2006 in Sinya Mine as part of a breeding herd. He separated from the breeding herd in 2007 and moved to Amboseli NP in southern Kenya. From here, he began his dispersal to Natron via the West Kilimanjaro Ranch, crossed the road, and continued to the foothills of Ketumbeine Mountain in the Natron region, representing the longest dispersal distance (131 km) of our 21 collared elephants. He remained only 5 days and then returned to Sinya Mine via the Oltupai Thicket. Two other West Kili elephants (T1, T3) moved into the corridor during the dry season of 2007, moving within 3 km of the road where they fed on wild sisal for 1-3 days before returning back east to the Oltupai Thicket. Three female elephants (T10, T15, T18) used the corridor from the west. T15, a 20 year old female, was collared 35 km west of the Arusha-Nairobi Road near Mriatata Hill. She remained in the Lake Natron region for all of the wet and early dry seasons of 2007, moved east to West Kili where she spent the later part of the dry season before returning back to the Natron region. Similarly, T18, an 18 year old female, was collared 7 km east of the Arusha-Nairobi Road in Nov 2007, as she was moving east towards West Kili in a herd of 25 elephants. After collaring, she moved back west across the road where she remained for about two weeks. This herd then moved east again along the corridor to the Oltupai Thicket, returned to the Natron region for the remainder of the wet and early part of the dry seasons of 2007, and then moved back to West Kili again for the later part of the dry season. The third female (T10) moved into the corridor from the west during the dry season of 2006, and approached within 500 m of the road before returning back to the ridge.

Conservation Potential – Currently, there no permanent settlements or shacks within the primary corridor; however, there are small settlements along the pathway that leads along the base of the ridge northwest from the Telcom Hill. Yet, there is little conflict from the Maasai in these small settlements. Thus, there is little resistance to elephant movements through this corridor at present except where it crosses the Arusha-Nairobi Road. The 25-elephant herd of T10 appeared to be scared of crossing the road when they reversed their direction upon reaching the road. However, the Town of Longido, 15 km north of the corridor crossing, is expanding rapidly and the road is being widened along its entire length. There are also plans to bring electric transmission lines to the town along the road from Arusha. This utility access will encourage much development along the road. Thus, it is critical that this area be secured for conservation before human settlements expand into the corridor.

There is much potential for working with the local Maasai communities to establish a land use plan similar to the one implemented for the Kitendeni Corridor. As pastoralists, the communities are supportive of establishing a corridor, providing an area for cattle grazing and dead wood collection, and also to reduce the numbers of non-Maasai people from moving into the area. There is also strong political support for the corridor in the Longido District. Further, there is also a growing concern at the western end of the corridor on the Kiserian-Mriatata Ridge where increasingly woodlands are cut for charcoal production. Expansion of the Hifadhi Network is needed to reduce woodland loss and illegal poaching in this area.

Manyara-Tarangire Region

Mswakini Chini Corridor (formerly Kwakuchinja)

Description and Use – For over 20 years, the linkage of Tarangire and Lake Manyara national parks has been a concern for conservationists. From 1987 to 2000, the proportion of cultivated land in the corridor doubled from 8 to 16% of the land area (Kidegesho, 2000). Although the purchase of the Manyara Ranch (2001) and its management for conservation by the Tanzania Land Trust contributed greatly to the implementation of this linkage, two significant gaps still occur. The Mswakini Chini Corridor, typically referred to as the Kwakuchinja Corridor, is a 3 km-long, 2 km-wide corridor between Manyara Ranch and the northern tip of Tarangire NP. This corridor is highly impacted by humans. There are many bomas and crop fields both within and adjacent to the corridor. Only a few scattered large *Acacia* trees occur within the corridor. A paved road between the villages of Minjingu and Makuyuni crosses the northern end of the corridor adjacent to Manyara Ranch.

Two (female T17, bull T19) of the three elephants we collared on Manyara Ranch used the corridor. Although our collared elephants only moved between Manyara Ranch and Tarangire NP on several occasions, there is frequent movement of elephants between the two areas in both the wet and dry seasons. They always move through the corridor quickly and at night, using darkness and the few scattered trees to conceal them as they move along narrow pathways between the bomas. Considering the number of bomas within the corridor, there is much human-elephant conflict from crop-raiding and injuries/deaths to people. Several people have been killed by elephants, and some elephants were killed as problem animals by the Wildlife Department. Wildebeest and zebras also frequently use the corridor to move between the two areas, and there are increasing human-lion conflicts and retaliatory killings (B. Kisui, pers. com.).

Conservation Potential – The viability of this corridor critically depends on relocating the people and their bomas out of the corridor. Several NGOs have been working with the communities for several years to negotiate land use restrictions in the corridor, but little progress has been made. There is much risk that the communities will lose interest if more progress is not made soon. Now that our collared elephants have identified the boundaries of the functional corridor, attention should be focused on negotiating compensation with the individual households that need to be relocated out of the corridor, and working with the communities to restrict future settlements within the corridor. These negotiations will require people with technical skills in resolving conflicts and negotiating equitable compensation. Tanzania National Parks and Wildlife Department also need to be fully vested in the success of the project. Without significant and timely progress in securing this corridor, expanding human settlements, continuing loss of trees and construction of fences in the corridor will further restrict elephant and wildlife dispersal and increase human-elephant conflicts in this area. Further, the future status of wildlife populations in Manyara Ranch is at risk. Without this corridor, the ranch is too small (82 km^2) and too isolated by human settlements to sustain viable populations without regular dispersal of animals from Tarangire NP.

Jangwani Corridor

Description and Use – This corridor extends from the northeast corner of Lake Manyara NP southeast for 10 km to Eslalei Village continuing for 15 km to Manyara Ranch. Corridor width ranges from 3.5 to 6 km. Dense yellow fever acacia's forests occur in the first 5 km of the corridor along the northern border of the park, switching to shrublands further east until the corridor turns south to Manyara Ranch. Scattered huts and open woodlands occur within the southern segment of the corridor extending to Manyara Ranch. The first 8 km section of the corridor extending east out of Lake Manyara NP was demarcated with beacons in 1996 by Tanzania National Parks, the regional authority and the Mto wa Mbu Village. Cattle grazing occurs throughout the corridor, but there are no crop fields.

Two of our collared elephants (bull T19, female T20) used the Jangwani Corridor to move from Manyara Ranch to north shore of Lake Manyara as far as the Simba River. The dense *Acacia* forests provide cover for the elephants during the day and they disperse out at night. A variety of other wildlife (zebras, buffaloes, wildebeests) also use the corridor to disperse out of the park. From the

Eslalei Village, elephants and other wildlife also disperse eastward to the foothills of the Losinguri Mountains. The bull elephant T19 dispersed several times eastward to Olsimingor Mountains during the wet and dry seasons of 2008, spending several months in the area.

There are several other corridors in the area for which none of our collared elephants used. The Jangwani-Upper Kitete Corridor joins the Jangwani Corridor near Eslalei Village. This corridor extends northward 18 km through the Selela Forest, turning westward for 15 km to the Upper Kitete Corridor that enters Ngorongoro Conservation Area. Reports from scouts indicate that elephants and buffaloes use this corridor to move between the Ngorongoro Crater and the Selela Forest, possibly moving further east to the foothills of the Losingor Mountains. Another corridor extends north from the Selela Village to the Natron region. This corridor is used primarily by wildebeest and zebras during the wet season as they disperse out of Tarangire and Lake Manyara NPs.

Conservation Potential – Although the Jangwani Corridor is relatively intact, there are several bomas within the corridor as it nears Manyara Ranch; these bomas need to be relocated in the near future. There is also a lodge on the northern border of the corridor near the Jangwani Sub Village where there is the potential for disturbance if not properly managed. Poaching and tree cutting are under control in the corridor due to the regular patrols by community scouts. There is strong local support for the corridor from the three communities because it is used for cattle grazing. There is also strong support from the District Council to conserve this corridor. The critical need now for the corridor is to provide assistance and support to the local communities to gazette the corridor as a conservation corridor for wildlife and cattle grazing.

The conservation challenges for the Jangwani-Upper Kitete Corridor are more complex, especially near the Mto wa Mbu-Makuyuni Road that intersects the corridor. This paved road in combination with electric transmission lines and water promote development along this roadway. A water tower was constructed near the Village of Kigongoni within 500 m of the corridor that will attract settlements and crop fields within the corridor. The absence of land use regulations in the area is a major challenge for protecting the corridor, and there is a critical need to prevent human settlements from expanding into the corridor. The District Council needs to develop a land use plan with the local communities to set the corridor aside for wildlife and cattle grazing. It is important that the conservation planning for the Jangwani and Jangwani-Upper Kitete corridors be coordinated to facilitate the protection of both corridors at the same time.

Discussion

Although eight corridors/linkages were identified in our study, these areas are based primarily on the movements of 15 GPS-collared elephants in three study regions, a relatively small sample considering the size of northern Tanzania and the large variation in individual elephant movements reported by Kikoti (Chpt. 2) for these elephants. However, average herd size for 13 females collared was 20 (9 – 32). Thus, more elephants were moving through these corridors in addition to the single GPS-collared elephant. Never-the-less, additional corridors/linkages may exist that were not utilized by our collared elephants. Further, in several cases, the delineation of a corridor was based upon relatively few fixes. Yet, elephants tend to move quickly through narrow corridors (Douglas-Hamilton et al. 2005, Galanti et al. 2006). This rapid movement in combination with the 4-12 hour intervals between fixes with our collars reduced the numbers of fixes obtained. Despite many anecdotal reports on corridors used by elephants in Tanzania, few studies provide data to actually delineate the actual corridors used by elephants with the exception of the studies by Kikoti (2002) in the Kitendeni Corridor in West Kilimanjaro and Hofer et al. (2004) in the Selous-Niassa Corridor in southern Tanzania. Considering the large proportion of elephant range that occurs in unprotected lands (63%) and the rapidly growing rural population in Tanzania, it is critical that resource managers have the necessary information on elephant movements to conserve these corridors and linkages.

Based upon the degree of threat and conservation potential, we recommend that the Kisimiri Corridor is the highest priority for conservation efforts in the West Kili region. This corridor provides the last remaining dispersal area for wildlife moving into and out of Arusha NP. In the Manyara-Tarangire region, the Jangwani and Jangwani-Upper Kitete corridors are high priority for conservation. They provide the primary linkage between Lake Manyara NP and the Ngorongoro Conservation Area to the north and Manyara Ranch to the south. Without these corridors, the Lake Manyara NP will be largely isolated with little opportunity for wildlife to disperse into and out of this small park. Of equal importance is the Mswakini Chini Corridor linking Manyara Ranch and Tarangire NP. Without this linkage, the relatively small Manyara Ranch will be largely isolated and will not be able to function as a linkage in the Manyara-Tarangire Ecosystem. Currently, several NGOs are working to conserve this corridor, but the challenge is great.

Designation of wildlife conservation corridors is hindered by the absence of regulations to designate and protect corridors under the Tanzania Wildlife Act of 1974. Thus, the first wildlife conservation corridor in Tanzania, the Kitendeni Corridor, was established as a farm with specific uses designated under Tanzania land laws. Thus, the Wildlife Act needs to be amended to designate and protect conservation corridors. Further, Tanzanian ministries and their departments need to become fully involved in the environmental review process for proposed development projects as required under the Environmental Impact Assessment regulation. Coordinated review will promote the consideration of corridors in land use management decisions. Corridors could also be identified and conserved as special units of wildlife management areas. This would also encourage ownership and management of corridors by local communities.

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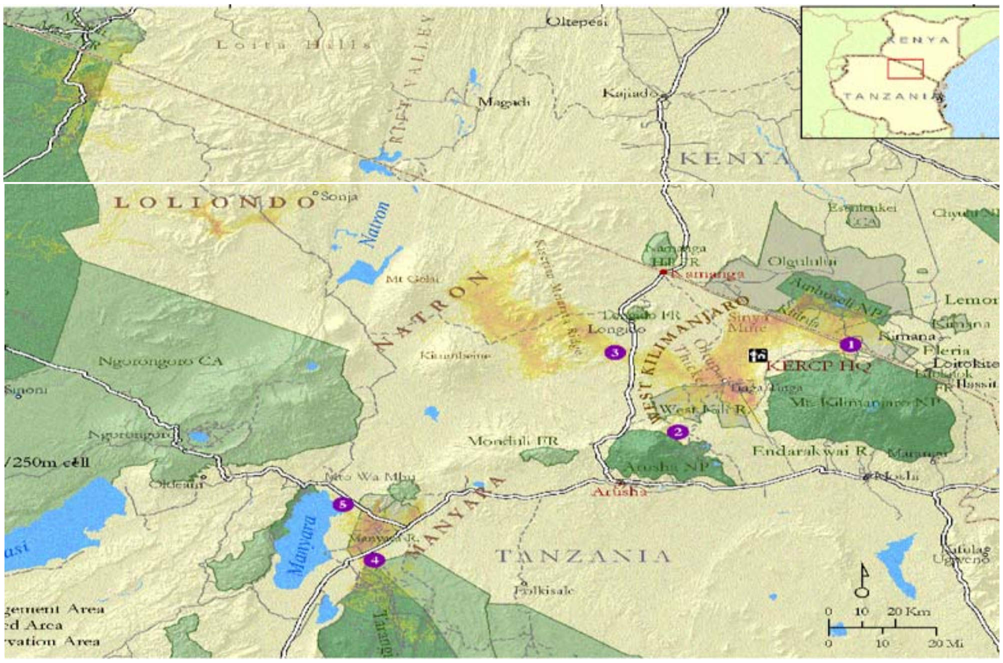
Figure 4.1. Study area, GPS locations, and corridors used by 21 GPS-collared elephants in northern Tanzania.



CHAPTER V

ELEPHANT USE AND CONFLICT LEADS TO ESTABLISHMENT OF TANZANIA'S FIRST WILDLIFE CONSERVATION CORRIDOR

Abstract

Conservation corridors linking protected areas are recommended for reducing the effects of human settlements that fragment African elephant (*Loxodonta africana*) home ranges and dispersal areas, and increase human-elephant conflicts. Community interviews and hilltop surveys were used in two Maasai villages in northern Tanzania in 2000 and 2001 to determine the extent of wildlife conflict, community attitudes towards elephants, and if elephants were using a vegetation corridor between the two villages to move between Tanzania and southern Kenya. Elephants were the most problematic wildlife species in the two villages adjacent to the corridor due to crop-raiding of primarily maize (*Zea mays*) and beans (*Phaseolus vulgaris*). Although villagers considered elephants a nuisance, they believed they attracted tourists, and generally did not believe elephant numbers should be reduced. Elephants used the corridor primarily in the wet and early dry seasons, and breeding herds were more numerous than bull herds. Based upon elephant conflict and use and the communities' need to maintain areas for cattle grazing and medicinal plant collection, the two Maasai communities established the first wildlife conservation corridor in Tanzania working in cooperation with government authorities and other stakeholders, providing a model for establishing additional wildlife conservation corridors in African.

Introduction

With nearly 70% of the African elephant range outside of protected areas and increasing human settlements in these unprotected areas (Blanc *et al*., 2007), elephant home ranges and dispersal areas are increasingly fragmented and human-elephant conflicts increasing (Dublin *et al*., 1997; Hoare & du Toit, 1999; Sitati *et al*., 2003). Protection of movement corridors was recommended for linking protected areas and reducing human-elephant conflicts in Zimbabwe (Osborn & Parker, 2003), Kenya (Douglas-Hamilton *et al*., 2005) and Tanzania (Mwalyosi, 1991; Hofer *et al*., 2004), and as a potential option for reducing elephant densities in over-abundant elephant populations (Balfour *et al*., 2007; van Aarde and Jackson, 2007). Further, in Tanzania human settlements and farms around several protected areas have increased their isolation and threatened traditional migration routes (Borner, 1985; Mwalyosi, 1991; Newmark, 1993, 1996; Kamenya, 2000; Hofer *et al*., 2004). Although efforts are underway (2009) to establish the Selous-Niassa conservation corridor in southern Tanzania (Hofer *et al*., 2004); no conservation corridors were permanently protected by the Tanzanian national government until this project.

Grimshaw and Foley (1990) first suggested that elephants may be using a vegetation corridor to move between Mt. Kilimanjaro and Amboseli National Park in southern Kenya; however, the occurrence of this corridor was surmised from discussions with local Maasai communities and limited field observations. Thus, the objectives of this study were to determine if this elephant movement corridor existed and the extent of its use by elephants, and to assess the extent of wildlife conflicts and human attitudes towards elephants in two nearby Maasai communities. In addition, we describe the process of working with the communities, government authorities and other stakeholders to establish the first wildlife conservation corridor in Tanzania. We hope that this report provides tools for establishing additional wildlife conservation corridors in Tanzania and other African elephant range states.

Study Area

The study area is in the West Kilimanjaro region of northern Tanzania, a complex mosaic of diverse natural communities, extensive grazing lands, large agricultural fields at lower elevations on Mt. Kilimanjaro, and diverse human populations including agro-pastoral Maasai communities. The unprotected lands in West Kilimanjaro may support as many as 600 elephants in the dry season (KERP, 2003). The study area (3059 ha) for the hilltop surveys was a 6-km-wide vegetation corridor off the northwest corner of Kilimanjaro NP (formerly Forest Reserve)(Fig. 5.1). The corridor extends from the forest border of Kilimanjaro NP north to the Tanzania-Kenya border (6.6 km along the mid line). Amboseli National Park is 15.5 km to the north of the international border.

The corridor is located within two Maasai villages, Kitendeni to the west and Irkaswa to the east. A ridge along the mid line of the corridor delineates the boundary of the two villages. Two intermittent streams occur in the corridor, Olkeju-Loorgum stream defines the eastern edge of the corridor and the somewhat larger Kitendeni Stream is along the western edge of the corridor. Numerous bomas (~ 20) were immediately adjacent to the corridor along about half the length of the eastern border in Irkaswa Village. On the Kitendeni side, there were five bomas within the corridor and another 12 bomas outside the corridor (≤ 1 km) during the study. There is one artificial water point within the corridor on the Kitendeni side. Two hills are adjacent to the corridor. Kitashu Hill (1754 m) is about 800 m west of the western corridor boundary, and Kilima Nyuki (1750 m) is about 750 m from the eastern border of the corridor on the Irkaswa side.

The corridor occurs from about 1600 - 1750 m elevation with a savannah climate (annual rainfall of 220 cm; Rohr *et al*., 2003). Vegetation varies according to elevation with *Acacia seyal, A. nilotica, A. drepanalobium,* and *Balanite aegyptiaca* dominating the woodlands at the upper portion of the corridor. *A. nubica* and *Commiphora africanus* dominate the shrub communities in the lower portion of the corridor. Several large pockets of grassland (dominated by *Themeda triandra, Cynodon plectostachyus, C. dactylon and Pennisetum strammineum*) also occur on the eastern side of the upper portion and throughout the lower portion of the corridor. *Lantana* spp. shrubs occur throughout the corridor in the open areas.

Both Kitendeni and Irkaswa are agro-pastoral communities that graze cattle and other livestock and raise subsistence crops, primarily corn, beans, wheat (*Triticum aestivum*), and potatoes (*Ipomea patatas*). Kitendeni is a small traditional Maasai village (n = 78 households; unpubl data, Monduli District Council, Monduli, Tanzania), whereas Irkaswa is a larger village (n = 501 households; unpubl data, Monduli District Council, Monduli, Tanzania) consisting mostly of Maasai (~70%) and other tribes (Waarusha and Chaga) and is a market center for three surrounding villages. Each village has a village council, consisting of an elected village chairman, a village executive officer appointed by the Monduli District Council, and 25 community members elected to the council.

Methods

Community Interviews

Interviews were conducted in October and November 2000 in the two villages adjacent to the corridor, Kitendeni and Irkaswa. Letters requesting a meeting to conduct interviews in each village were sent to the respective village chairman and execute officer. They announced a meeting date and location for the interviews. In Kitendeni, three distinct groups were interviewed, the village chairman and executive officer, a village women’s group and village men’s group who were not on the council. In Irkaswa, two groups were interviewed, the village chairman and executive officer, and a combined group of village men and women not on the council. After explaining the purpose of the interview to each group, each group member was individually interviewed. Following Maasai custom, a woman interviewed the women from the women’s group in Kitendeni, whereas a man conducted the individual interviews for all other group members. Each interviewee was asked a series of questions about their background, wildlife conflicts in their village, and attitudes towards elephants (Table 1). All interview questions were asked in Kiswahili, translated into Maasai, and responses again translated back into Kiswahili for recording. Individual interviews lasted 20-60 min. Responses to the first six background of respondent questions were not used in the analyses because of small sample sizes.

Hilltop Surveys

From December 2000 to May 2001, systematic observations were made simultaneously from the Kitashu and Kilimanyuki hilltops by six observers who recorded numbers of elephants within the corridor during a 7-hour period (0730-1230 hrs and 1500-1700 hrs) for 3-5 contiguous days per month. Using 12 x 50 mm binoculars, the hilltop vantage points provided observers complete views of the corridor from the forest border at Kilimanjaro NP north to the international border, and extending across the corridor to the ridgeline. Observations stopped during periods of moderate to heavy rain and when fog limited visibility. We reduced the potential for multiple counts of the same herd during a day's observation period by having simultaneous observations from each hilltop, and subsequently comparing times of herd observations, herd size and unique ear and tusk characteristics of individuals within each herd. Further, the ridge running along the mid line of the corridor also prevented the hilltop observers from seeing across the entire width of the corridor, thereby reducing the potential for duplicate herd counts. Vegetation within the corridor limited our ability to determine herd structure consistently, especially the young elephants. Further, we could not always distinguish between individual herds during the monthly 3-5 day observation periods. Our primary objective for this segment of the study was to record the presence/absence of elephants within the corridor and relative abundance between months. Thus, we focus on the maximum count of elephants recorded during one of the observation days for each month.

Results

Wildlife Conflicts and Community Attitudes

We interviewed 15 people in Kitendeni (11 men, 4 women) and 20 in Irkaswa (15 men and 5 women). Although five other species were identified as problem wildlife in the two villages [bush pig (*Potamochoerus larvatus*)(n = 2 respondents), bushbuck (*Tragelaphus scriptus*) (n = 1), southern eland (*Tragelaphus oryx*) (n = 1), African buffalo (*Syncerus caffer*)(n = 1), spotted hyena (*Crocuta crocuta*)(n = 1)], respondents considered elephants (n = 25) the major problem wildlife species. Crop-raiding was the most frequent conflict caused by wildlife cited by respondents (n = 29), while one respondent cited goat predation. Maize was the most frequently raided crop by elephants (n = 21 respondents) with beans (n = 8), wheat (n =1), and potatoes (n = 1) raided less frequently. Seventeen of the respondents in the two villages indicated that elephants primarily occurred in their villages from November to July. Respondents indicated that elephants used the area as a corridor (n =12), feeding area (n = 11), because food (n = 6) and water (n = 2) were available, or to escape ants and tsetse flies (n = 4). All respondents believed that elephants in their villages were coming from Amboseli NP (n = 19) or Kilimanjaro NP (n = 15), except one respondent who didn’t know.

All (15/15) respondents from Kitendeni and 19 of 20 from Irkaswa disagreed with the statement that ‘elephants are a nuisance and should be kept away', one respondent from Irkaswa agreed with this statement. For Kitendeni, 14 of the 15 respondents agreed/strongly agreed with the statement that 'elephants are a nuisance but attract tourists', and one respondent strongly disagreed with this statement. Similarly, 16 of the 20 respondents in Irkaswa strongly agreed/agreed with this statement, while four disagreed/strongly disagreed. All but one respondent for the two villages disagreed/strongly disagreed with the statement that 'elephants should be left to roam free'. Most of the respondents in both villages disagreed/strongly disagreed with the statement that 'there are too many elephants', and three agreed with that statement in Irkaswa and two stated 'they don't know'. All of the respondents in both villages disagreed/strongly disagreed with the statement that 'elephants should be killed to reduce the numbers'.

Hilltop Surveys

A total of 39 herds were counted within the corridor during the 24 observation days, but there was much variation in numbers of elephants observed on a single day, ranging from three to 55. Breeding herds (n = 29) were observed more frequently than bull herds (n = 10). Both breeding and bull herds occurred in the corridor each month during the 6-month observation period (Dec – May), but bull herds predominated in mid May at the beginning of dry season. The maximum daily number of elephants per month (n = 55) occurred in March, and the lowest in May (n = 7) (Fig. 5.2). Based upon the maximum daily number observed per month, typically more elephants were observed from Kitashu ($\overline{X}$ =

22.8, SD = 4.9, n = 6) than the Kilima Nyuki ($\overline{X}$ = 16, SD = 7.9, n = 6) hilltop for the 6-month observation period (t = 2.62, df = 5, P = 0.047).

Discussion

Relatively few people from each village participated in the interviews, considering the numbers of households. These low numbers were probably due to the timing of the interviews in October/November, the peak period for cultivating their fields, and many of the Maasai grazers had moved their herds to areas distant from the villages. Crop-raiding by elephants was the most serious wildlife problem for the two villages most likely because of the close proximity of the corridor to the villages and its high use by elephants as reported during interviews. Maize was the crop most frequently raided by elephants probably because it is the most extensively grown crop in the two villages. Similar to other human-elephant conflict studies in southern Kenya (Sitati *et al*., 2003) and southern Tanzania (Malima *et al*., 2005), this is the crop most heavily raided by elephants. Despite the extensive problems that elephants caused in villages, respondents did not believe that elephants should be kept away; however, they did not want elephants to roam freely in their villages. This positive attitude towards elephants may be related to the perception of the respondents that elephants bring tourists to their villages. Although there is no evidence to indicate that these two villages directly benefited from tourism, community conservation programs sponsored by Tanzania National Parks in both communities may have influenced their attitudes linking elephants and tourism. Further, we believe that reports of monetary benefits of wildlife and tourism in another nearby Maasai community

(Sinya Mine) may have affected this attitude. In contrast to the problems that elephants caused in both communities, most of the respondents did not believe there were too many elephants and none of the respondents wanted elephants killed to reduce their numbers. The individual experiences of respondents with elephants undoubtedly affected their responses. For example, if the respondent was a teacher or nurse who had no association with farming or livestock, they typically did not identify elephants or other wildlife as a problem. In contrast, farmers whose maize field had been destroyed by wildlife reported serious wildlife problems.

Our hilltop surveys and interviews confirmed that elephants extensively utilized the corridor between the two villages of Kitendeni and Irkaswa, especially during the wet season. Further, respondents believed that the elephants in the corridor came from Amboseli or Kilimanjaro national parks. Although our hilltop surveys were conducted primarily in the wet season, respondents in the interview confirmed that elephants occur within the corridor during the wet season and part of the dry season. We believe that clay soil conditions in the lowlands of southern Kenya to the north of the corridor may discourage elephants from using these lowland areas during the wet season. Thus, elephants move up into the corridor where soils are better drained, and there is extensive scrub and woodland vegetation that provides abundant forage and cover from human disturbance. Further, human disturbance within the corridor is reduced during the wet season when the Maasai move their herds further west out of the corridor into the open woodlands where grass is more abundant. Typically, the Maasai herds return to the corridor during the dry season when grass diminishes in the lowland plains and woodlands. Although vegetation is still available for elephants to browse in the dry season, water in the two streams is limited to small pools by mid May; thus elephants begin moving out of the corridor. They move into the lowland plains and woodlands to the west where there are seasonal pans with water, and north into Amboseli NP where there are permanent swamps with water. Breeding herds moved out of the corridor earlier than bull herds at the beginning of the dry season, consistent with observations of elephants at seasonal water points in Botswana (Stokke & du Toit, 2002). Elephants may use the corridor beyond July, but may be less noticed because of their lower numbers and absence of crop-raiding because all crops have been harvested by that time.

The occurrence of more herds on the Kitendeni side of the corridor was probably due to several factors. First, the only permanent water available within the corridor was the artificial water point on the western side of the corridor (Fig. 1). This water point provided a reliable water source for elephants throughout the year, especially during the dry season when there was no water in the two intermittent streams within the corridor. Further, the larger Kitendeni Stream forms the western border of the corridor and water persisted longer into the dry season than the smaller Olkeju-Loorgum stream along the eastern border of the corridor. The occurrence of two of the primary traditional elephant trails, one from Sinya Mine and the other from southern Kenya, converged on the west side of the corridor about 1.5 km south of the Kenya-Tanzania border. This trail continues up the western portion of the corridor to the artificial water point and further on to the forests of Kilimanjaro NP. Levels of human disturbance were probably higher on the eastern side of the corridor. Numerous bomas (~ 20) were immediately adjacent to the eastern corridor boundary in Irkaswa Village. In contrast, only five scattered bomas occurred within the corridor on the western side of the corridor boundary in Kitendeni. Additionally, the corridor was primarily the only place where the Maasai from Irkaswa had access to graze their cattle. However, in addition to the corridor, the Kitendeni Maasai had access to the open woodlands and grasslands on the western side of their village away from the corridor to graze their cattle. Thus, their use of the corridor for grazing was reduced, thereby decreasing the potential for disturbance of elephants within the western portion of the corridor.

Threats to the Corridor

Foley and Grimshaw (1990) noted that the vegetation corridor extended for about 10 km west of Irkaswa Village when they first visited the area in 1989. By the beginning of our study in 2000, the corridor was only 6 km wide. In this intervening decade, Irkaswa Village had expanded westward and numerous bomas and agricultural fields now occurred within the eastern 4-km portion of the original 10 km-wide corridor. On the western Kitendeni side, a school and five bomas occurred within the corridor. Further, in early 2001 after our hilltop surveys had begun, many people from Irkaswa Village (possibly as many as 200) began to mark trees, claiming plots of land within the corridor for future agricultural development. These expanding human settlements into the corridor threatened the integrity of the remaining 6 km-wide vegetation corridor for cattle grazing and wildlife, and would result in increased human-wildlife conflicts and disturbance of wildlife. These increasing threats to the corridor were the impetus for us to initiate protective measures for the corridor.

Establishing the Kitendeni Corridor

Establishing the Kitendeni Corridor was a multi-step process over 18-mo period involving local communities, government authorities and other stakeholders. Our first step was to meet with the Enduimet Division Officer to discuss the threats facing the corridor and obtain his support and assistance in working with the two villages that owned the corridor. He agreed to help, and he arranged meetings with the chairman and executive officers of each village.

Although a meeting might be scheduled for 0900 hrs, typically only a few, often the most influential, of the participants would arrive at that time. It was usual that meeting participants would continue to arrive over a three-hour period. Thus, general conversation occurred for extended periods before the formal meeting began. These informal conversations with participants were critically important because 1) they helped us to identify the most influential participants and many of the key issues that would arise later in the formal meeting; 2) 'get to know' people so that they were more likely to express their views in front of a 'stranger' during the formal meeting later; and 3) reduce misconceptions and reassure participants' concerns that their 'land would not be taken away' or 'the government would limit the use of their land'.

Preparing and taking food to each meeting was critically important, no matter how large. There were upwards of 400 people at one of the early meetings.

Making food available at the end of every meeting encouraged people to attend and stay at meetings until the end. Another important meeting strategy is to have distinct question and answer segments. In the first segment, participants present all of their concerns and questions to a committee composed of village authorities. If there were questions that the committee may need assistance with answering later, we would write the answer on a note and pass to the committee for use during the answer period. This process was critically important to avoid the perception that this was a meeting controlled by 'outsiders' not the village authorities. Thus, we made every effort to minimize the number of questions we had to answer at meetings. This process helped to ensure ownership of the meeting by the villages.

During this first meeting in each community, we asked the village leaders why the corridor area had not been settled extensively as other areas, if it was important to the village in any way, and if there were any threats to area. We then shared our hilltop observations of both cattle and wildlife use in the corridor, and that the existing bomas and threat of expanding human settlements and agriculture into the corridor would be problematic both for cattle-grazing and wildlife. These first meetings served to make official contact with village leaders through the division authority and to raise awareness in the village leadership about the importance and threats to the area. The village leadership in each of the communities recognized that expansion of bomas and agricultural fields, burning and tree-cutting were threats to their cattle-grazing activities and to wildlife use of the area. With these threats acknowledged by the village leadership, within two weeks they called a village meeting to discuss the issue.

The village meetings were organized because the village leadership recognized that the problems were a result of the land use activities of the community at large. At the village meeting, the people of Kitendeni recognized the importance of the corridor for cattle-grazing and wildlife and also for medicinal plants, the threats of human settlement, and they wanted to find permanent solutions to the problem. Similarly, most of the community members in Irkaswa recognized the importance of the area and the threats to it, but several community members (~ 15 people) argued that the village had no room to expand and this area was needed for settlement and agriculture. This small, but vocal opposition in Irkaswa required a different strategy for working in this community.

To build stronger consensus in the Irkaswa community for protecting the corridor, the Kitendeni village leadership agreed to attend a village meeting in Irkaswa to discuss why they believed it was important to protect the area. This meeting served to reduce the number of people who opposed protecting the area, and in the end only about five people out of the community of over 500 households still opposed protective measures. However, the Irkaswa community decided to continue with efforts to protect the area despite this small opposition.

In retrospect, another critical element that played a pivotal role in building community support for the corridor was begun when we first initiated the research project, almost a year and a half before the first village meetings on the corridor. Without a strong, trusting relationship with the village elders developed over these early years, it would have been impossible to obtain the support and approval of the local communities to protect the corridor.

Once both communities had agreed with the need to develop an initiative to protect the corridor, a task force committee was formed, consisting of five representatives from each village, the division officer, and the district game officer, and the field researcher (A. Kikoti). This task force developed a report that recommended designation of a 5 km-wide corridor (2881 ha), documented the threats to the corridor, and what activities should be permitted within it. These activities included: livestock grazing, medicinal plant collection, and firewood collection of only dead wood. Villagers collecting honey are required to obtain a permit. This was done in an effort to reduce the incidence of wildfires that can result from untended fires used during honey collection. No settlement is allowed, including temporary bomas. The task force also recommended that five bomas in the corridor and the Kitendeni School be relocated. Although the school was not within the proposed 5 km-wide corridor, it was located 600 m west of the corridor border and 70 m south of the artificial water point. This proximity to the corridor and the water point that is used extensively by elephants posed much risk to the students and staff.

The draft corridor management plan was presented as a workshop, one in each community. Following minor revisions, the plan was submitted to the Ward Development Committee. Although several members of the task force also served on the Ward Development Committee, many other stakeholders were on the committee, including village and natural resource authorities, head teacher from the Kitendeni School, private landowners, and representatives from tour operators and non-governmental organizations. After minor revisions, the committee approved the plan and forwarded the plan to the Monduli District Council.

The district council sent their technical staff into the field to confirm the details of the report, verify there was support for the plan in the two villages, and to request assistance from the villages to survey and demarcate the corridor. The boundaries of the corridor were surveyed and a map prepared for district council review. Upon approval by the district council, the mapped boundaries were confirmed again at village meetings, after which the district council installed survey beacons along the boundaries of the corridor. A final district council report was developed justifying the establishment of the corridor and documenting the survey points, and sent to the National Land Commission for final approval.

The land commission sent a technical team to verify the report received from the district council, and to confirm the boundary and those villagers were aware of the corridor designation. Although the proposal had been submitted to the land commission as the Kitendeni Wildlife Corridor, there was no provision under the Wildlife Act of Tanzania of 1974 to establish a wildlife corridor. Thus, the corridor was registered in October 2002 by the land commission as a farm where the only allowable activities were defined by the corridor management plan developed by the task force and accepted by the communities.

Following designation by the land commission, people living in the five bomas within the corridor were given land elsewhere within the village and time to establish their new bomas. The Tanzania National Parks, Monduli District

Council and other stakeholders provided funds to build and furnish a new school away from the corridor. After these relocations, the corridor was expanded by 178 ha to include the area around the borehole and former school. Since designation in 2002, local game scouts from the villages regularly patrol the corridor for unauthorized activities. This monitoring of the corridor by local game scouts and the strong resolve of both communities to enforce the provisions of their corridor management plan are critical for protecting the integrity of Tanzania's first wildlife conservation corridor.

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Table 5.1. Questions for respondent background, wildlife conflict and attitudes about elephants used in interviews in Kitendeni and Irkaswa villages in northern Tanzania, October and November 2000.

A. Background of respondent

1. How many people in your household:
2. Age of respondent:
3. Sex of respondent:
4. Education? Primary/secondary/college
5. Occupation?
6. How long have you lived in this village?

B. Wildlife conflicts

1. What are the problem wildlife species in your village?
2. What problems do they cause?
3. What crops do elephants raid?
4. Why are the elephants here?
5. Where do the elephant's come from?

C. Attitudes about elephants

1. To what degree do you agree or disagree with the following statements:
   (strongly agree, agree, no opinion, disagree, strongly disagree)
   a. Elephants are a nuisance and should be kept away
   b. Elephants are a nuisance but they attract tourists
   c. Elephants should be left to roam free
   d. There are too many elephants
   e. Elephant should be killed to reduce the numbers

Figure 5.1. Kitendeni corridor showing study area and observation hills, physical and cultural features, and designated corridor boundaries (courtesy of African Wildlife Foundation, Nairobi, Kenya).

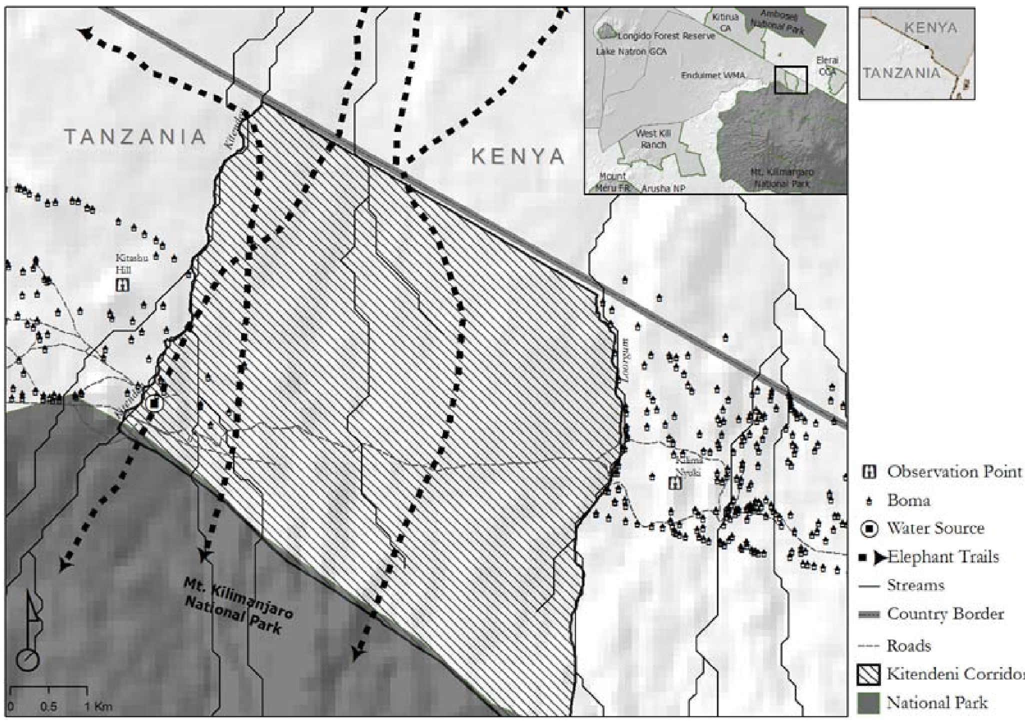
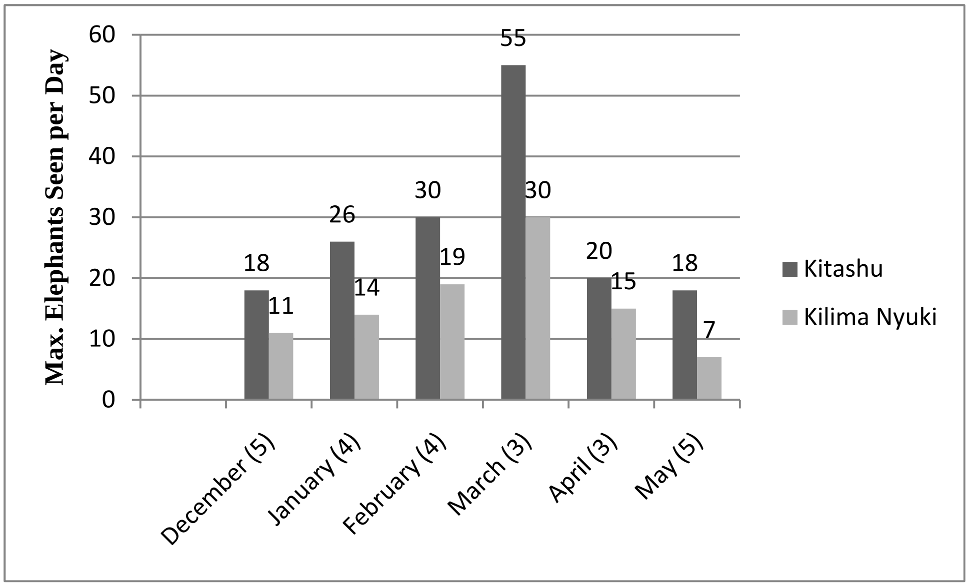


Figure 5.2. Maximum daily number of elephants observed per month from two hilltops within the Kitendeni Corridor in northern Tanzania from Dec 2000 - May 2001.



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