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FAULTY OF NATURAL AND ENVIROMENTAL SCIENCE

CENTRE FOR BIOLOGICAL SCIENCES

# THE MOUNT KENYA ELEPHANT CORRIDOR'S UTILISATION BY ELEPHANTS AND ITS PERCEIVED SUCCESS

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A dissertation submitted in partial fulfilment of the requirements for the degree of M.Res.

Wildlife Conservation

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## Abstract

Wildlife is becoming increasingly compressed to fenced and protected areas to safeguard endangered species and prevent human-wildlife conflict. There are a number of problems with isolating populations including inbreeding and degradation of habitats by impeding migration routes. In central Kenya the Mount Kenya Elephant Corridor was created to link Ngare Ndare Forest Reserve (an extension of the Samburu-Laikipia region) and Mount Kenya. The creation of the Corridor was to allow the free movement of elephants between these regions, to reduce human-elephant conflict and to increase the genetic diversity of the whole elephant population. Since its completion in late 2010, no evaluation of its success has been undertaken to date. Camera trap analysis from this research established that a minimum of 60 different elephants utilised the Corridor, of which 52% travelled the whole Corridor length. There was a ratio of 1:1.2 whole to partial journeys of the Corridor completed by different elephants, suggesting elephants used the Corridor as a linking route between the two ecosystems and as extended habitat. The whole Corridor took on average 3.03 days to traverse, which was 2.81 days longer than the time necessary to complete the journey. The first 10% of the Corridor was highly utilised with a potential bottleneck in the middle of the Corridor. The Corridor was perceived as a success by stakeholders, partners and the community representative. Human-elephant conflict of damage to property by elephants was seen to reduce after the Corridor was built. Overall the Corridor appears to be utilised by elephants as extended habitat and as a link between ecosystems. The Corridor was perceived as success and has provided many benefits to the local communities and farmers. This research hopes to provide to a measure of success for future corridor research to progress towards the wider goal of connecting isolated habitats and allowing gene flow between populations ensuring their future survival.

**Target Journal:** Biological Conservation

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# 1.0 Introduction

## 1.1. Human impact on wildlife movement

As humans become increasingly connected, wildlife and the natural landscape are becoming increasingly fragmented (Crooks & Sanjayan, 2006). The conversion of land to agriculture and infrastructure have caused habitat loss and fragmentation, which increasingly blocks wildlife movement across their previously connected habitats (Vitousek, 1997; Graham, *et al*., 2009). There is a necessity for more land to satisfy the needs of the increasing human population. It has been predicted, for example, that if the entire, relatively untouched Serengeti was handed over to the local Masai population, in 40 years it would be exhausted by the Masai's population growth (Prins, 1992). A common belief is that humans cannot co-exist with large carnivore and/or ungulate species (Carter *et al.*, 2012). Predators depredate livestock ( O'Connell-Rodwell *et al.*, 2000; Hayward & Kerley, 2009) and herbivores and livestock compete for forage ( Voeten & Prins, 1999; Young *et al.*, 2005).

In places where wildlife and humans find it difficult to co-exist, fencing has become a popular conservation tool; it is used worldwide to safeguard endangered species against encroaching human activities (Hayward & Kerley, 2009; Woodroffe *et al.*, 2014). Fencing is used for a number of reasons: to prevent spread of disease (Ferguson & Hanks, 2010; Jori et al., 2011), to prevent crop raiding (O'Connell-Rodwell *et al*., 2000), to prevent predation (Baskale & Kaska, 2005) and to protect endangered species (Gross, 2009). Fencing in Africa is predominantly focused on reducing human-wildlife conflict and poaching (Hayward & Kerley, 2009; Woodroffe et al., 2014).

These fences, once built for the protection of wildlife, are now believed to have increasingly negative consequences, outweighing the dangers wildlife may face outside of fenced areas (Hayward & Kerley, 2009; Woodroffe *et al.*, 2014). Fencing isolates populations which increases inbreeding, threatens long term genetic viability and can cause extinction of local populations (Terborgh *et al*., 2001). Terborgh et al. (2001) also highlighted another major concern, blocking of natural migrations. Migration is essential for a number of reasons including resource acquisition and dispersal (Bennett, Henein, & Merriam, 1994; Hobbs, 1992). Preventing migration can cause overgrazing in fenced areas and reduce the amount of food available which can lower the carrying capacity for grazers (Terborgh *et al*., 2001). Even large fenced areas can quickly become exhausted, leading to habitat degradation, with knock-on effects on other inhabiting species (Hayward & Kerley, 2009).

### 1.2. Wildlife corridors connecting isolated habitats

Wildlife corridors are being used to mitigate the detrimental consequences of fencing and fragmented habitats (Clevenger & Waltho, 2000; Hilty, Lidicker Jr., & Merenlender, 2006). Wildlife corridors are defined as an area, natural or man-made, which facilitates the movement of organisms between the patches of their habitat, allowing them to access essential food and water resources (Hilty et al., 2006; Perry & Falzon, 2014). They have an additional benefit of reducing human-wildlife conflict with local communities (Perry & Falzon, 2014). They have been used for a variety of fauna and flora from butterflies and wolves to bird-dispersed plants (Clevenger & Waltho, 2000; Haddad *et al*., 2003; Beier & Noss, 2008).

One of the benefits of a corridor is the immigration of new individuals, this can increase genetic diversity, therefore enhancing fitness and survival of a population (McKenzie, 1995; Mech & Hallett, 2001). A meta-analysis on the effectiveness of corridors by found, across different taxa, movement between habitats was 50% higher when connected by a corridor than for isolated habitats (Gilbert-Norton *et al.*, 2010). Arguments against corridors include their expensive management needs, high poaching rates and functioning as passages for the spread of disease and predators (McKenzie, 1995).

There are problems facing the establishment of wildlife corridors including social, economic and political impacts on local livelihoods, particularly in areas of high human population density (Ryan & Hartter, 2012).

### 1.3. The case of the African Elephant

African elephants, (*Loxodonta africana*), hereafter elephants, are an iconic and charismatic species (Blanc et al., 2007). The economic value of African elephants has been estimated at US$2.2 billion per year, this was based on their existence, bequest and experience value (Blignaut, *et al*, 2008). They also have important ecological roles including the diversification of savannah and forest ecosystems (Western, 1989; Owen-Smith, 1992; Blignaut *et al*., 2008). Elephants are crucial in the dispersal of many plant species by consumption and consequential dung dropping (Campos-Arceiz & Blake, 2011). In Hwange National Park, Zimbabwe, it was estimated on average an elephant disperses 3,182 woody plant seeds every day (Dudley, 2000). However, for people who live in close proximity to elephants they can be destructive and dangerous. Elephants are well known for crop-raiding, destroying food stores and water sources, and in some instances injuring and killing people (Hoare, 2000; Kikoti *et al.*, 2011).

The IUCN Red List status of African elephants is reported as "Vulnerable" but increasing in number (Blanc, 2008). Between 2008 and 2013 it was estimated that 30,000-50,000 elephants were illegally slaughtered every year for their ivory (Born Free Foundation, 2014). Although even if poaching intensity declines, habitat and range loss are still serious threats to the long-term survival of the species (UNEP *et al.*, 2013), as elephants are becoming increasingly confined to protected areas by human actions (Hoare, 2004). This concentration of elephants can in turn have negative effects on other components of the ecosystem, for example reducing plant diversity (Western, 1989; Clegg, 2008). Elephants are migratory species and travel considerable distances in search of sustenance (Osborn, 2004; Wittemyer *et al.*, 2007; de Beer & van Aarde, 2008;). These characteristics of migration and high resource requirements can bring elephants into conflict with humans (Hoare, 2000).

## 1.4. Elephant behavioural ecology

Elephants have complicated social structures known as fission-fusion systems (Couzin, 2006). Females tend to stay with their natal herds whilst males leave at about 14 years old (Moss *et al.*, 2011) Bulls (adult males) typically form bachelor herds when they are younger and increasingly roam alone as they get older, they have no permanent bonds with females (Cumming *et al.*, 1990; Moss *et al.*, 2011).

Elephants' spatial distribution varies both daily and seasonally depending on availability of food and water (Moss *et al.*, 2011; Wittemyer *et al.*, 2007). They drink almost every day and females with offspring are particularly reliant on water as young offspring are more susceptible to the heat (Kangwana, 1996).

Elephant corridors are generally in unprotected areas connecting protected safe havens (Nelson *et al.*, 2003). Previous studies have shown that elephants recognise these unprotected corridors as dangerous and change their behaviour accordingly (Graham *et al.*, 2009; Kioko &

Seno, 2011; Nelson *et al*., 2003). Speed of movement and distance covered by elephants were found to increase be due to the avoidance of human and agricultural activity (Foley, 2002). Stress levels of elephants also increase in corridors and when moving between protected areas (Jachowski *et al.*, 2013). Elephants generally use corridors at night to minimise the dangers of the unprotected areas (Kioko & Seno, 2011). Bulls are bolder than family groups, taking more risks, and use corridors more frequently (Kioko & Seno, 2011; Nelson et al., 2003).

### 1.5. Mount Kenya Elephant Corridor

As a result of expanding human activity, an elephant migration route was lost between the Samburu-Laikipia ecosystem and Mount Kenya ecosystem (Nyaligu & Weeks, 2013). To reconnect these areas, the Mount Kenya Elephant Corridor (hereafter the Corridor) was built to allow elephants to move freely between Mount Kenya and the Ngare Ndare Forest Reserve (NNFR). NNFR is openly connected to the southern side of Lewa Wildlife Conservancy (LWC) where wildlife has access to the Samburu-Laikipia region via elephant gaps in the boundary fence. Further goals and aims of the Corridor included enhancing genetic diversity of the whole population and a reduction in human-elephant conflict in the area (Nyaligu & Weeks, 2013).

The Corridor route was chosen as it was a natural valley and largely forested with open plain areas (Fig.1). The Corridor bisects the busy tarmac Nanyuki-Meru A2 Highway, which necessitated the construction of East Africa's first elephant underpass, hereafter Underpass, to allow safe passage beneath the road (Fig.1) (White, 2014). After its completion in late 2010, the corridor hosted its first elephant, seen at the Underpass on 1st January 2011 and the same elephant was the first to travel the whole length of the Corridor on 26th January 2011. Elephants are now found within the Corridor nearly every day (Nyaligu & Weeks, 2013).

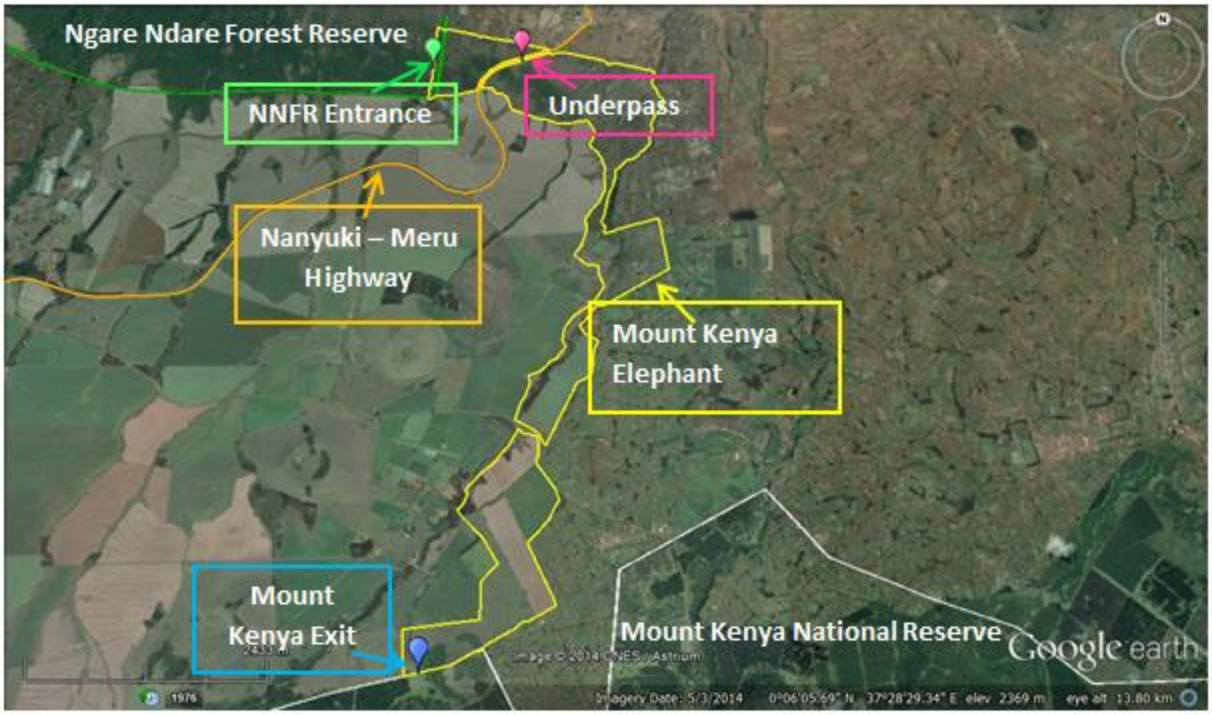


**Figure 1.** Map of the Mount Kenya Elephant Corridor (Map from Google earth, GIS data courtesy of Lewa Wildlife Conservancy and Mount Kenya Trust)

### 1.6. Gaps in Knowledge

LWC monitor elephants within the Corridor using camera traps located at the Underpass and Mount Kenya exit, however the number of elephants recorded at each section did not equate (Mwololo & Chege, 2014). In 2013, 461 elephants entered the Corridor from Mount Kenya, but only 290 were recorded at the Underpass moving from Mount Kenya to NNFR. Therefore it was suggested by the LWC research department that not all elephants were reaching the Underpass from Mount Kenya and instead used the Corridor for food and returned back to Mount Kenya (Mwololo & Chege, 2014). Only a small number of GPS collared bulls have been recorded traversing the whole Corridor (Nyaligu & Weeks, 2013), otherwise there is no individual identification of elephants to track their movement and there has been no formal evaluation of the Corridor's success.

### 1.7. Objectives of this Research

The elephant utilisation of the Corridor will be analysed to create a baseline measure of success of the Corridor against which further research can be compared. There has been no formal measure of success in terms of elephant movement between the two ecosystems to date. Subjective perceived success, with a focus on human-elephant conflict is also discussed.

1. **Do elephants traverse the whole Corridor?**
    - **Objective:** Demonstrate that elephants are moving between ecosystems and using the Corridor as a link by traversing its entire length. This will be assessed on the ratio of whole journeys to partial journeys of the Corridor.
2. **How long do they take to travel the whole length of the Corridor?**
    - **Objective:** Provide insight into how long elephants remain within the Corridor and utilise its resources, and whether access to the linked habitats is facilitated.
3. **Do elephants travel through the Corridor in both directions?**
    - **Objective:** Provide insight into whether the Corridor is suitable to traverse in both directions.
4. **How far do elephants move into the Corridor?**
    - **Objective:** Provide insight into any areas that are highly utilised by elephants or areas that are potentially bottlenecks. This will be assessed on the percentage of individually identified elephants captured at each camera trap station out of the total number of individually identified elephants captures overall.
5. **Is the Corridor perceived as a success or failure?**
    - **Objective:** Report on the perceptions of the Corridor's stakeholders, partner and local community as to its success.
6. **Has human-elephant conflict reduced since the Corridor was built?**
    - **Objective:** Assess whether the Corridor has had a positive effect on human-elephant conflict.

# 2. Methodology

## 2.1. Study area

The fieldwork element of this research was undertaken in the Mount Kenya Elephant Corridor, hereafter Corridor, located in central Kenya between $0^{o}08'03.72''$N - $0^{o}04'16.99''$N and $37^{o}27'21.45''$E - $37^{o}27'26.43''$E. The Corridor begins at the NNFR, in a natural valley running between Marania Farm and Kisima Farm which border either side of the Corridor, ending on the north-western side of Mount Kenya (Nyaligu & Weeks, 2013). NNFR is 5,540 ha of indigenous forest, openly connected to the southern section of LWC by a shared 11.5km boundary, but otherwise fenced (Northern Rangelands Trust, n.d.). On the south-eastern side of NNFR is a purpose-built elephant gap in the fence line, this is the entrance to the Corridor (Fig. 1). The elephant gap is 30m wide with stones piled across it (see Appendix A1) to prevent rhino from leaving the protected area, all other wildlife can pass through (Davidson & Chege, 2013). LWC is 25,090 ha and has a 142 km main boundary which is enclosed by a 12-stranded fence line (Mutinda, Chenge, Gakuya, & Otiende, 2014). The main boundary fence has two gaps for wildlife to enter and exit the Conservancy. The gaps are located on the northern (provides access to northern Kenya) and western boundary (provides access to Borana Conservancy) and built with the same specifications as the NNFR gap (Fig.1).

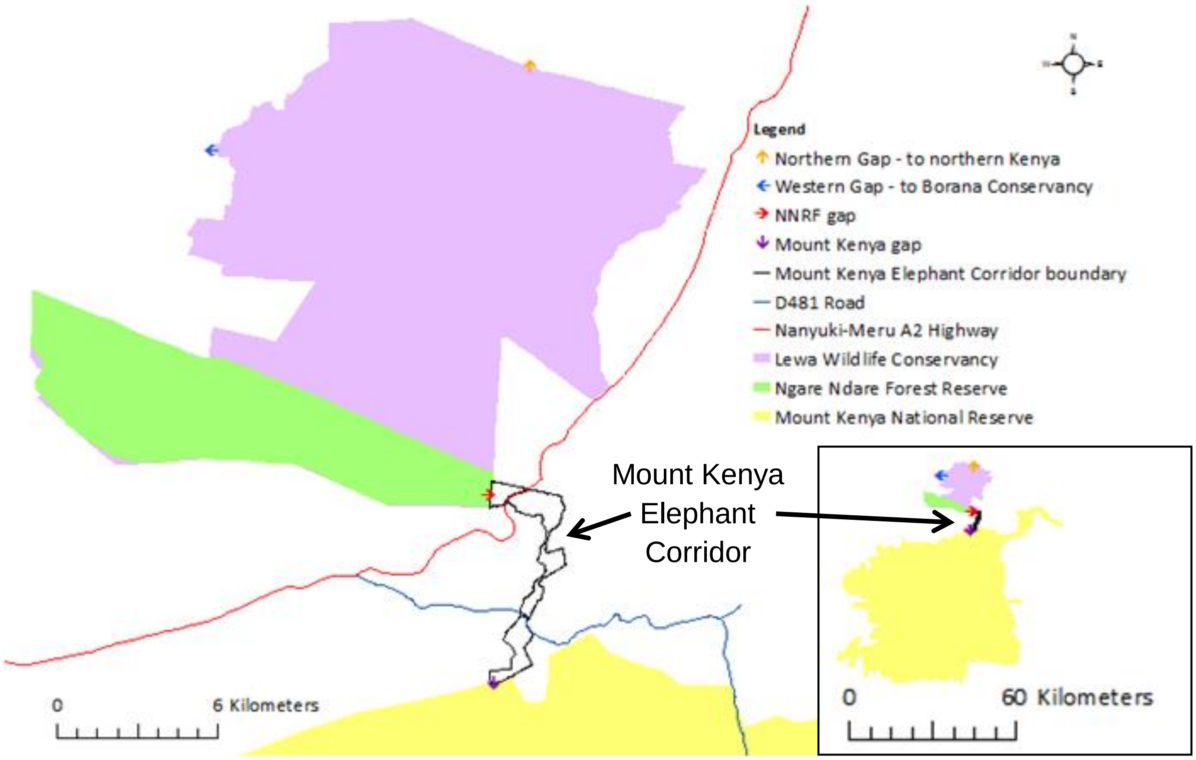


**Figure 2.** Location of the Mount Kenya Elephant Corridor

The Corridor is 14km long and it's width varies from 100-200m to 2-3 km (Nyaligu & Weeks, 2013; Rootham, 2010). The majority of the Corridor is dense forest with small areas of open grassland (Fig.1). There are no permanent water sources for wildlife within the Corridor, only ephemeral when it rains. It is fully fenced to prevent wildlife from entering both the neighbouring farmland and Ntirimiti community. There are two roads that bisect the Corridor, the Nanyuki-Meru A2 Highway which has a concrete Underpass (Appendix A2) and the unpaved D481 road (Fig.2). The only physical break in the fence line is for the D481 road which crosses through the middle of the Corridor, the fence is replaced with dangling electrified stingers (Appendix A3), allowing people and vehicles to cross the road but prevents elephant from leaving the Corridor. The Corridor is privately owned, north of the D481 road belongs to Kisima Farm and south belongs to Marania Farm; they jointly managed the Corridor with Mount Kenya Trust (MKT) and LWC. The MKT have five scouts patrolling the Corridor.

There are two rainy seasons in the region, the first rain usually occurs between April and May, and is typically heavier than the second which occurs between October and December (Gosling & Dunn, 2011). Fieldwork was undertaken in the dry season between 15th July and 8th September 2014.

### 2.2. Study subjects

LWC's elephant population (includes NNRF) fluctuates seasonally and annually between 100-500 individuals (Mutinda et al., 2014; LWC, unpublished data). The regional Samburu-Laikipia elephant population is estimated at 7,500 individuals and Mount Kenya estimate at 2,000 individuals (Thoma, 2012).

### 2.3. Camera trap data collection

Previous monitoring of the Corridor consisted of 4 permanent camera traps (Model: Reconyx HC600); a pair located on the Underpass (Underpass station) and another pair at the end of the Corridor on Mount Kenya (Mount Kenya exit), see Fig.3. The data recorded was date, species, number of individuals and their direction of travel.

For the data collection period an additional 11 camera traps were placed in the Corridor (Models: Bushnell 119476, 119577, 119437). GIS data for the area were provided by MKT and LWC, displayed in ArcMap 10.2.2 with GPS locations of paired camera traps (Fig.3). The camera traps were active in the Corridor for a total of 56 days (55 nights) and monitored and downloaded once a week. All 11 additional camera traps were initially set up with the same settings (Appendix A4) and the original four camera trap settings were synchronised. Recording was continuous, although there were a number of technical difficulties including cameras that stopped working and false triggering by vegetation.

Locations for cameras were limited to the suitability and availability of trees for attachment points, whilst ensuring their security and avoiding animal interference. Camera traps were positioned with the help and knowledge of the MKT scouts, who patrol within the Corridor and monitor elephant movements. They were located on known elephant paths that had evidence of elephant presence: dung and footprints. Cameras were set up in pairs to create 7 camera stations along the length of the Corridor (Fig.3), the single camera was used as an spare and for identification purposes 35/56 days at the Underpass station. Camera trap stations were described in terms as a percentage of the distance travelled into the Corridor from the NNFR entrance; this was calculated using the proposed route taken by elephants through the Corridor by MKT. There were three pinch point sections of the Corridor, NNFR entrance, Underpass and Mount Kenya exit where elephants were funnelled and had no other pathway options but to pass these sections.

At the Mount Kenya exit there is an electrified wire across the gap (Appendix A5), put in place during the day to prevent community livestock from entering the Corridor and taken down at night and when elephants are present, to allow them to pass (Pers. Comm. Maurice Thure).

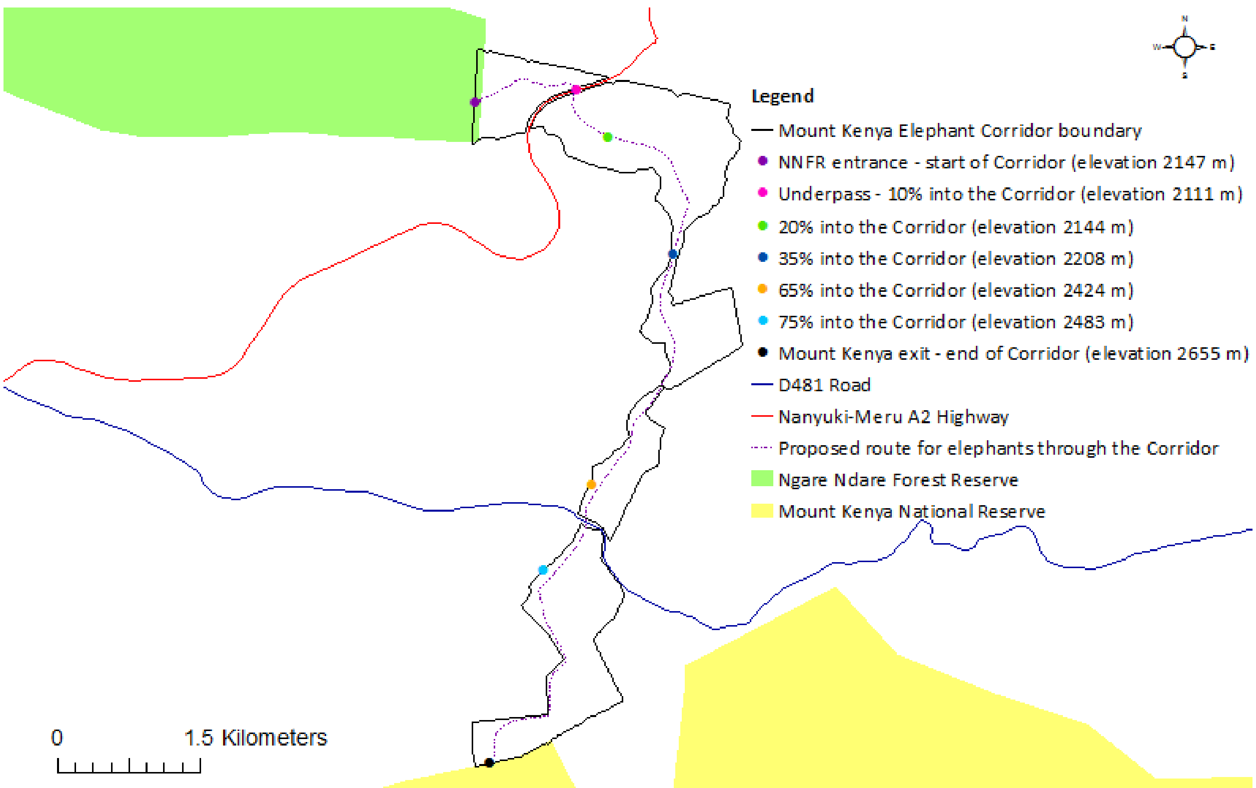


**Figure 3.** Map of Mount Kenya Elephant Corridor showing camera locations

From the camera trap data, the following was recorded:

- location
- date
- start time - first elephant in a photo sequence
- end time - last elephant/elephant in a group in a photo sequence
- complete cross (elephant travelled in one direction either towards NNFR or Mount Kenya, along the pathway and into the next section of the Corridor) /incomplete cross (elephant did not move across the camera and remained on the same side of the Corridor)
- if wire present - at the Mount Kenya exit only
- direction of travel - NNFR-Mount Kenya/Mount Kenya-NNFR
- group structure - individual/pair/group - travelling within a 10 minute interval of each other (Gessner, Buchwald, & Wittemyer, 2014)
- family group - name of family group (if known) /adults/bachelor group
- number of individuals - in pair/group
- age class (see table 1)
- distinguishable features - tusk shapes, ear notches, other feature including GPS collar
- elephant ID code - for adults only
- sex

Family groups were defined as females that were predominantly found with other females and offspring ((Moss et al., 2011). Groups that contained a female/s and offspring were considered part of a family group. Those that contained unidentified/bull adults and no offspring were assumed bulls/bachelor groups.

**Table 1.** Classifications of age classes (Kangwana, 1996; Moss et al., 2011)

| **Age Class** | **Definition** |
|---|---|
| Adult | 10 years or older |
| Juvenile | Between 1-10 years old |
| Young of the year (YOY) | Between 0-1 years old |

To improve the age classification accuracy an attempt was made to estimate age by height (Kangwana, 1996) using the camera traps to capture a ladder showing a scale of known heights and at a known distance(Appendix A6). Then a comparison of the captured elephant photo and ladder photo when the elephant was standing in the same place to determine its height. Unfortunately, this was unsuccessful as a number of camera traps failed to trigger the ladder photo (n = 11).

An Elephant Identification Database (EID) was generated of adults only found within the Corridor. During data entry and three additional sweeps of the camera data, adults were individually identified, if possible, using their distinguishable features including ear notches, tusk shape and prominent veins in their ears (Elephant Voices, 2014). The most reliable method was found to be the prominent ear veins, but these were not always easily seen, particularly at night. The EID was created using representative photos of each individual showing front, back, left, right sides of the elephant (if possible). These representative photos were then compared to ensure each individual was unique. Identification was not always possible due to poor photo quality and the angle of the elephant was facing. Identification of individuals was in collaboration with LWC's Elephant Officer, Kimeli Maripet and a resident of LWC who has collected data on LWC's elephants for 10 years, Susannah Rouse. Individuals that were unknown were given ID code names: males M (A-Z) and females F (A-Z).

## 2.4. Analysis of camera trap data

Data was statistically analysed using chi-square (expected 0.5:0.5) and two way ANOVA in R (version 3.1.0) to a 95% confidence interval, $p < 0.05$.

A capture was defined as an individual elephant caught on a camera trap. As camera traps were in pairs, most elephants were captured on both cameras. To eliminate repetitions, for every download of camera data, the paired camera with the higher number of elephant captures was used in analysis, both were used for individual identification. If pairs captured the same number of captures, the most reliable camera was used which was determined by its overall performance.

To assess how many identified elephants travelled the whole length of the Corridor, defined as a whole journey, only captures from NNFR entrance and Mount Kenya exit were used. In calculating journey time one female from a family was used and any unlikely long journey times were removed (> 7 days). Journey time to traverse the whole Corridor was calculated using the start time that the individual/first in group was initially captured at their entrance and the end time when the individual/last in group exited the Corridor, therefore journey times are an overestimation. This was because the elephant could have been travelling at the front of the herd, but at the back of the herd when exiting. The effect of sex and direction on journey time were analysed.

The ratio of whole journeys to partial journeys was calculated by dividing the number of partial journeys by the number of whole journeys. Partial journeys included journeys where elephants returned back to the entrance they came from and elephants that reached the other side of the Corridor but did not cross. To calculate the percentage of journeys where the elephant used the Corridor as linking route between NNFR and Mount Kenya, the number of whole journeys were represented as percentage of the total journeys.

To determine if any sections of the Corridor were highly utilised or bottlenecks (i.e. section of the Corridor, the total number of identified individuals at each camera station were represented as a percentage of the total number of captures across all stations. The stations with the highest captures were identified as highly utilised; stations with the lowest captures were identified as bottlenecks.

To exemplify movements within the Corridor, five individuals captured at each camera station were shown over the whole data collection period, 15th July to 8th September. The sample individuals were chosen because they were easily identifiable, therefore their sightings were considered more reliable.

To determine if there was an influence of daylight, each capture was sorted into day and night. Civil twilight was used as a measure of daylight hours, defined as enough light to distinguish objects (LMK Webmaster, 2006) on the presumption that elephants could see any potential dangers. Civil twilight hours were used from the closest city to the area, Nairobi (Time and Date, 2014) and daylight hours were calculated between 06:07:00 and 18:54:00. The earliest start time of civil twilight was chosen and the latest end time of the first day (15th July) and last (8th September) of data collection to avoid misidentification of night as day. Start times of captures were highlighted to enable calculation of the number of elephants captured during day and night.

The previous analysis assumption of camera trap data in the Corridor was if elephants were travelling all the way through the Corridor, there would be the same number travelling in the same direction expected at the Underpass and Mount Kenya exit. This assumption was tested using the number of captures at the NNFR entrance (true entrance of the Corridor), Underpass and Mount Kenya exit.

**2.5. Questionnaire: Perception of Corridor success**

To evaluate the perceived success/failure of the Corridor a questionnaire was compiled and presented as an interview to stakeholders and partners of the Corridor involved with the initial idea of the Corridor, its establishment and/or management. The questionnaire contained 27 questions and was designed to be completed in approximately 20 minutes. A pilot questionnaire was undertaken by three people to ensure the questions elicited relevant responses and could be analysed.

15 people were extended the invitation of an interview. These included the main stakeholders and partners of the Corridor: Mount Kenya Trust (MKT), LWC, Marania Farm and Kisima Farm. To establish their involvement, the first set of questions regarded their role and whether they were still directly involved. This information was not analysed but used to exclude any irrelevant answers to sets of questions. The remaining questions covered a variety of topics:

- information provided and received
- the perceived goals and aims of the Corridor
- the  perceived success or failure of the Corridor
- attitudes towards the Corridor before and after it was built
- problems of elephants before and after the Corridor was built
- their knowledge of elephant movement within the Corridor
- any aspects that could be improved

For the full questionnaire see Appendix A7. Questions were asked in a specific order to prevent any questions influencing answers.

### 2.6. Data analysis of questionnaire

For the purposes of the questionnaire, this project's specific indicators of success were defined as:

- achieving the goals and aims described
- reducing the problem of elephants
- reducing human-related incidences with elephants

Fisher's exact test was used on all questionnaire analysis due to the small sample size and to a 95% confidence interval, $p < 0.05$.

# 3. Results

## 3.1. Camera trap results

### *3.1.1. Camera trap overview*

There were 1049 captures by 15 camera traps between 15th July and 8th September, elephants were captured 53 out of 56 days (55 nights). The cameras at the station 65% into the Corridor were only active 27 days as they were stolen.

Elephants of all age classes used the Corridor (Fig.4). There was no difference between the number of adult captures and offspring (juveniles and YOY), (chi-square = 41.64, d.f. = 1, N = 1049, $p > 0.05$). 60% of captures were adults (n=629 captures), 75% of adult captures were individually identified (n=472 captures). The offspring which were found with adults at all times except one (n = 352 juvenile captures, n = 68 YOY captures).

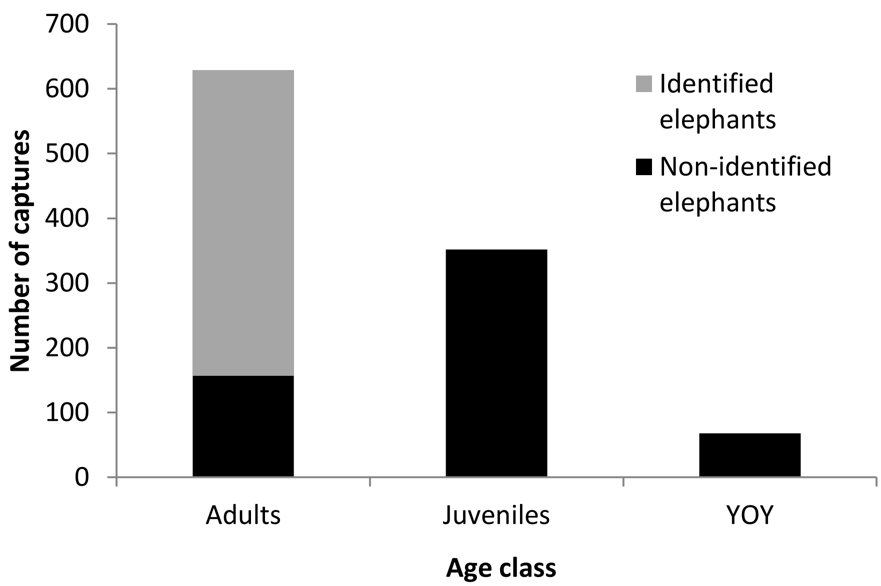


**Figure 4.** Age structure of captured elephants within the Corridor

*3.1.2. The EID - Individually identified elephants*

The EID had a total of 44 individual adult elephants; 36 bulls (n = 264 captures) and 8 females (n = 208 captures).

Females travelled with a family group in 99.5% of captures (n = 207 captures) (Fig.5). 7 females were represented in 3 families that were captured on multiple occasions; Liqueurs (Tia Maria is a female from this family group), FA's and FF's. The Liqueurs contained 5 of the identified females (Rouse, unpublished data). FA's and FF's families each contained one female and their offspring, recorded separately (n = 10 each) and together (n = 4), they are potentially one larger group that splits. Liqueurs and FA's/FF's were never seen together. In 26% of identified bull captures, they travelled with a family group (n = 69 captures). As females travelled with their offspring, there was a combined total of 16 offspring between the three families; therefore a minimum of 60 elephants used the Corridor during the data collection period.

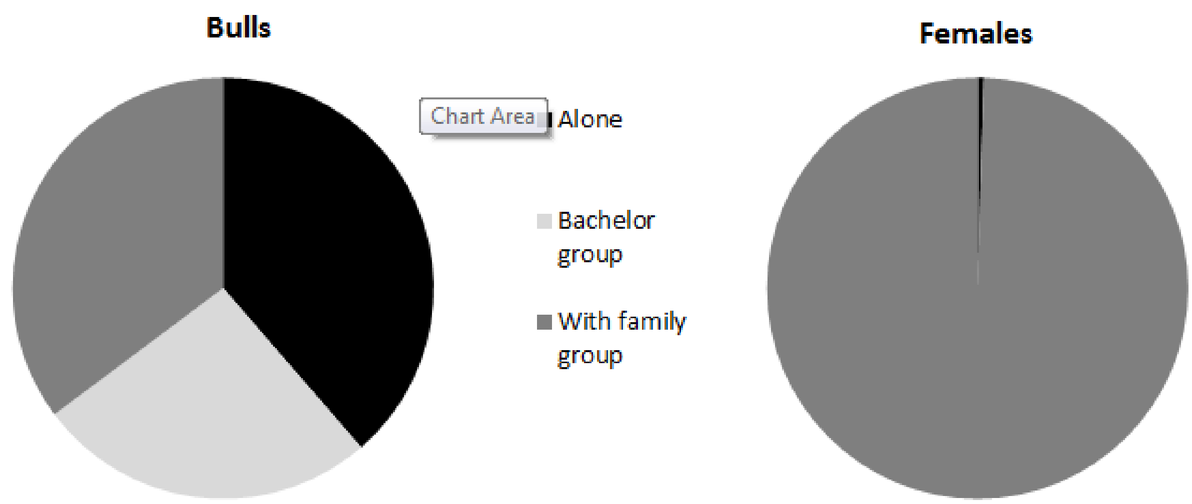


**Figure 5.** Group structure of identified bulls (N = 264) and females (N = 208) captured within the Corridor

*3.1.3. Whole journeys between NNFR and Mount Kenya*

There were a total of 22 whole journeys by 17 identified individuals (Fig. 6). More bulls (n = 13, 11 individuals) made the whole journey than females (n = 8, 6 individuals).

One bull elephant made the whole journey NNFR to Mount Kenya twice, but was not identified re-entering at the Mount Kenya exit (see later Fig. 9c). Two females, Tia Maria and

FA, completed the journey across the whole Corridor in both directions with their families (see later Fig. 9a & c). Therefore, as females travelled with their offspring, a minimum of 31 individual elephants, 52% of all identified individuals travelled the whole Corridor.

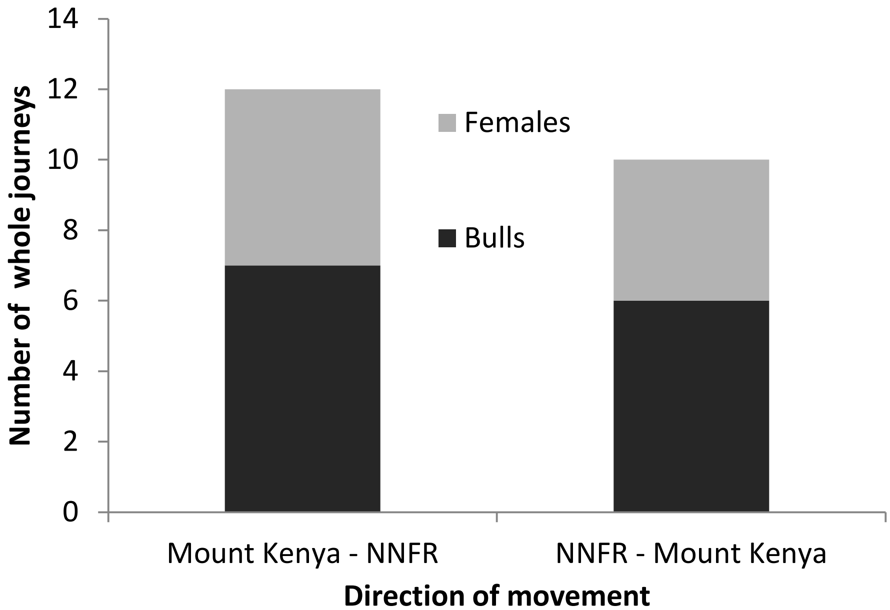


**Figure 6.** Total number of whole Corridor journeys by direction of movement and sex

*3.1.4. Journey time to traverse the whole Corridor*

To calculate journey time, five journeys (4 individuals) of the 17 whole journeys were removed. Four females were travelling in the same family so one female represented this family movement. The 5th journey, by a bull, was removed as he took 9.2 days, therefore it is more likely he was unidentified when entering and leaving as he was only captured at 2 camera trap stations during this time period.

The average journey time through the whole Corridor was 3.03 days (Table 2). Bulls moved faster through the Corridor, completing in 2.55 days (n = 12), than females who took 4.20 days (n = 5). Bulls had the fastest transit time through the Corridor at 0.22 days (n=1), in total three elephants, all bulls, travelled the Corridor in less than 24 hours, whereas the female fastest time was 3.14 days. The slowest transit time was the same for bulls and females (6.52 days).

**Table 2.** Journey times for whole journeys of the Corridor

| Sex | Fastest Journey (Days) | Slowest Journey (Days) | Average Journey Time (Days) |
|---|---|---|---|
| Bulls | 0.22 | 6.52 | 2.55 |
| Females | 3.14 | 6.52 | 4.20 |
| Total | 0.22 | 6.52 | 3.03 |

Despite some differences, there was no significant effect of sex (Two way ANOVA, $F(1,14) = 3.22$, $p > 0.05$) nor direction (Two way ANOVA, $F(1,14) = 0.01$, $p > 0.05$) on journey time through the whole Corridor.

*3.1.5. Tracked movements of identified elephants after entering the corridor*

More identified elephants were captured at the NNFR entrance (n = 54) than Mount Kenya exit (n = 38) (Fig. 7). The majority of elephants returned back to the ecosystem they entered from, although more elephants entered from NNFR and returned back (n= 29 journeys by 15 individuals) than at the Mount Kenya exit (n = 14 journeys by 11 individuals). However, NNFR entrance had more individuals repeating the journey. Therefore a minimum of 47% of captured elephants returned back to their original ecosystem of entrance. A similar number travelled the whole journey of the Corridor in each direction, (NNFR n = 10, 9 individuals; Mount Kenya n = 12, 12 individuals). A minimum of 24% of identified elephants travelled the whole Corridor. One bull made the journey NNFR-Mount Kenya twice (See Fig. 5d). Four individuals that travelled the whole Corridor NNFR-Mount Kenya returned back to NNFR through the Corridor at a later date. Elephants that made incomplete camera crosses at the Mount Kenya Station travelled back through the Corridor and exited into the NNFR. Individuals travelling to the other side of the Corridor but did not cross were only found coming from NNFR as the wire was across the Mount Kenya exit preventing them from crossing over (n = 2, 2 individuals).

A similar number of elephants were not identified exiting at both stations (NNFR n = 13; Mount Kenya n= 12).

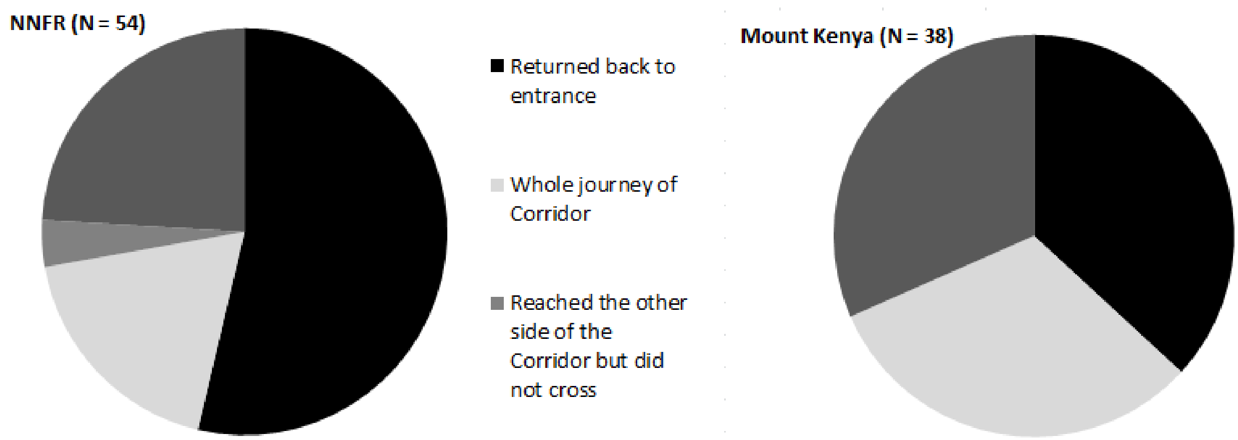


**Figure 7.** Tracked movements of identified elephants after entering the Corridor from NNFR and Mount Kenya

The ratio of whole journeys to partial journeys was 1:2; the Corridor was used for 33% of journeys as a linking route between NNFR and Mount Kenya. However, splitting the journeys into movements by different individuals, whole journey movements to partial movements was 1:1.2; 45% of individuals used the Corridor as a linking route between ecosystems.

*3.1.6. EID individual's movements within the Corridor*

51% of total captures of identified elephants were at the NNFR entrance (26%) and Underpass (25%), classifying them as highly utilised areas (Table 3).
Stations 20% and 65% into the Corridor captured the lowest percent of captured individuals, 4% and 2% respectively; classifying them as bottlenecks.

**Table 3.** Identified elephants captured at each camera station

| Camera trap stations | No. of identified individuals captured | Percent of identified individuals captured |
|---|---|---|
| NNFR entrance | 124 | 26 |
| 10% into the Corridor - Underpass | 118 | 25 |
| 20% into the Corridor | 21 | 4 |
| 35% into the Corridor | 50 | 11 |
| 65% into the Corridor | 11 | 2 |
| 75% into the Corridor | 65 | 14 |
| Mount Kenya exit | 83 | 18 |
| Total | 472 | 100 |

There was a drop off of percentage of identified individuals captured around the middle of the Corridor, suggesting a bottleneck. Both ends of the Corridor have higher percentage captured, but NNFR entrance was higher than Mount Kenya exit. s

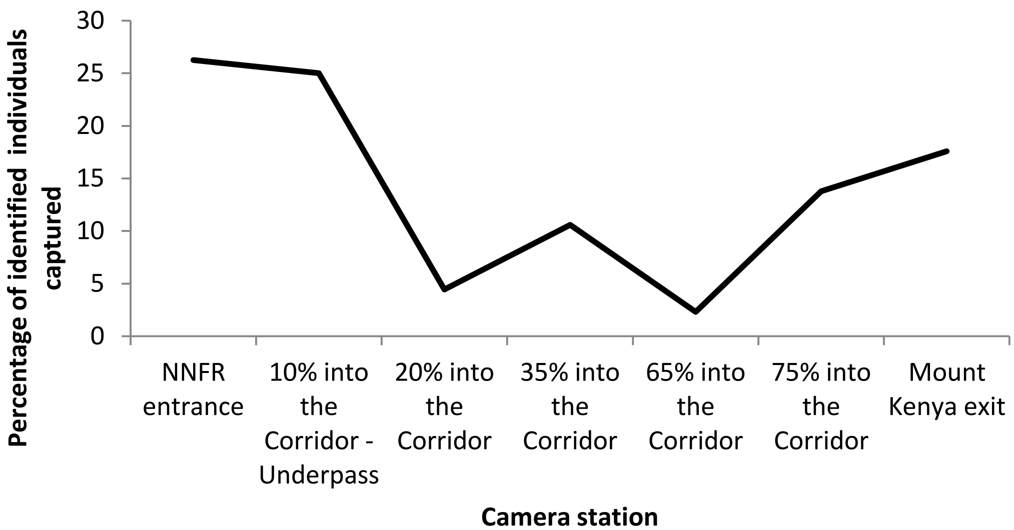


**Figure 8.** Percentage of identified individuals captured at each camera station in the Corridor

The five sample elephants entered the Corridor on multiple occasions, predominantly returning to the ecosystem they started from, but roamed into and within the Corridor to different extents. Tia Maria and FA are females, travelled with their families, Saidimu, MD and Gumo were bulls (Fig.9 a-e).

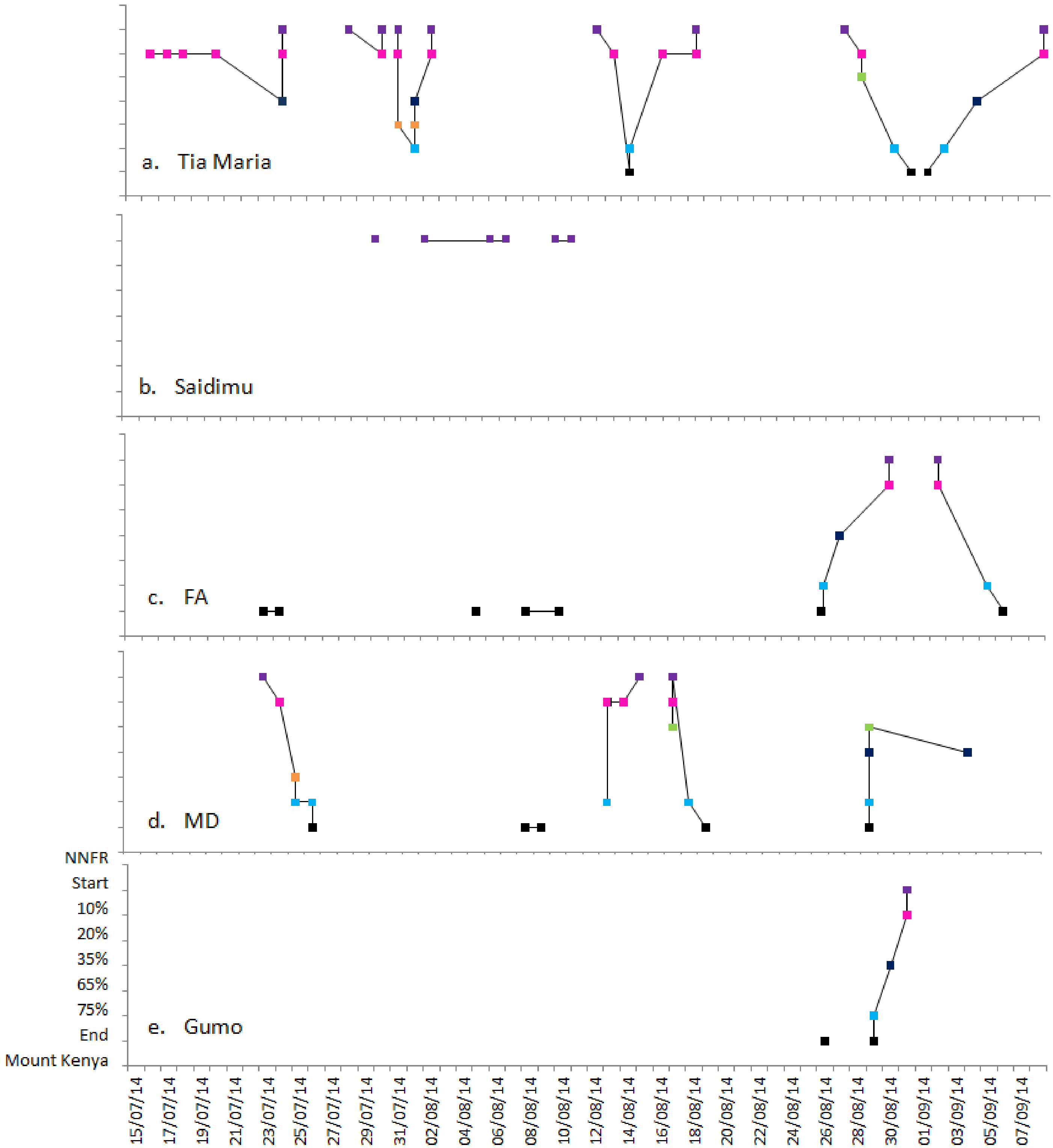


**Figure 9a-e**. Identified elephants movement within the Corridor during the data collection period (15th July - 8th September 2014), an individual captured at a camera station is represented by a data point, the colour corresponds to a different camera station and coordinates with the Corridor map (Fig. 3), lines represent the movement between stations. Gaps show when the elephant exited the Corridor or was not identified re-entering.

*3.1.7. Number of elephant captures*

97% of captures were complete camera crosses (n = 1016 captures) and 3% were incomplete camera crosses (n = 33), of the 1049 total elephant captures on 14 camera traps (Fig.8). The Underpass station had the highest total number of captures (n = 312) and station E had the lowest (n = 35).

The highest number of incomplete camera crosses were at the Mount Kenya station (n = 15 captures). Eight of these were due to the wire across the gap at night, when it is supposed to be down. Every time the wire was recorded as across the gap, no elephants crossed and were all during the night. For the other seven incomplete camera crosses the wire was down, but their reason for not crossing was unknown.

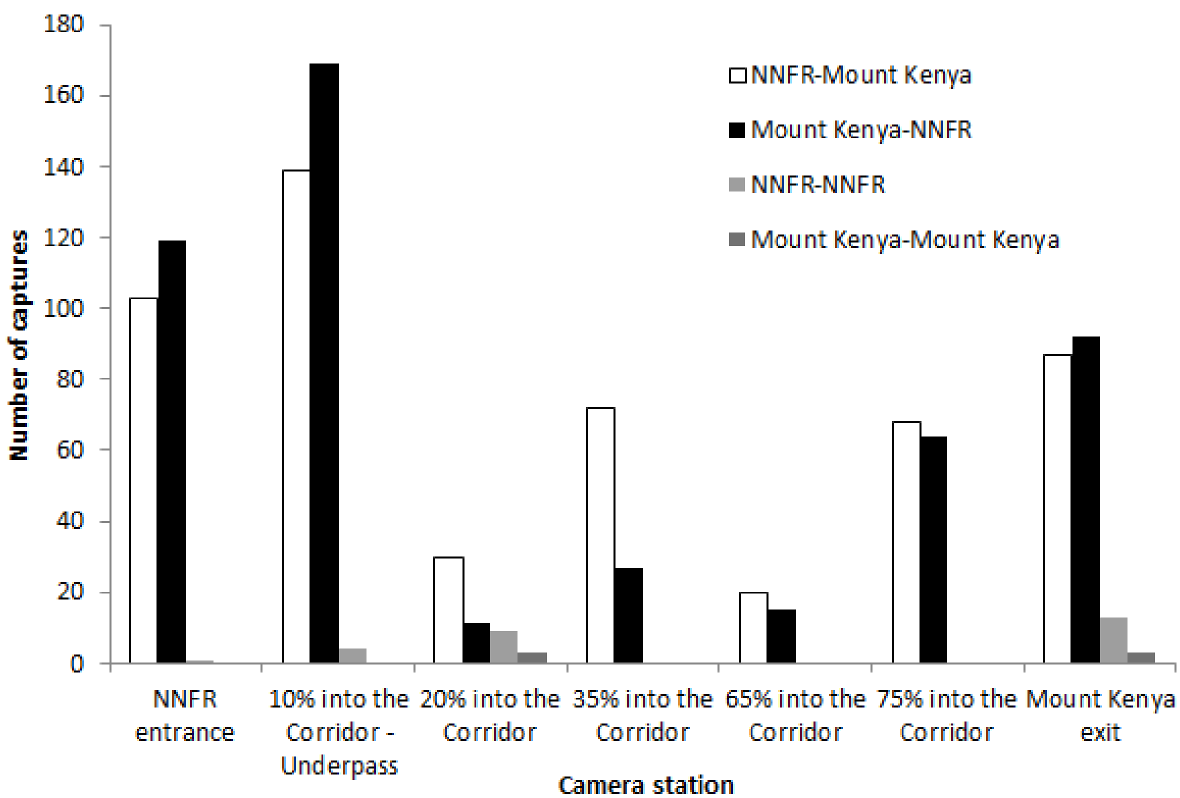


**Figure 10.** Total number of elephant captures at each camera trap station and their direction of movement

There was no difference in the total number of captures moving in each direction for complete crosses, (chi-square = 0.48, d.f. = 1, n = 1016, $p > 0.05$).

Camera stations 20% and 35% into the Corridor were the only stations with a difference in number of captures moving in each direction (Table 4).

**Table 4.** Number of complete crosses captured at each camera station and chi-square analysis with expected 0.5:0.5, bold highlights p values < 0.05

| **Camera trap stations** | **Direction** | | **Chi-square analysis** | | |
|---|---|---|---|---|---|
| | **NNFR-Mount Kenya** | **Mount Kenya - NNFR** | **$X^2$** | **d.f.** | **p value** |
| NNFR entrance | 103 | 119 | 1.15 | 1.00 | 0.28 |
| Underpass - 10% into the Corridor | 139 | 169 | 2.92 | 1.00 | 0.09 |
| 20% into the Corridor | 30 | 11 | 8.80 | 1.00 | **<0.001** |
| 35% into the Corridor | 72 | 27 | 20.45 | 1.00 | **<0.001** |
| 65% into the Corridor | 20 | 15 | 0.71 | 1.00 | 0.40 |
| 75% into the Corridor | 68 | 64 | 0.12 | 1.00 | 0.73 |
| Mount Kenya exit | 87 | 92 | 0.14 | 1.00 | 0.71 |
| All stations | 519 | 497 | 0.48 | 1.00 | 0.49 |

*3.1.8. Elephant day and night movements through the Corridor*

Total elephants captures across all the stations were higher during the night ( chi-square = 77.4, d.f. = 1, n = 1049, $p < 0.05$) (Table 5) except station 35% into the Corridor, which was lower, and 65% into the Corridor and NNFR station, which did not show a difference.

**Table 5.** Day and night captures for each camera station and chi-square goodness of fit analysis, bold highlights p value < 0.05

| Camera trap stations | Presence of daylight | | Chi-square analysis | | |
|---|---|---|---|---|---|
| | **Day captures** | **Night Captures** | $X^2$ | **d.f.** | **p value** |
| NNFR entrance | 116 | 107 | 0.36 | 1 | 0.55 |
| Underpass - 10% into the Corridor | 116 | 196 | 20.07 | 1 | **<0.001** |
| 20% into the Corridor | 37 | 16 | 8.32 | 1 | **<0.001** |
| 35% into the Corridor | 62 | 37 | 6.31 | 1 | **<0.001** |
| 65% into the Corridor | 12 | 23 | 3.46 | 1 | 0.06 |
| 75% into the Corridor | 29 | 103 | 41.48 | 1 | **<0.001** |
| Mount Kenya exit | 10 | 185 | 157.05 | 1 | **<0.001** |
| All stations | 382 | 667 | 77.43 | 1 | **<0.001** |

*3.1.9. Underpass capture numbers against the entrance and exit of the Corridor*

There was a difference in the number of captures between the Underpass and Mount Kenya exit in both directions, NNFR-Mount Kenya (chi-square = 11.96, d.f. = 1, n = 226, p < 0.05), Mount Kenya-NNFR (chi-square = 27.0, d.f. = 1, n = 261, p < 0.05). However, there was no difference between number of captures for both directions, using the entrance and exit of the Corridor (NNFR entrance and Mount Kenya exit), NNFR-Mount Kenya (chi-square = 1.35, d.f. = 1, n = 190, p > 0.05), Mount Kenya-NNFR (chi-square = 3.46, d.f. = 1, n = 211, p > 0.05).

There was a difference between the number of captures at NNFR entrance and the Underpass for both direction, NNFR-Mount Kenya (chi-square = 5.36, d.f. = 1, n = 242, p < 0.05), Mount Kenya-NNFR (chi-square = 8.68, d.f. = 1, n = 288, p < 0.05).

*3.1.9. Group structure of elephants*

The group structure revealed that the majority of captures were groups (n = 864), in particular groups containing females and offspring (n = 755) (Fig.11). There were a total of 109 groups with an average group size of eight. Group size varied; the largest containing 17 individuals, a family group with bulls, and the smallest three individuals. Adults without offspring travelled alone (n = 131 captures) more than in pairs (n = 40 captures) or a group (n = 109 captures).

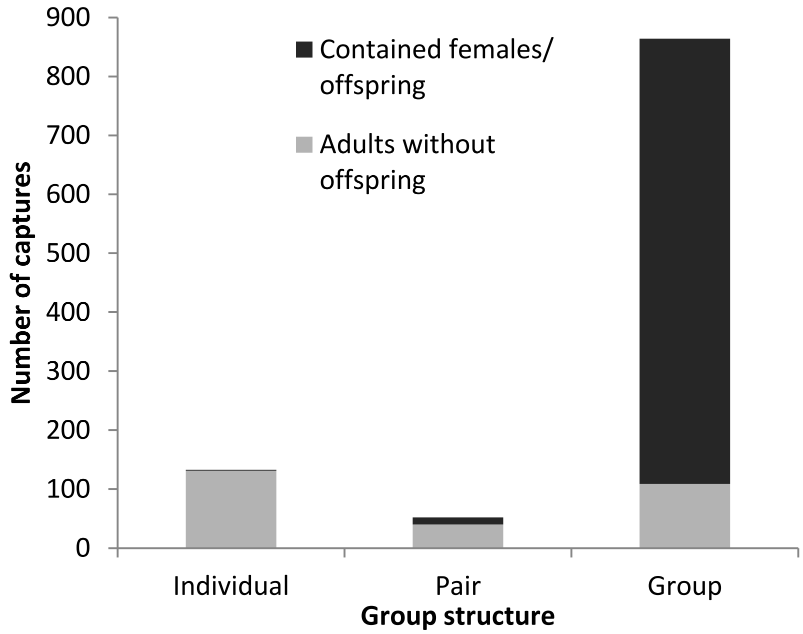


**Figure 11.** Group structure of elephant captures within the Corridor

## 3.2. Questionnaire Results

*3.2.1. Overview of questionnaire results*

Of the 15 people invited to interview, 12 replied, but only 11 were available during the data collection period interviewed, for full details of respondents see Appendix B1.

The Corridor was considered a success by the stakeholder, partners and Ntirimiti community. Human-elephant conflict had reduced for property damage such as crop raiding and fence destruction. Human-related incidents remained the same after the Corridor was built as a result of a trespasser being killed by an elephant within the Corridor.

*3.2.2. Perceived goals and aims of the Corridor and its success* (N = 11 respondents)

All respondents had similar concepts of the Corridor's was built for the benefit of elephants. 9/11 included it was for reduction of human-elephant conflict.

The Corridor was considered highly successful; the average success rating for the goals and aims respondents described was 4.9/5.

*3.2.3. Overall attitudes towards the Corridor before and after it was built* (N = 11 respondents)

9/11 respondents said there were mixed feelings towards the Corridor before it was built, 2/11 said there were positive feelings.

The overall attitude towards the Corridor changed from mixed to positive after the Corridor was built ($N = 11$, $p < 0.005$, Fisher's exact test) (Table 6). All respondents said there was a positive attitude towards the Corridor after it had been built.

**Table 6.** Attitudes towards the Corridor before and after it was built

| Overall attitude towards the Corridor | Before the Corridor was built | After the Corridor was built |
|---|---|---|
| Positive | 2 | 11 |
| Negative | 0 | 0 |
| Mixed | 9 | 0 |

*3.2.4. Impact of the Corridor on the problem of elephants* (N = 10 respondents)

9/10 respondents identified crop damage as a problem before the Corridor was built (Fig.12). 6/10 respondents identified the problem of fence damage. Livestock loss did not appear to be a regular conflict issue with only one incident reported (10-15 years ago elephants trampled 5-6 sheep and chased cows).

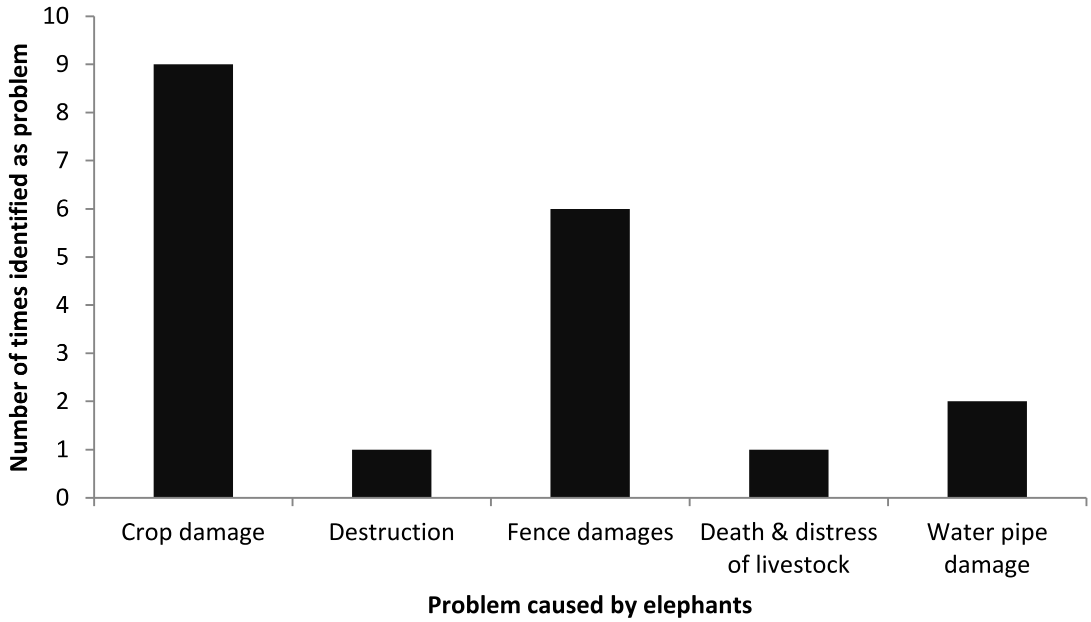


**Figure 12.** Problems caused by elephants before the Corridor was built (N = 10 respondents, 8 respondents gave multiple problems)

50% of all respondents reported that elephant conflict ceased after construction of the corridor (N = 10, $p < 0.03$, Fisher's exact test). The remaining 50% of respondents reported that there was still a problem (Table 2), three reported this was due to a single elephant, Mountain Bull.

**Table 7.** Problem of elephants before and after the Corridor was built

| **Problem of elephants?** | **Before the Corridor was built** | **After the Corridor was built** |
|---|---|---|
| Yes | 10 | 5 |
| No | 0 | 5 |

*3.2.5. Impact of the Corridor on human-related incidents* (N = 10 respondents)

There was no difference in human-related incidents before and after the Corridor was built (N = 10, $p > 0.05$, Fisher's exact test), see Table 8. 6/7 respondents stated that after the Corridor was built a man had been killed by an elephant whilst trespassing within the Corridor on 7$^{th}$ September 2011.

**Table 8.** Human- related incidents before and after the Corridor was built

| **Human-related incident?** | **Before the Corridor was built** | **After the Corridor was built** |
|---|---|---|
| Yes | 5 | 7 |
| No | 5 | 3 |

*3.2.6. Knowledge of elephant movements* (N = 11 respondents)

10/11 respondents said elephants moved through the entire Corridor and in both directions. 1/11 did not know if either occurred.

*3.2.7. Limitations and suggested improvements for the Corridor* (N = 11 respondents)

- Easy aspects or areas of the Corridor (n = 1)

The forested area next to the Mount Kenya exit was identified by one respondent as an easy aspect/area, as elephants stay there during the day and move during the night. Another respondent also highlighted this area as an example of a potential problem in the future as in the three years of the Corridor opening, elephants have heavily thinned this area.

- Hard aspects or areas of the Corridor (n = 5)

The D481 road crossing area was identified and seen as a weak spot and too narrow (n = 3). For improvements to the Corridor, 7/11 respondents suggested a second underpass at this road crossing.

3/11 respondents thought the current Underpass would be a problem but added that it appears not to be as elephants use it at night to avoid traffic.

*3.2.8. Information received by respondents regarding the Corridor* (N = 9)

The types of information provided to the respondents regarding the Corridor were written reports, verbal reports and organisational newsletters (from MKT & LWC). 3/11 respondents received all types of information, 1/11 respondent received two types and 5/11 received only one type. Verbal reports were the most commonly received type of information (n = 7) and organisational newsletters the least (n = 3) (Fig.13). MKT provided information to everyone still directly involved in the Corridor, including individuals within their own organisation.

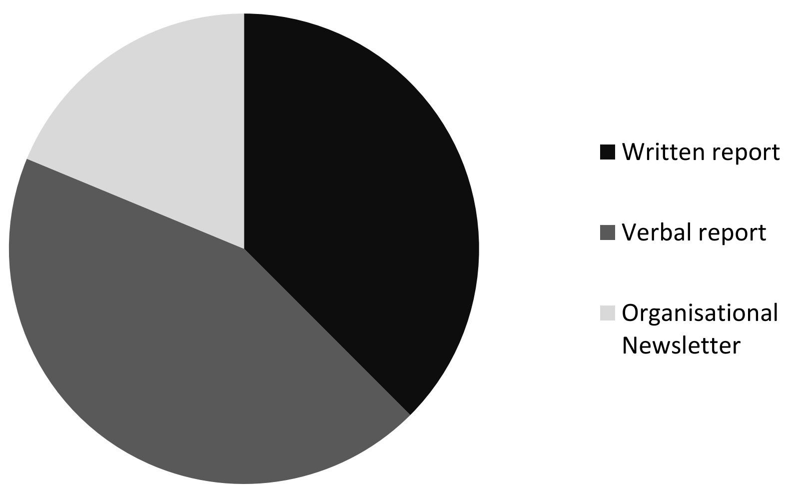


**Figure 13.** Types of information provided about the Corridor (N = 16 by 9 respondents)

The majority of respondents would like to receive more information about the Corridor (n = 6). The remaining three were satisfied with the amount they already receive, and were the only ones to receive all three types of information. All respondents who would like to receive more information requested specifically more extensive elephant data and analysis. Other information requested included data regarding people and livelihoods and number of intruders found within the Corridor.

# 4. Discussion

## 4.1. Camera trap results

A minimum of 60 different elephants utilised the Corridor in 56 days (55 nights), 52% of all identified elephants, plus their families, traversed the whole Corridor. The ratio whole to partial journeys was 1:2; more journeys were made to use the Corridor as extended habitat than a link between NNFR and Mount Kenya. Although, when split into journeys made my different individuals the difference decrease to 1:1.2. On average the journey took just over three days to complete, which was 2.81 days longer than the fastest time. Elephants travelled the Corridor in both directions and there was no difference in number of elephants traversing the whole Corridor in either direction; direction did not affect journey time. Elephants were captured almost daily and there was no difference in number of elephants entering the Corridor at either end. The first 10% of the Corridor was classified as a highly utilised section, whereas the middle of the Corridor is a potential bottleneck. From the sample of five elephants tracked movements, they all to travelled within the Corridor to varying degrees, entering multiple times suggesting using it as extended habitat. One bull did not move more than 10% into the Corridor over the data collection period, whilst others went the entire length.

There was no difference between the proportion of adults and juveniles captured within the Corridor, which is contrary to a previous study where the numbers differed, particularly when they were in close proximity to humans as females with young offspring were cautious (Kioko & Seno, 2011). This suggests that the Corridor may be perceived as a safe area by elephants as families frequently utilised it.

More bulls were captured in the Corridor than females, this agrees with previous studies (Kioko & Seno, 2011). Bulls typically range further than family groups as they are not limited by offspring (Stokke & Toit, 2002). As females travel in family groups (Moss et al., 2011), it was unlikely many females were unidentified and there were just fewer females in the Corridor. This observation agrees with a previous study where bulls were found to be bolder than family groups and use corridors more frequently (Kioko & Seno, 2011). More bulls made the whole journey than females, however as there were more bulls identified, this was expected. Proportionally, of the identified elephants, more females made the journey. Although another study found family groups used corridors more than bulls  (Kikoti et al., 2011). There were few whole journeys, in particular for females, therefore data collection would need to be carried out for a longer period to determine if there was a bias of sexes utilising the Corridor.

Double as many partial journeys were made to whole journeys, therefore implying the Corridor was used more for extended habitat than as a linking route between NNFR and Mount Kenya. However, examination of the number of journeys by different individuals revealed a 1:1.2 whole to partial journey ratio. 45% of individuals were utilising the Corridor as linking route; therefore despite higher proportion of partial journeys, the number of different individuals making the journeys were comparable. Further research over a longer period of time would determine if the utilisation of the Corridor as a linking route or extended habitat varies seasonally or annually. These ratios can be used as baseline for future analysis to determine any change in utilisation by elephants.

25% of bull captures were in the company of a family group; this is a minimum as bulls may have been unidentified when travelling with a family group or not passed a camera station with them. The interaction between bulls and females from different populations provides the potential for genetic mixing between the populations; however in this research is it not known where the bulls and females originate. To test if elephant populations are genetically mixing, the genetic distances between the two populations can be determined (Mech & Hallett, 2001), although this may be impractical and expensive. To determine if both populations are utilising the Corridor and mixing, elephants need to be identified if possible with their ecosystem of origin. Contrary to previous impacts of fencing (Graham *et al*., 2009; Hayward & Kerley, 2009; Nelson *et al*., 2003), the Corridor’s fencing is likely to increase genetic diversity for elephants as it has extended their home ranges rather than compressing it, whilst protecting them from poachers.

The NNFR entrance and Underpass (10% into the Corridor) represented 51% of identified elephants captures, classifying the first 10% of the Corridor as a highly utilised area by elephants. As these stations were both pinch-points in the Corridor this may explain why they had a high number of captures. There could be a valuable resource in this area may mean elephants do not need to travel further into the Corridor, or the next section (20% into the Corridor) could be unfavourable and/or impeding them advancing along the Corridor. More extensive camera trap analysis of these areas would be needed to determine this. An assessment into if this high proportion of utilisation is having adverse effects on the vegetation in this section may be needed to prevent degradation of the section and to funnel elephants through to the next sections of the Corridor.

The middle of the Corridor had a drop off of percentage of captured individuals, in particular stations 20% and 65% into the Corridor represented the lowest percentage of identified individuals. These sections could potentially be bottlenecks of the Corridor and impeding movements of elephants through these sections. As station 65% into the Corridor cameras were stolen and only recorded 27/56 days of data collection, the section may not be a bottleneck but rather were active for a shorter period of time and consequently had less data. Further investigation and longer term data collection would be necessary to conclude if these sections or any others were bottlenecks and identification as to why they were. Mitigations against any bottlenecks should increase the proportion of elephants captured in the future and improve the connectivity between NNFR and Mount Kenya.

Only females Tia Maria and FA were recorded to have made the whole journey travelling in both directions, entering the opposite ecosystem (for between 1-3 days), but returning to their initial location. This suggests these females, and their families, are using the Corridor as part of their home range, more than as a transit route. GPS tracking of these families would be needed to confirm their ranging patterns (Douglas-Hamilton *et al.*, 2005). Alternatively, they could be making exploratory ventures into new areas in search of resources, for when conditions become drier and less favourable; this inference would need further research.

Despite, at least bulls', being able to travel the whole Corridor in less than a day, the average was just over three days and the slowest was twice the average. Elephants were travelling through the Corridor slower than it appears necessary to cover the distance. If this is true and elephants are not rushing through the Corridor, it would contradict previous studies that found elephants move faster in corridors (Douglas-Hamilton *et al*., 2005; Foley, 2002). However, there was no comparison of calculation of speed as elephants travelled an unknown distance within the Corridor and no data collected of speed outside of the Corridor. Corridors are usually seen as dangerous by elephants as corridors are generally in unprotected areas and connecting protected areas (Graham et al., 2009; Kioko & Seno, 2011; Nelson *et al*., 2003). As the Corridor is for wildlife only, patrolled daily and no incidents of elephant poaching have been recorded, it is unlikely elephant perceive the Corridor was a threat, especially as they spend much longer periods than appears necessary inside. Elephant forage for 16-18 hours a day (Ruggiero, 1992) and drink almost daily (Kangwana, 1996), sufficient resources must be available within the Corridor to sustain them.

During the data collection period, the sample elephants appeared to utilise the Corridor as extended habitat rather than to move between the two ecosystems. This was exemplified by the individual movements within the Corridor entering the Corridor on more than one occasion. Tia Maria and her family extensively used the Corridor, seeming to have incorporated this area into their home range. However, data would need to be collected over a longer period to confirm this. The Liqueurs were captured most often at the NNFR entrance and Underpass, indicating they spent extended periods within these sections or used pathways that were not cover by camera stations. To further investigate which areas are being heavily utilised, GPS tracking of routes taken within the Corridor and continued camera trapping within the area, over a longer period of time may provide an insight.

Tracking of individuals revealed that the despite a similar number of captures at the entrance and exit this does not necessarily provide evidence that elephants are moving all the way through the Corridor. Therefore to estimate the movement patterns of elephants between ecosystems, individual identification needs to be integrated into monitoring. As the NNFR entrance, Underpass and Mount Kenya exit were pinch-points, had the highest number of capture, they would therefore be ideal locations for monitoring individuals between ecosystems. Therefore the addition of permanent camera traps to the NNFR entrance would benefit the current monitoring method as the current method of using the Underpass and Mount Kenya exit may not be representing the full picture of how many elephants are entering and exiting the Corridor and travelling the whole length. Particularly in light of the difference in captures between the NNFR entrance and Underpass.

The pathway covered by the station 75% into the Corridor appears to be well utilised by elephants, with a high capture number despite being active only 49 days in this location. Whereas the stations 20% and 35% into the Corridor had lower captures and were in wide and forested areas with multiple available pathways. The incomplete crosses at the station 20% into the Corridor were due to elephants not following the road instead crossing horizontally over it and remaining on the same side of the Corridor (see Appendix C1). Elephants could have circumvented the cameras and still passed this wide, forested section of the Corridor. At the Station 35% into the Corridor, over 70% of captures were in the direction NNFR-Mount Kenya indicating they could have used a different pathway on the downward journey. This station was also shown to be the only station to have a higher number of captures during the day than at night. This area was the hardest to access by vehicle due to the high vegetation density, which may explain why it appears safer to travel through during the day. As there are multiple pathways through this area, more cameras covering this particular area would reveal to what extent elephants utilise it.

The wire across the Mount Kenya exit prevented a number of elephants from entering and exiting the Corridor. All records of elephants being prevented from crossing were during the night, when the wire should have been removed to allow wildlife to cross. Other wildlife using this gap also found it difficult to cross due to the wire. When the wire was flat on the ground, elephants trod carefully on or around the wire. This may be because they had previously hit the electrified wire or were daunted by the open area around the gap. When Tia Maria and her family were prevented from crossing, it appeared to influence their movement as they travelled back the length of the Corridor and re-entered NNFR. In the case depicted, the Liqueurs did return and cross into Mount Kenya National Park 17 days later. However other elephants may be deterred by the wire for longer periods. Females have been known to avoid areas after the erection of electrified fences (Nelson *et al.*, 2003). In light of this, careful attention needs to be paid to the wire management so that it does not prevent elephants and other wildlife from crossing as this is the intended purpose of the Corridor, allowing free movement.

## 4.2. Questionnaire results

Overall the Corridor was considered successful by respondents in the goals and aims they described for the Corridor. Human-elephant conflict has been seen to reduce since the Corridor was built for incidents of crop raiding and destruction of fences. It remained the same with human-related incidents due to the mortality of a trespasser in the Corridor. The overall attitude towards the Corridor is now positive.

There was a high level of awareness of the goals and aims of the Corridor and the benefits that were hoped to be gained for elephants; examples included linking the two ecosystems, genetic mixing of populations and restoring historical migration route. Also for the reduction of human-elephant conflict; examples included were reducing crop damage and conflict with locals and farmers. This was further shown by all respondents stating there was an overall positive attitude towards the Corridor after it was built. A potentially confounding factor of this question was that people may be reluctant to admit they were against the Corridor before it was built, especially if it is seen as a success, as all respondents considered it to be. The negative feelings resulted from a lack of understanding as people thought that the Corridor would bring more elephants closer to the crops and community. The change in attitude was explained as simply because ‘it worked’ and there was reduced elephant conflict for both farmers and the community.

Crop damage was perceived as more detrimental for small farm holders. This was owing to the fact that a whole season’s crop could be demolished by a single elephant in one night. Whereas commercial farms may more easily withstand the damage inflicted. Elephants are more likely to be injured by people when in close proximity to arable farms (Mijele *et al*., 2013). One respondent stated that before the Corridor, elephants had been found speared in NNFR in retaliation of crop destruction. This highlighted that human-elephant conflict was high in the area and there was a need for a change in community attitude. Fundraising from the Corridor has provided a local community Ntirimiti with a clinic which has up to 500 patients per month and provides support in health education. These people had never seen benefits from conservation before, and this may have been a factor encouraging local support.

Participation of the community in conservation can be mutually beneficial for people and wildlife, as they can act as a key contact on the ground (Mijele *et al*., 2013).

Fence breakages are a common issue in the area and occur daily on LWC (Pers. Comm. Kimeli Maripet). To alleviate the number of breakages on LWC, frequent fence breakers are de-tusked and this has proved effective, although the behavioural consequences to de-tusking are still unknown (Mutinda *et al.*, 2014). The Corridor concept was envisaged owing to the activity of one notorious fence breaking elephant named Mountain Bull. The bull continued to use the blocked migration route and cross community and farm lands despite the corridor having been provided) (Lewa Wildlife Conservancy, 2014). In an attempt to halt this behaviour, he was de-tusked in October 2012 and in January 2013 he was captured for the first time at the Underpass (Lewa Wildlife Conservancy, 2013). This was the bull named as a remaining problem after the Corridor was built, regrettably he was found dead on 15th May 2014 on Mount Kenya, killed by poachers (Lewa Wildlife Conservancy, 2014), therefore is no longer an issue. Elephants are now confined to the Corridor by the fences which are regularly maintained; therefore fewer elephants trample through community lands and raid farmland crops. Fence breaking is a worldwide problem with elephants; there are many different types of fencing used to prevent humans and elephants from coming into contact. It has become an "arms race" between the elephants and new fence designs as once an elephant finds a method that breaks the fence, they teach it to others making fences that are effective in one area, ineffective in others (Evans, 2013; Hoare, 2000; Thouless & Sakwa, 1995).

Human-related incidences did not differ before and after the Corridor, this was largely explained by the single isolated incident of a trespasser killed in the Corridor by an elephant. Therefore human-related incidences may have reduced but have been masked by this single incident. Trespassers enter the Corridor to harvest wood and grass and are commonly apprehended, but many are not taken to the police due to a lack of transport (Mount Kenya Trust, 2013). After the Corridor was built, more comprehensive record-keeping began by MKT. Particularly with the focus and "celebrity" of the Corridor there is now more awareness that could highlight and emphasise incidences.

If elephants continue to thin the forest next to the Mount Kenya exit, and throughout the Corridor, there is a possibility that it will turn into open plains, which may be considered dangerous by elephants. Elephants confined to small/fenced areas commonly exhaust resources quickly (Clegg, 2008; Douglas-Hamilton *et al.*, 2005; Hayward & Kerley, 2009). Despite elephants being free to enter and exit the Corridor, the large numbers of elephants utilising it and remaining there for extended periods, this could produce similar results in the Corridor resulting in habitat degradation.

A proposal for the addition of a second underpass at this open road crossing has been submitted. It is crucial to the continued success of the Corridor, reducing human-elephant conflict and providing the elephants with a safe route. Despite no recorded incidents between humans and elephants at this section to date, one respondent stated that children had refused to go to school for a month, too scared to cross because of the elephants. Any clashes between humans and elephants could prove devastating for the positive attitudes towards the Corridor and conservation. As mentioned previously, corridors are known for increased rates of poaching and wildlife trapping, it is thus imperative that elephants are separated from the open access of the road. Although no incidences of elephant poaching have been recorded in the Corridor, snares have been found for other wildlife (Mount Kenya Trust, 2013). Trespassers enter the Corridor from the road crossing, as demonstrated by the theft of the cameras from the station 65% into the Corridor, which were a short distance from the D481 road crossing.

Respondents receive various forms of information, from a variety of sources, with MKT a common source to all. Whilst numbers and sightings of elephants are already collected by MKT and LWC, there is the question of who requires what data and why. This data would prove very helpful to NNFR, as conservation measures may need to be implemented to protect the indigenous forest if the numbers of elephants passing through to use the Corridor are increasing. Given the current ivory poaching crisis (IUCN, 2013; Lemieux & Clarke, 2009; UNEP *et al.*, 2013), this data is sensitive and there may be dire consequences in the wrong hands. Distributing information regarding any intruders within the Corridor coupled with number of arrests, already collated by MKT and reported monthly in a newsletter, would reinforce the concept that the Corridor is being patrolled and belongs to the wildlife.

Continued support to local communities would also positively emphasise this concept. To ensure everyone receives the same baseline information, a quarterly newsletter with key points highlighted, could be assembled and distributed. Key points could include the number of elephants travelling in each direction on each camera station, any arrests/trespassers, fence breaking occurrences (human and elephant) and fundraising projects. MKT already provide some of this information monthly, however this could be combined with LWC's research reports for increased circulation.

A continuation of this in-depth research is necessary to monitor any changes in utilisation over time. Barriers to movements and fragmentation of habitats are serious threats to elephants and can increase human-elephant conflict tensions (UNEP *et al.*, 2013). The continuation of habitat fragmentation is anticipated to accelerate the worldwide species extinction crisis, therefore conservation efforts should be focused towards connecting isolated habitats to allow to gene flow between populations (Reed, 2004).

## 4.3. Limitations of this research project

### *4.3.1. Limitations of camera trap data collection*

There were some technical difficulties, which included cameras that stopped working completely (n = 3), partially stopped working (n = 2), ran out of battery (n = 1), memory storage space (n = 1).

During data collection it was noted clock times between camera pairs sometimes were not remaining synchronized and were adjusted if the discrepancy was more than two minutes (n = 29).

One of the permanent cameras was delayed in syncing as the 15 second interval was not apparent until camera analysis.

There were some issues with obtaining photo clarity and ensuring images were of use in elephant identification, e.g. camera misalignment by wildlife (n = 1 week) and vegetation causing false triggering (n = 3 cameras). Distinguishable features were more difficult to determine at night as photo quality was poorer.

There was no prior record of elephant movement between NNFR and Mount Kenya therefore comparison could not be achieved and consequently no evaluation of success.

### *4.3.2. Limitations of the questionnaire*

A restriction of my questionnaire was respondent's success rating based their own subjective goals and aims. It could have been beneficial to specify goals and aims at the start of the interview process, thus making responses objective and comparable.

There was no official record of human-elephant conflict incidences or attitudes towards the Corridor before it was built. This meant there was no objective quantitative conclusion to compare human-elephant conflict and attitudes before and after the Corridor was built with the respondent's perception.

## 4.4. Extension of this research

- The ratio of whole journeys to partial journeys is a baseline to assess the future success of the Corridor. An increase in whole journeys implies the Corridor as a success in providing a linking route between Mount Kenya and NNFR, in extension the Samburu-Laikipia region.

- Further examination of potential highly utilised and bottleneck sections within the Corridor to identify any improvements that would increase the proportion of elephants using the Corridor as a linking route between NNFR and Mount Kenya.

- GPS tracking of elephants using the Corridor would provide an insight into any particular areas highly utilised within the Corridor and the speed of movement inside and outside of the Corridor.

- Vegetation surveys within the Corridor and NNFR would allow monitoring of any potential habitat degradation.

- Individual identification of elephants within the region would improve identification within the Corridor and could provide an insight both their movement patterns and their ecosystem of origin.

- Determining the movement between NNFR and Mount Kenya with environmental variables such as rainfall determine if there was any seasonal migration of elephants, which was implied by respondents.

### 4.5. Summary of implications in conservation management of this research

- The ratio and percentages of journeys and identified individuals utilising the Corridor can provide a baseline of the proportion of elephants using the linking route between the two ecosystems or as extended habitat, which was previous unknown.

- The methodology of this research and the EID will enable LWC to continue this research and improve the understanding of the utilisation of the Corridor by elephants.

- Providing feedback to everyone involved with the implementation of the Corridor and suggested improvements. For example by identifying potential bottlenecks within the Corridor strategies can be implemented to improve the movement of elephants through the whole Corridor.

- Insight into the seemingly high utilisation of the Corridor by elephants which can be used to inform management decisions regarding the Corridor. This includes the proposal for the second underpass, particularly as middle of the Corridor appears to be a bottleneck.

## 5. Conclusions

- A minimum of 60 different elephants utilised the Corridor (44 adults and 16 offspring).
- 52% of identified elephants (adults and offspring) traversed the whole Corridor.
- The ratio of whole journeys to partial journeys was 1:2; the Corridor was used for 33% of journeys as a linking route between NNFR and Mount Kenya.
- The ratio of different individuals making the whole to partial movements was 1:1.2; 45% of individuals (adults only) used the Corridor as a linking route between NNFR and Mount Kenya.
- It took on average 3.03 days to travel the length of the Corridor, but the journey was achievable in less than 24 hours.
- Elephants travelled through the whole Corridor in both directions.
- Elephants moved into the Corridor to varying degrees, more elephants returned to the ecosystem of entrance than going all the way through.
- A highly utilised area was the first 10% of the Corridor with 51% of total captures of identified elephants between the NNFR entrance and the Underpass.
- The middle section of the Corridor was identified as a possible bottleneck, in particular stations 20% and 65% into the Corridor.
- The Corridor was perceived as a success by stakeholders, partners and the community representative.

- The problem of elephants reduced in the region suggesting the Corridor had a positive impact and was successful in this aspect; however human-related incidences remained that same due to a mortality of a single trespasser.

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# 7. Appendices

**Appendix A1** Elephant gap the NNFR entrance, line of stones and posts prevent rhino from leaving NNFR


**Appendix A2** Concrete elephant underpass under the Nanyuki-Meru A2 Highway

**Appendix A3** Ntirimiti road crossing gap in fence line with dangling electrified stingers to prevent elephants from leaving the Corridor whilst allowing human traffic to use the road

**Appendix A4** Camera trap settings used across all cameras

| **Parameter** | **Camera trap setting** |
|---|---|
| Mode | Camera |
| Image Size | 8 M Pixel |
| Image Format | Full Screen |
| Capture Number (number of photos taken in a sequence) | 3 Photo |
| LED Control | High |
| Interval (seconds until responds to an additional trigger) | 1S |
| Sensor Level (sensitivity of PIR sensor) | High |
| Time Stamp (time and date imprinted on photo) | On |
| Field Scan | Off |

**Appendix A5** Wire across the Mount Kenya exit; left side of the wire is the Corridor, right is Mount Kenya


**Appendix A6** Estimating height of elephants with known distances from the camera trap at Mount Kenya exit

**Appendix A7** Questionnaire

# Mount Kenya Elephant Corridor Questionnaire

Hello, as I said in my introductory email I am researching the Mount Kenya Elephant Corridor and focusing on elephant movement. This is part of my Master's degree for the University of Southampton but I am also working with the Lewa Research Department to evaluate its success and function. The project is currently underway and over the past month I have been analysing camera trap data from the underpass and the endpass which opens out to Mount Kenya. To gain more of an understanding of elephant movements within the corridor, additional camera traps have also been set up inside the corridor.

By talking to you I am hoping to improve my understanding of the corridor's background and the perspective of the people involved with the corridor. The information will be used to inform my Masters dissertation and to produce a report about the corridor. Both of these documents will be made available to you. I will ask 27 questions and it will take at least 15 minutes, but please feel free to add any extra details you think are relevant and important. If you don't wish to answer any of the questions, or you wish to stop the interview at any time, then that will not be a problem. If you wish, the information you provide can be given anonymously.

Name:

Position:

Date:

Time:

Location:

Contact details:

Farm/Organisation:

1. Which stages were you involved in for the Mount Kenya Elephant Corridor and what was your involvement?

| Stages | Tick | Details |
|---|---|---|
| Planning | | |
| Implementation | | |
| Monitoring | | |
| Management | | |

2. Are you still involved with the corridor?

   Yes No

How:

3. Do you receive information or reports regarding the corridor?

   Yes No – skip to Q7

4. Who provides this information?

5. What type of information do you receive?

| Type of information | Tick if apply |
|---|---|
| Written report | |
| Verbal report | |
| Organisational newsletter | |
| Other - specify | |

6. How often do you receive this information?

   Weekly Monthly Quarterly Yearly Other

7. Would you like to receive more or less information on the corridor?

   More Less

8. Is there any particular information would you like to receive about the corridor?

9. Do you provide data on the corridor and who do you provide it to?

10. From your perspective, what were the goals and aims of the corridor?

11. How successful do you think the corridor has been in meeting the goals and aims you described on a scale of 1 – 5 (1 = Not successful at all, 5 = completely successful)? Please explain your answer.

| | | | | |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

12. What was the general attitude towards the corridor before it was built?

    Positive Negative Mixed

    Explanation:

13. Has the attitude has changed since the corridor opened?

Yes No

Explanation:

14. What problems did elephants cause before the corridor was built?

15. How often?

Weekly Fortnight Monthly Quarterly Yearly Other

16. Were there any human related incidences before the corridor was built?

Yes No

Explanation:

17. Have there been any incidences or problems with elephants since the corridor opened?

Yes No

How?

18. Were there any human related incidences after the corridor was built?

Yes No – skip to Q21

Explanation:

19. How often have elephants been a problem since the corridor was built?

Weekly Fortnight Monthly Quarterly Yearly
Other

20. Who were these incidences reported to?

21. Do you know if the elephants move through the entire corridor?

Yes No

22. Do you know if there is a particular direction the elephants move?

Ngare Ndare Forest to Mount Kenya Mount Kenya to Ngare Ndare Forest Both ways equally

23. Are there any aspects or areas of the corridor that the elephants find particularly easy or difficult to move through?

24. What improvements would you suggest to make the corridor a better connection for elephants and for the people who live and work around the corridor?

25. Are there any farming practices in the corridor?

Yes No – skip to Q27

26. What are these practices?

27. Any last thoughts or comments you would like to add about the corridor?

Thank you very much for your valuable time. Would you like to be sent a copy of my final report?

Yes No

Do you wish this information to be anonymous?

Yes No

**Appendix B1** List of people interviewed and their position, in alphabetical order

| Name | Position |
|---|---|
| Geoffrey Chege | Chief Conservation Officer of Lewa Wildlife Conservancy |
| Ian Craig | Director of Conservation for Northern Rangelands Trust |
| Charlie Dyer | General Manager of Kisima Farm |
| Tony Dyer | Resident in neighbouring conservancy Borana |
| John Kinoti | Lewa Wildlife Conservancy Community Development Manager |
| Jonathan Moss | Managing Director of Kisima Farm |
| Jamie Murray | General Manager of Marania Farm |
| Mbaya Solomon | Chairman Community Forest Association and Ntirimiti Community Representative |
| Maurice Thure | Mount Kenya Trust Northern Sector Supervisor |
| Susie Weeks | Executive Officer of Mount Kenya Trust |
| Charlie Wheeler | Chairman Ngare Ndare Forest Trust |

**Appendix C1** Elephants crossing over the road, instead of down in on a camera at station 20% into the Corridor