A rapid assessment of the status and distribution of *Loxodonta cyclotis* in South East Cameroon

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DECLARATION OF OWN WORK

I declare that this thesis, "A rapid assessment of the status and distribution of Loxodonta cyclotis in South East Cameroon," is entirely my own work, and that where material could be construed as the work of others, it is fully cited and referenced, and/or with appropriate acknowledgement given.

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CONTENTS

TABLES

FIGURES

LIST OF ACRONYMS AND ABBREVIATIONS

UFA	Overall logging concession unit
AAC	Annual Allowable Cut
ZSL	Zoological Society London
RO	Research Officer
TC	Timber Concession
TCW	Timber Concession Workers
LV	Local LV
CDP	Chef de Poste
ZIC	Hunting Safari
NP	National Park
CAR	Central African Republic
ETIS	Elephant Trade Information System
MIKE	Monitoring the Illegal Killing of Elephants

ABSTRACT

Information on the distribution and abundance of elephants must be available in order to appropriately allocate limited resources and to set conservation goals. However, monitoring at large scales in forest habitats is complicated, expensive and time consuming.

This study has explored the potential of applying interview based occupancy analysis as a tool for the rapid assessment of the distribution and threats to the forest elephant (*Loxodonta cyclotis*) in the eastern region of Cameroon.

Models have allowed the covariates that affect occupancy and detectability to be explored and for spatial and temporal patterns in population change and occupancy to be identified. The use of quantitative and qualitative socio-demographic data provides additional depth and understanding to the perceptions and threats to elephants across the region, placing the occupancy analysis in context and providing valuable information to guide conservation action.

This study finds that this method is a reliable and suitable method for a rapid assessment of forest elephant occupancy across a large scale, as a compliment or first stage in a monitoring process. It concludes by discussing the implications of the findings, the limitations of the methodology and makes suggestions for conservation action based upon the findings of this study.

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Imperial College London

CHESTER ZOO ACT FOR WILDLIFE

ZSL LIVING CONSERVATION

1 INTRODUCTION

1.1 Problem statement

Population status and distribution assessments are required to gather the basic information needed for effective conservation management (IUCN 2008). This data is the basis by which the IUCN Red List assesses the conservation status of species (IUCN 2012) and conservation policymakers and managers decide on the management strategies which best serve the taxon in question (Maisels et al., 2013). Anthropogenic pressures continue to threaten large mammals in the world's tropics (Maisels et al, 2013), however due to difficulties in surveying in forest habitats, the scale of the forest elephant decline has been difficult to quantify. For many rare or cryptic species, monitoring changes in distribution and abundance over large spatiotemporal scales remains a serious challenge (Thompson, 2004). This is compounded in a tropical forest habitat, where existing survey methods have a limited use (Hedges, 2012) and covering a large area of difficult ground is both expensive and time consuming.

2011 was the worst year for illegal poaching of elephants on record, with central Africa badly affected (CITES, 2013a; Maisels et al., 2013). The forests of South East Cameroon represent a stronghold for the species, and have been identified as a priority for conservation efforts. However, effective action is hampered by a lack of knowledge on the status and distribution of elephants. A recent CITES-MIKE assessment acknowledges that elephant population estimates in the Congo Basin are based on 'guesswork'; however the recent work of Maisels (2013) provides more robust estimates. The IUCN 2007 African elephant status report records a definite population of only 179 for Cameroon, but less than half of the potential Cameroonian range has been assessed, and the report speculates that the true population could be up to around 16,000. A lack of information on forest elephant populations is a key concern for conserving the species. Thus the forests of Cameroon have been given the highest priority for surveys to address this gap and guide conservation action. Addressing this uncertainty is vital to guide effective action to conserve the species.

In this context, there is great potential for the use of social surveys to assess the status and distribution of the forest elephant. Interview-based surveys are not regularly used in the context of occupancy analysis (van der Hoeven et al. 2004; Sheil & Lawrence 2004; Meijaard et al. 2011). However, in 2011, three papers were published highlighting the effectiveness of interview-based occupancy analysis (Martinez, 2011; Pillay et al, 2011; Zeller et al, 2011). The method is proving to be useful for systematic and reliable large-scale estimation of species distributions and abundances from a cost-effective survey. This project is looking to apply and develop these approaches to address an urgent problem.

1.2 Study aim and research objectives

Rapid assessment of forest elephant distribution, status and threats across the forests in east Cameroon to fill existing knowledge gaps and guide conservation action, focusing on areas classified as 'unknown' by the IUCN Elephant specialist group.

Table 1.2-1: Study research objectives and questions

Research objectives	Research Question
To determine the distribution, occupancy and status of forest elephants in the eastern region of Cameroon using interview based occupancy analysis	1a. What is elephant occupancy and detectability across the landscape? 1b. What variables most influence elephant occupancy and detectability?
To assess the reliability and suitability of this method of rapid assessment in the context of forest elephants in Africa	2. Is interview-based occupancy analysis a suitable and reliable method for elephants in Central Africa?
To gain a deeper understanding of the threats to elephants	3a. What are the biggest perceived threat to elephants? 3b. How do the perceived threats to elephants differ across the eastern region? 3c. Where are the poaching 'hotspots' in the eastern region?
To gain a deeper understand of the perceived level of population change	4a. Are elephant populations perceived to have changed over the past 5 years? 4b. How does perceived population change differ across the landscape?
To increase understanding of people's attitudes towards elephants	5. How are people's attitudes affected by human-elephant conflict?
To make recommendations for conservation action in the eastern region	NA

2 BACKGROUND

2.1 Elephant population status assessment

In order to assess a species population status, accurate population estimates are needed (Joseph, 2006) recent worldwide mammal declines have highlighted the conservation importance of effective assessments of trends in distribution and abundance of species (Pillay et al. 2011). Population assessments are stand-alone assessments that should form part of a monitoring programme with clear management objectives. Information on elephant distribution and abundance must be available in order to set goals and in order to measure the effectiveness of management actions (Blanc et al. 2007), however there are difficulties involved in surveying elephants despite them being the world's largest land mammal. Table 2.1-1 summarises the current direct and indirect survey method techniques available for assessing elephant populations.

Table 2.1-1: Direct and indirect elephant population survey methods

Direct Observations		
Method	*Strength*	*Limitation*
Aerial surveys	Long established standards (Craig, 2004) permit rapid counts of elephants in *open areas*.	Not suitable for elephant populations living in tropical forest as visibility is limited (Hedges, 2012).
Sightings and distance sampling along transects	A powerful approach to the estimation of densities of elephants, in areas of open vegetation types where elephants are visible [Goswami *et al*. 2007; Wegge and Storaas 2009; Hedges, 2012].	Biological and logistical considerations often impose severe constraints on being able to execute theoretically justifiable line transect surveys in the field. Where elephant densities are low, investment of even a large sampling effort (long distances walked) may yield a small sample size of visual detections, leading to a relatively poor density estimate.
	Distance sampling to estimate absolute densities of elephants where it is possible to observe the individual (Hedges, 2012).	There are a number of assumptions that, if violated, would undermine the reliability of the method and lead to bias (See Hedges, 2012 for a summary).

Capture-recapture sampling	Suitable where it was possible to catch and mark the target species to permit individual identification (e.g.,Silvy *et al*. 2005)	Expensive, dangerous, challenging in the forest environment. Not suitable for large study area, or for rapid assessment.
Indirect observations		
Method	*Strengths*	*Limitations*
Dung pile density	A well-established method (see Barnes, 2001; Buckland *et al*. 2001 for reviews), especially for forest environments (Barnes and Jensen, 1987; Hedges, 2012) Dung counts have been shown to give estimates that are as accurate as other methods (Barnes 2001).	Elephant dung classification systems are complicated by highly variable decay rates. Diet (White 1995); rainfall and temperature (Barnes *et al*. 2006) play a major role in determining decay rates. Therefore, an inter site difference in environment prevents extrapolation between sites. Furthermore, within site variation in dung decay rates is also very significant (Hedges, 2012)

As the table highlights, there are logistical constraints to all current survey methods, especially in challenging forest environments and over a large spatial scale. Typically, applying the labour intensive methods of abundance estimation across large survey areas is not possible, especially in forested areas. Additionally, there is a greater reliance upon the detection of signs left by elephants (tracks, dung, etc.) at large spatial scales, rather than direct observations as required by distance sampling and capture–recapture sampling methods.

Landscape-scale studies of occupancy are important for regional conservation planning (Hedges 2012), yet traditional survey methods do not consider the threats posed to the target species and rarely make recommendations for conservation (Meijaard & Sheil 2007). Recent advances in occupancy modelling methods show that abundance can be inferred from occupancy surveys, enabling estimations over large landscapes (Conroy et al., 2008; Hedges, 2012; Royle & Nichols, 2003; Royle & Andrew, 2004; Stanley & Royle, 2005), allowing information that could inform conservation decision making on a large scale to be collected swiftly and more cost-effectively; highly valuable for a widely distributed species such as the African elephant.

2.2 Occupancy modelling

Occupancy (i.e. the presence or absence of a species within sampling sites) is widely used in studies such as species distribution and range analysis(MacKenzie et al., 2006; 2009) and conservation status evaluation (e.g. IUCN red list). The detectability of the species influences the choice of state variable[1] (Royle et al. 2005) and MacKenzie *et al*., (2004) propose that occupancy may be used as an informative state variable for the monitoring of rare and elusive species. Occupancy surveys involve visits to the sample sites in search of evidence that the target species is present and as such are often less costly than the more costly and time expensive methods typically required for estimating abundance (Hedges, 2012).

Joseph *et al.* (2006) conducted a simulation study comparing abundance and detection/non-detection sample strategies, and found that the optimal strategy is budget dependant. At low budgets or for cryptic species, detection/non-detection methods are more desirable than abundance in assigning IUCN red list categories of threat to the target species.

Indirect sample counts (e.g. tracks, dung) are often the only way to obtain objective estimates of elephant populations in forests, where it is hard to see animals (Blanc *et al.* 2007). Detection/non-detection surveys of indirect signs can be used as an indicator of occupancy when the sampling area is comparable to the species territory size (Mackenzie & Royle 2005) and can accurately represent trends in population size (Gaston et al. 2000). Due to its financial and logistical advantages and ease of implementation, monitoring based on detection/non-detection surveys has been used in many large-scale studies and programmes (Royle & Nichols, 2003)

2.3 Detection/non-detection surveys and imperfect detection

For most rare and cryptic species, one cannot assume that they will be perfectly detected in detection/non-detection surveys (MacKenzie et al., 2002). Therefore, occupied sites may be classified as unoccupied under imperfect detection circumstances. Many studies fail to account for imperfect detection of their study species as is common in rare and/or cryptic species (Yoccoz, et al, 2001). False absences in occupancy estimation result in biased data that underestimates occupancy, a problem that is particularly significant when detecting change over time as its

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[1] Variable used to characterize the status of a system (e.g. population size, proportion of area occupied...)

variation will be confounded with any potential true temporal variation (MacKenzie, 2006).

2.4 Likelihood-based occupancy model

Numerous approaches are proposed to estimate the proportion of sites occupied by a species when detection is imperfect. These can be classified under two broad categories (MacKenzie et al., 2006); two-step ad-hoc estimation, where detectability is estimated and is then used in a second stage to estimate occupancy (Nichols & Karanth 2002) and model-based approaches. In 2002, MacKenzie *et al* developed an important new method which allowed both detectability and occupancy to be estimated in a single-model framework known as the maximum likelihood model (MacKenzie *et al* 2002). The basic principle behind the likelihood-based method is to build a detection history from collected data and from this construct a probability model in terms of occupancy and detectability. Wintle *et al* (2004) found it was the least biased estimator of detection history and therefore occupancy. Using this method, it is possible to investigate potential relationships between the probabilities of occupancy and detection and socio-demographic or ecological factors, by incorporating them into the model as covariates for analysis

2.4.1 Assumptions of the model

MacKenzie et al., (2006) describe five main assumptions involved in the description of this model:

1) another species is never wrongly identified as the target species
2) occupancy status at each site does not change during the survey season
3) occupancy is either constant across sites or differences are modelled using covariates
4) detectability is either constant across sites and surveys or differences are modelled using covariates
5) detection histories at each location are independent.

It is important to consider these assumptions as the inferences extracted from the model may be incorrect if the assumptions are not met.

Since its introduction, models have been extended to cover multi-season analysis (MacKenzie et al, 2003), to allow the estimation of abundance based on presence-absence data (Royle & Nichols, 2003) and to estimate occupancy when heterogeneity in detection probability is present (Royle, 2006). These methods have been implemented into the R package unmarked (Fiske & Chandler 2011).

2.5 Interview based occupancy analysis

Interview-based surveys are not regularly used in the context of occupancy analysis (van der Hoeven et al. 2004; Sheil & Lawrence 2004; Meijaard et al. 2011) due to fears over implementation and robustness of the acquired data. For example, Kelvey et al, (2008) provide three case studies where anecdotal evidence is badly used, concluding that qualitative data is not reliable for rare species, and that stringent standards must be applied to the data for rare species.

In response to the need for a more robust approach to interview data, Meijaard et al., (2011) conduct a study on the distribution and threats to the Bornean orang-utan, which involved interviews with nearly 7000 people. Evaluating interview surveys as a complementary conservation tool, the paper provides guidance to address potential methodological weakness in social surveys, including sampling and questionnaire design, respondent biases, statistical analyses, and sensitivity of resultant inferences. They conclude that interview based surveys can provide cost effective and statistically robust methods to better understand poorly known populations of species that are relatively easily identified by local people (Meijaard *et al*. 2011).

Martinez , (2011) used semi-structured interviews with key informants at 25km2 sampling units, aiming to assess the current status of the leopard and golden cat in Equatorial Guinea in order to provide baseline information for their conservation. Interviews were designed to gain detection/non-detection data for occupancy modelling to describe the geographical range of cats, great apes and forest elephants and identify the principal factors explaining their distributional range and their threats. The report highlights the importance of this new methodology, proving to be useful for large-scale estimation of multiple-species distributions and abundances from a single cost- effective survey in a systematic and statistically sound manner. Interviews were used in an occupancy context as a first step in gaining baseline quantitative and qualitative information and as a scoping study to identify more intensive research in the future (Martinez, 2011).

Key informant surveys were used in Pillay et al., (2011) to generate detection histories for 18 species of large mammal at two points in time (present and 30 years ago) in the Western Ghats, India. Detection/non-detection surveys of key informants were used in a multiple-season occupancy modelling framework to provide the potential for rapid conservation status assessments of multiple species across large spatial scales over time. A limitation to their study is the reliance on the recall of the informants as far back as 30 years ago, meaning that the past detection history data is potentially less reliable than the present data set. Karanth et al, (2009) combined structured interviews with local experts with formal sampling designs and modelling frameworks to enable robust inferences about the status of wildlife populations and Zeller et al., (2011) integrate interview data and occupancy modelling to identify Jaguar corridors in Nicaragua.

2.6 Eastern Region of Cameroon

The eastern region is the largest in Cameroon (109,011 km²) occupying the south eastern portion of the country.

Maps soured from the World Resource Institute (2013)

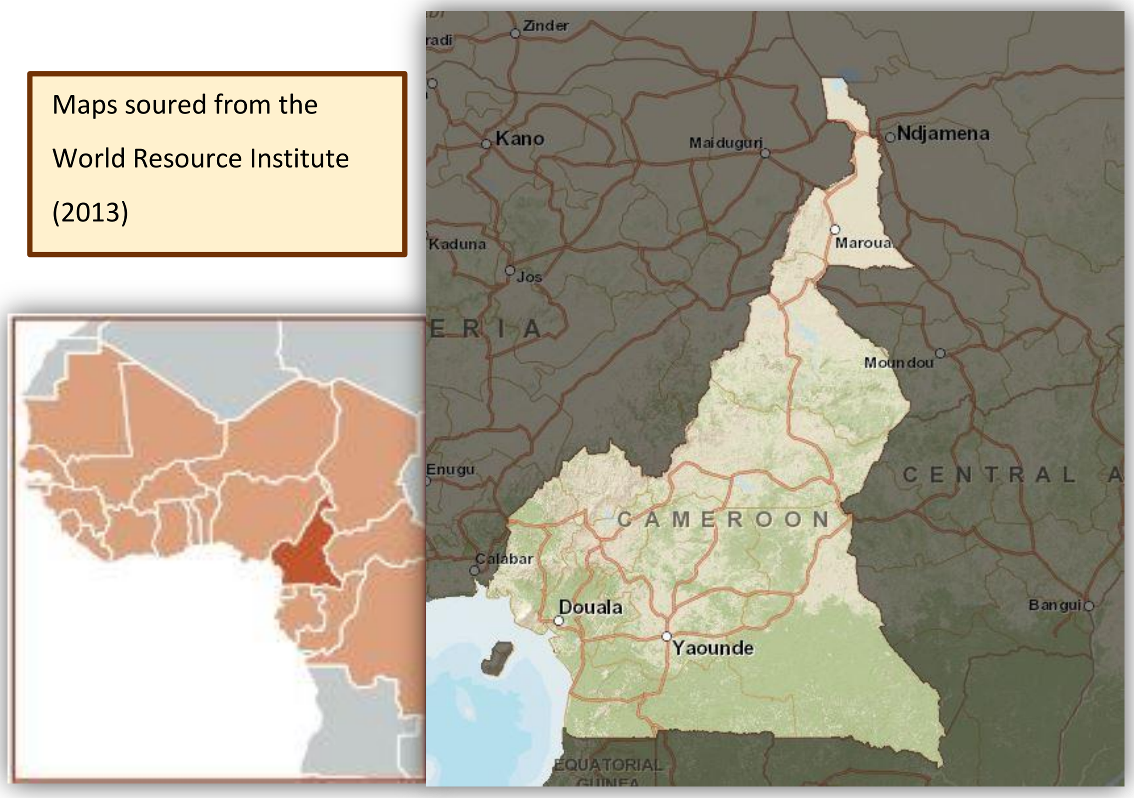

Figure 2.6-1: Map of Cameroon

Bordered to the east by the Central African Republic and to the south by Congo, it is the most sparsely populated region (population density of 7.35/km², World Bank, 2013) although this can increase to between to 20-60/km² in villages along main roads (World Bank, 2013). This habitation pattern is a result of deliberate government policy during and after the colonial period to move people from the forest to the roads (Neba, 1999). The east has a wet equatorial climate, with high temperatures and two wet (May-June, October-November) and two dry seasons (December-May, July-October). Precipitation averages 1500–2000 mm per year. The region contains several river systems, and floods can occur along the rivers during the rainy seasons (Neba, 1999).

As the poorest of Cameroons regions, the bulk of its inhabitants rely on subsistence farming for food security and livelihoods (World Bank, 2013). Between 2001 and 2007, poverty rates across Cameroon were at 40%, of which 87% of the poor live in rural areas, revealing wide geographic and socioeconomic disparities in Cameroon (World Bank, 2013).

Cameroon has the highest deforestation rate in Central Africa, with an estimated loss of 220,000 ha (1%) of forest annually, between 2000 and 2010 (FAO 2011). Over 60-80% of Cameroon's forests are now classified as timber concessions (Bikie et al. 2000). Despite this rate of deforestation, the eastern region of Cameroon is believed to be home to some of the last remaining populations of forest elephants (Blanc et al. 2007). The African Elephant has been listed as CITES Appendix I since 1989. Within Cameroonian wildlife laws, elephants are listed as Class A (fully protected), unless they have tusks weighing more than 5kg, which are then class B (subject to killing under licence)(Stiles 2011b).

2.7 The Forest Elephant: *Loxodonta africana cyclotis*

The African forest elephant is a forest-dwelling elephant of the tropical forest. The species range from West Africa, spreading across into the Central African forests of Cameroon, Gabon, Equatorial Guinea, Congo the Central African Republic, and the Democratic Republic of Congo. To the east, forest elephants also occur in Uganda and possibly Rwanda, and to the south they may still be present in Angola (Blake & Hedges 2004). In Cameroon, savannah elephants are found in the northern Sahalian and Sudanian regions, whilst forest elephants occur in the southern forested area (Tchamba 1996). Forest elephants range throughout a region of political instability and poverty, placing this endangered population at high risk from human exploitation (WCS, 2013).

African forest elephants have deep ecological, morphological and social differences from savannah elephants (Grubb et al, 2000; Maisels et al., 2013; Shoshani & Tassy, 1996) including a longer, narrower trunk, rounded ears and straight, downward tusks. Additionally, male African forest elephants rarely exceeds 2.5 m in height, while the African savannah elephant is usually over 3 m. Weight is reportedly around 2.7 tonnes, with the largest reaching 6 tonnes (ARKive 2013). The elephant is a "keystone" species that plays a pivotal role in structuring both plant and animal communities (Shoshani, 1993) and are 'mega gardeners' of the forest (Beaune et al, 2013) vital for maintaining the forest structure and diversity (Blake, 2009) upon which timber concessions depend.

Elephants have large home ranges (de Boer et al. 2013)and their sometimes unpredictable seasonal and cross-border movements make their ranges hard to define (Blanc et al. 2007). Shuttler, Blake & Eggert (2012) provides data on the spatial relationships among forest elephants using data from six tagged elephants in Gabon. They record the smallest home ranges for any elephant species or population (Sukumar 2003; Charif et al. 2004), suggesting that they are no longer using their entire available habitat, possibly due to compression caused by anthropogenic threats (Barnes, 1997; Blake et al., 2008).

Whilst a wide body of evidence from molecular genetic studies points to the forest elephant being a distinct species (Rohland et al, 2010), it is important to note that at present the IUCN recognizes only one full African elephant species (*Loxodonta africana*) with the forest elephant (*Loxodonta africana cyclotis*) as subspecies. The overall redlist assessment for the African elephant is vulnerable, however in recognition of the marked geographic variation in threat a regional assessment was carried out which found the central African population to be endangered. According to the most recent assessment of elephant numbers available, there may be between 472,269 and 689,671 elephants on the African continent (Blanc et al. 2007). Detailed knowledge of elephant distribution is poor, but improving, in Central Africa (CITES 2013b).

Recently, several papers (De Boer et al., 2013; Maisels,et al., 2013; Schuttler, et al 2012) have tried to tackle this lack of understanding on their distribution and status, although civil unrest has prevented surveys in some Central African countries (CITES 2013a). Hart (2009) found that there are likely to be only six populations with more than 500 elephants, with all other populations being defined as remnant in the Democratic Republic of the Congo. Maisels *et al*. (2013) analysed the largest survey dataset ever assembled for forest elephants across Central Africa. The disturbing findings revealed that population size declined by ca. 62% from 2002–2011, and the taxon lost 30% of its geographical range. The population is now less than 10% of its potential size, occupying less than 25% of its potential range. Blake et al (2008) reported an abundance of 0.1/km2 in Boumba Bek National Park (NP), southeast Cameroon and in areas where there is little or no poaching Maisels et al (2013) found elephant density to be 0.5-1.0/km2. Martinez (2011) found that in Equatorial Guinea, forest elephant occupancy and detectability are 0.44 and 0.857 respectively.

A wide body of literature suggests that anthropogenic influences are a greater determinant of elephant distribution than ecological factors(Barnes et al., 1997; Blake et al., 2007; Buij et al., 2007; Clark et al, 2009; de Boer et al., 2013; Maisels et al., 2013), although there is some dispute as to which factors are the strongest determinant of elephant occupancy and distribution. Elephant occupancy is found to have negative correlation with noise (Richardson et al, 1995), roads (Stokes et al. 2010; Blake et al. 2008), hunting pressure ((Douglas-Hamilton et al. 2005; Blake, 2002; Clark et al. 2009; Yackulic et al. 2011) and human density (Buij et al., 2007; de Boer et al., 2013; Maisels et al., 2013, although see Clark *et al*. 2009 for an opposing opinion).

2.8 Threats

Of concern is the increasing fragmentation of elephant habitats across many parts of its range, leading to possible compression of elephant populations (CITES 2011). As human populations grow, and industrial logging and mining spreads, roads and settlements are encroaching deeper into the forest. New timber concessions give improved access to once remote areas, usually bringing hunting, often targeted at elephants (Walsh et al. 2000) and routes for the transport of ivory and meat (Blanc et al. 2007; Stiles & Randolph, 2011).

However, there is evidence that well-managed concession areas can provide refuge to forest elephants in an otherwise insecure landscape (Clark et al., 2009; Kolowski et al., 2010; Stokes et al., 2010; Weinbaum, 2007). Clark *et al* (2009) conducted a study in four logging concessions in The Congo to assess the direct and indirect effects of logging on mammals. They conclude that elephant presence and abundance is greater in logged than unlogged forests, increasing for 15-20 years post exploitation, then returned to an abundance higher than in an unexploited forest. However, the advice offered by Clark *et al* (2009) to promote wildlife conservation in production forests are all steps which are already required to be followed in order to be certified and therefore do not offer anything new.

Evidence suggests that secondary vegetation created by logging is preferred by elephants (Barnes, 1991; Lahm, 1996), although it may encourage elephants closer to human settlements, increasing the risk of human-elephant conflict (HEC). Lamb et al, (2005) also found that managed forests may be valuable, especially when they are adjacent to or surround protected areas. However, they request that poaching is well policed but law enforcement, particularly in the east of Cameroon, is lacking (Blanc et al. 2007).

2.9 Human-elephant conflict

HEC remains one of the primary challenges for elephant conservation throughout the species' range and is intensified by the spread of agriculture into previously unoccupied wildlife habitat (Barnes 1996; Gachago & Waithaka 1995; Tchamba 1996).

In some areas of Central Africa, high levels of insecurity have made it difficult for the government to address the problem, yet it is clear that this problem is widespread in both forest and savannah habitats (CITES 2011). Lamarque et al., (2009) provide a comprehensive review of the conditions required for human wildlife conflict, whilst Eyebe, et al (2012) provide a HEC overview of Cameroon, stating that due to a weak legal framework, communities have taken the policing of crop raiding into their own hands (Hoare 2000; Blanc et al. 2007).

2.10 Illegal killing

Illegal killing of elephants has risen to alarming levels in many parts of Central Africa. Ivory poaching is stated as the biggest threat to elephants in the Congo Basin (Blanc et al., 2007; CITES, 2010; CITES, 2013a). Worryingly, data analysed by the Elephant Trade Information System (ETIS) and the Monitoring the Illegal Killing of Elephants (MIKE) programme demonstrate that the illegal trade is escalating (CITES, 2011, 2013a; Milliken et al, 2009; CITES 2013b) and that Central Africa remains the sub region with the highest poaching pressure on the continent.

The latest CITES MIKE report confirms that Central Africa is a major source of ivory (CITES 2013b), with Cameroon identified as having the largest unregulated domestic ivory market in Central Africa in 2002 (TRAFFIC 2004; Hunter et al. 2004). Increasing trade has been linked to increasing demand and value of ivory in China (Martin & Vigne, 2011.; Milliken et al, 2002). Although ivory is the primary reason for poaching, elephant meat may be an important side- product (Stiles 2011b) and in one study, a decreasing supply of bush meat from smaller animals led to an increase of consumption of elephant meat (Blake & Hedges 2004).

Furthermore, Cameroon has an annual CITES export quota for elephant trophies of 160 tusks (80 animals) (CITES 2013a) however this quota is not based on elephant population monitoring data (Blake, 2005). Blake *et al* (2007) call for accurate estimates of elephant population trends and rates of illegal killing in order to improve our understanding on the status of forest elephants.

2.11 Barriers to conservation action

A lack of understanding with regards to the forest elephant status, distribution and threats is highlighted as a key concern for conserving the species (Blake, 2005; Blake & Hedges, 2004; Blanc et al., 2003; Blanc et al., 2007; Karanth et al., 2003; Sutherland et al, 2004). In Central Africa, a lack of institutional capacity and resources aggravates the situation (Blanc *et al* 2007). Most

African savannah elephant populations are well known (Maisels *et al* 2013), yet there are relatively few data on forest elephant numbers for Central Africa.

The most recently published elephant status update (Blanc *et al* 2007) shows that for Cameroon a high level of uncertainty exists (published figures in Blanc et al 2007 come with an 'Information quality index[2]' of close to zero), with only 179 confirmed individuals and speculative population estimates ranging up to almost 16000 for both elephant species. To highlight this uncertainty, the estimated range area in the 2007 report is less than half of that reported in the previous 2002 report, due to the reclassification as DOUBTFUL of large transects of formerly POSSIBLE range in Cameroon.

Despite uncertainly, the African Elephant Database (Blanc et al. 2003) remains the best reference on the population status of forest elephants. Although the survey effort has increased with the development of the CITES MIKE Programme, only 6 of the 27 new estimates in the 2007 report are deemed sufficiently reliable to be classified as DEFINITE. In addition, elephant abundance information is only available for just over half a million km2, 52% of the total regional elephant range (Blanc et al 2007). Thus Cameroon has been given the highest priority for future surveys.

The most recent CITES MIKE assessment of the status of elephants in the Congo Basin acknowledged that a lack of data means that any estimate of elephant populations in the area are based on 'guesswork' (Blake *et al* 2008; CITES, 2013a), rendering the estimates inadequate for effective conservation planning (Blake & Hedges, 2004). Despite this, well documented on-going threats mean that this crucial population urgently needs attention (Blake *et al* 2008).

The relationship between elephant range and distribution and anthropogenic pressures has led to a number of papers (de Boer et al. 2013; Stiles 2011a; Meijaard & Sheil 2007)that call for conservation strategies to take account of the underlying socioeconomic factors that may be key drivers of threat. Current survey methods, although useful for better understanding species distributions, are of limited use within a conservation strategy as they rarely consider the socio-economic factors that underlie conservation threats and in turn influence the species distribution and density (de Boer et al., 2013; Maisels et al., 2013; Meijaard & Sheil, 2007), potentially leaving conservation managers unaware of the most urgent threats (Meijaard *et al* 2011).

[2] Quantifies the overall data quality at the regional level, based on the precision of estimates and the range for which estimates are available. Index ranges from zero (no reliable information) to one (perfect information).

3 METHODS

3.1 Overview

Figure 3.1-1 Photographs of interview methods employed within the study. Photo credits (top-bottom) Stephanie Brittain, Madeleine Ngo Bata, Madeleine Ngo Bata

Rapid social surveys in the form of semi-structured and informal interviews were conducted with timber company workers (TCW), authorities and local villagers (LV). Detection/non-detection data were collected, along with additional data on perceived threats, abundance and change in population (Martinez, 2011; Meijaard et al., 2011), utilizing local ecological knowledge and experience. Detection/non-detection data were analysed following MacKenzie et al., (2002) for single species, single season occupancy models. Using interview data over a long period of time means that fluxes in the occupancy of a site may occur. Therefore, occupancy requires an alternative interpretation, from ''proportion of area occupied'' to ''proportion of area used'' (MacKenzie & Nichols, 2004; Martinez, 2011; Zeller et al., 2011). Following Martinez (2011), individual interviewees were treated as effective repeat surveys for occupancy analysis.

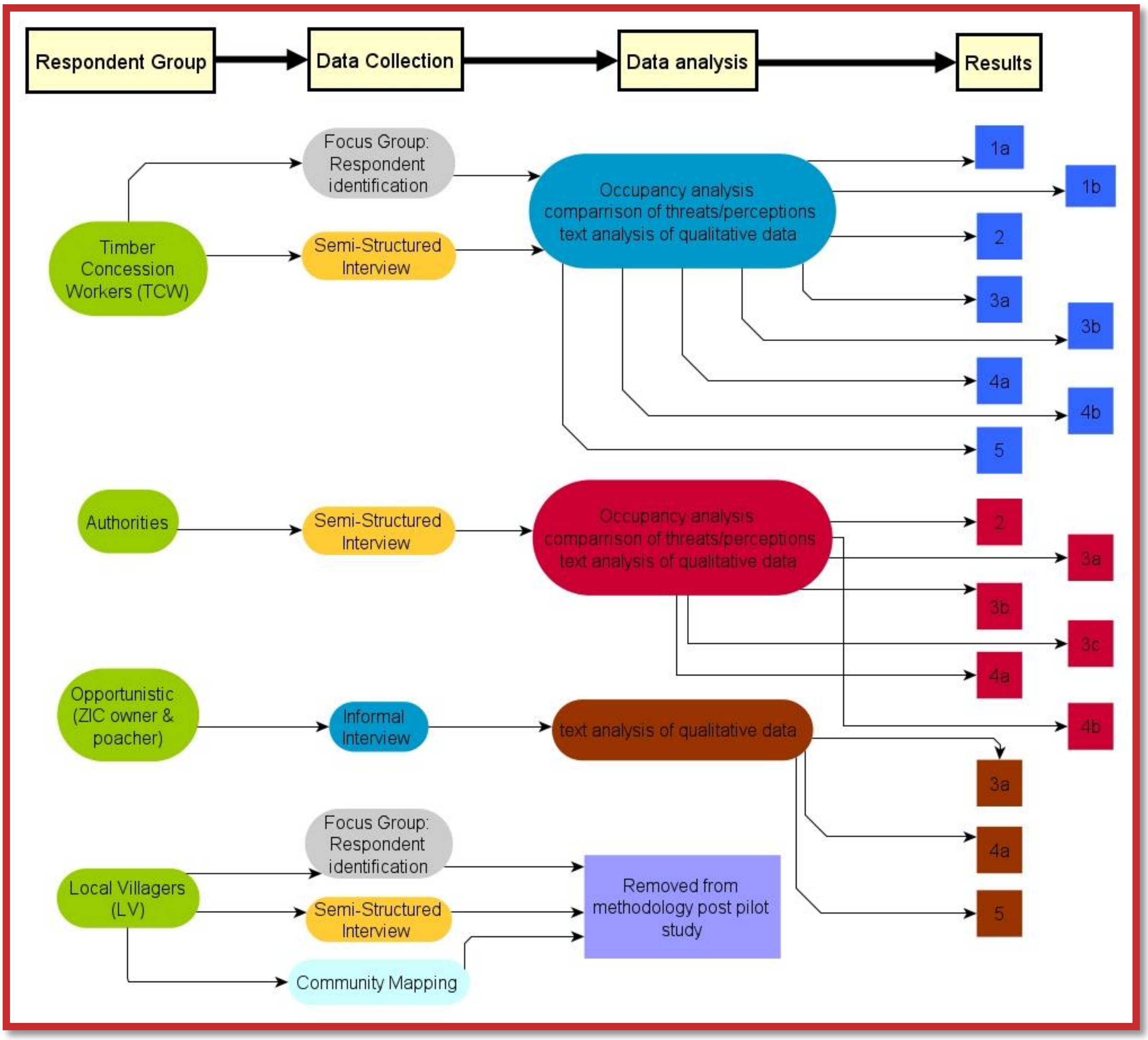

Figure 3.1-2: Diagram summarising the research framework for this study.

The research framework for this study can be seen in Figure 3.1-1. Each result code (e.g.1a, 1b, 2a, 2b etc.) corresponds to the research questions laid out in table 1.2-1.

3.2 Study region

This project was carried out in Cameroon, West Central Africa, focused on the forested eastern region.

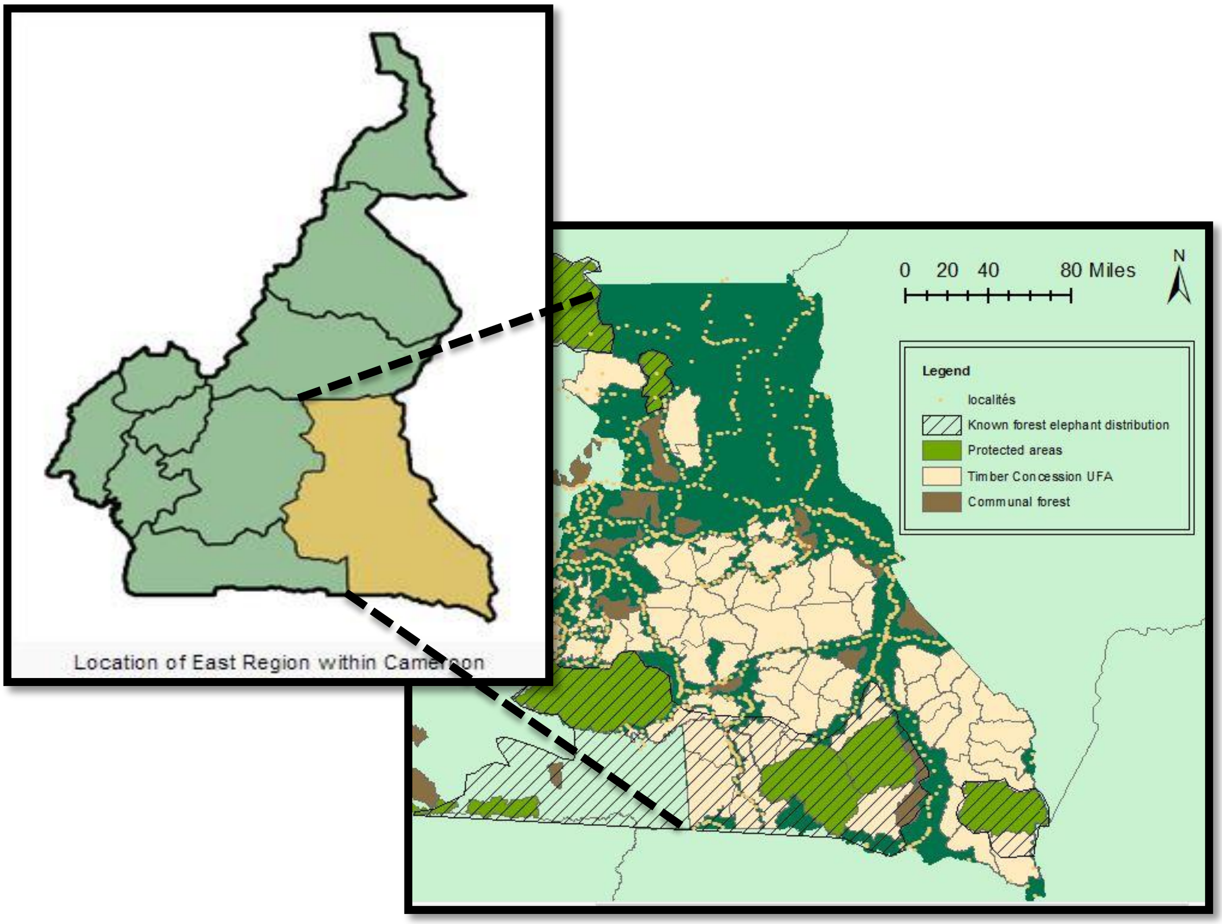

Figure 3.2-1: Geographical location of Cameroon and Figure 1b) showing the eastern region within Cameroon

3.3 Target groups structure

60-80% of the region's land cover is comprised of timber concessions, therefore targeting these concessions and their workers were of great importance for the aims of the study.

Timber concessions are split up into separate UFA (Forest Management Unit), typically ranging in size from 50-60,000ha up to 150,000ha. They are a well-defined and demarcated land area, predominantly covered by forests and managed on a long-term basis (FAO, 1997). Each UFA is divided in 30 roughly equal sized Annual Allowable Cuts (AAC's), of which one can be exploited each year over the course of 30 years.

There are 3 main teams of interest for interview within the timber concession;

1. Prospection team: Delimitate the AAC for the year and identify trees that are suitable for exploitation. They generally enter the forest between 6 months-1 year prior to exploitation, produce maps of where trees are located and mark them ready for the exploitation. They enter the forest on foot, do not operate any loud machinery and are often the first team to enter untouched forest, cutting paths with a machete in order to allow the following teams access. They spend the most time in the forest (up to 3-4 weeks camping in one trip) and are one of the teams that are most aware of animals, as they often disturb them and need to be aware for their own personal safety.
2. Fauna: Monitor and patrol within the UFA's to deter poachers. Produce reports on the biodiversity of the UFA, where different species are located and how the exploitation is affecting this. They are naturally aware of signs of animals, and would be able to provide key information on the whereabouts of signs of elephant if present. They travel on foot, camp in the forest and come to understand issues on poaching from surrounding villages.
3. Pre/post evaluation teams: Although generally focussed on the efficiency of exploitation, evaluation teams enter an AAC either prior to, or post, exploitation. They are on foot, do not work machinery and are aware of their surroundings. Many are required to report on signs of animals within the UFA.

In addition to the timber concession workers (TCW), authorities were also targeted for contextual information. MINFOF (The Ministry of Forests and Wildlife) are the governmental department responsible for the protection of forested areas and its biodiversity in Cameroon. Managers of the Department of Fauna, the managers of the eastern region departments and the Chef de Postes (CDP) from MINFOF were interviewed at the regional and departmental level. The job of the CDP is to monitor what is happening in the forest and report on any infractions of the law on a regular basis (ForestMonitor.org - Cameroon, 2013).

3.4 Location Selection

To ensure the robustness of the survey, care has been taken to define the sample units using an existing demarcation system with approximately equal area. Sites were defined as AAC's, allowing timber concession worker (TCW) respondents to recall reliable, fine scale, temporal and spatial data as they are familiar with the sample unit and were able to confidently provide information specifically relevant to that particular site. UFA's were assigned to four spatially distinct groups, allowing for analysis at the site, UFA and group scale. Figure 3.4-1 displays as example of the UFA with corresponding AAC's;

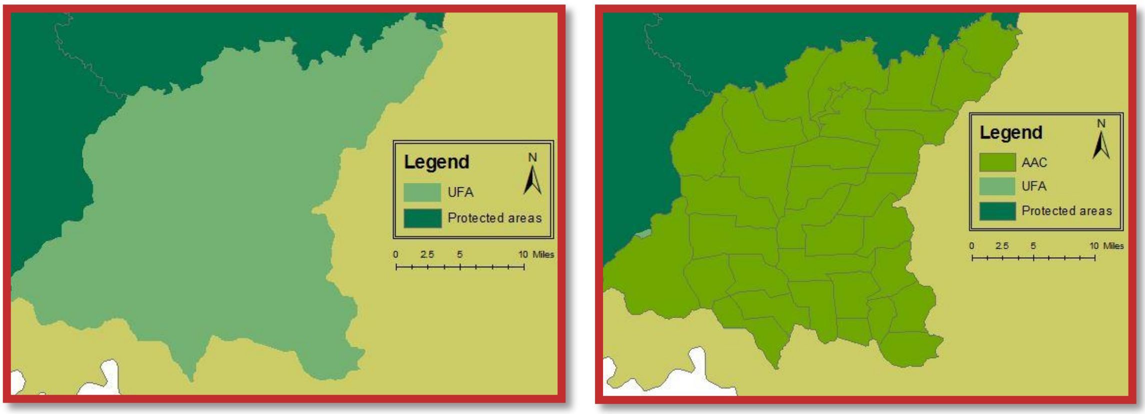

Figure 3.4-1: Example UFA (left) and UFA with Annual Allowable Cuts (AAC's, right) displayed.

3.5 Data collection

Data were gathered from the 23rd of April – 30th June 2013. The research was split up into 3 phases;

Phase 1: 4th-18th May

Phase 2: 24th May - 13th June

Phase 3: 18th- 25th June

3.5.1 Research Team

The field team was comprised of two research officers and an experienced driver to reach these isolated locations and conduct the necessary interviews in the time available.

3.5.2 Semi-structured interviews

Semi-structured interviews concerned with addressing all research objectives (1a-4a) were designed and administered by the research team. Table 3.5-1 outlines the structure of the semi-structured interview (see appendix 2 for full example).

Table 3.5-1: Components of the semi-structured interviews for each respondent group

Section	Description	Respondent group
1.Interview information	Date and location of interview	TCW's, LV and authorities
2.Interviewee information	Closed ended questions gathering demographic data, specifically age, gender and how long they had worked there	TCW's, LV and authorities
3.Detectability covariates	Time the respondent spends in the forest, number of trips, nights camped and how they have come to recognise signs of elephants. Closed and open ended questions	TCW's and LV
4.Occupancy data	Detection/non-detection of elephant sign. Closed ended questions	TCW's and LV
5.Abundance and distribution	Perceived abundance within the AAC's they have worked. Perceived change in population over the past 5 years. Closed and open ended questions.	TCW's and LV
6.Threats	Perceived threats to elephants in the UFA/ area of control. Closed and open ended questions	TCW's, LV and authorities
7.Attitudes	Open ended questions to understand the range in attitudes towards elephants and any geographical patterns/ links to conflict	TCW's, LV and authorities

Central to the study, semi-structured interviews are easily replicated and administered by researchers, whilst retaining standardisation. The combination of closed and open-ended questions enabled quantitative and qualitative analysis, strengthening the results by drawing on the information gathered from each.

Context validity is to do with how far the situation under which the research is carried out represents 'real life'(Newing et al, 2011). It is lower with structured interviews than with qualitative methods, because the structure creates an artificial situation. Additionally, people's stated views may differ from those expressed in daily life because they want to appear in a good light (MacMillan et al, 2002). Therefore, open-ended questions were included to get an in-depth understanding of poaching and threats, reducing bias and increase context validity.

3.5.2.1 Bias

Efforts were made both in the design of the survey and the interview process to minimise respondent bias. Deference effect bias is when respondents respond in a manner that reflects well on themselves (Newing et al. 2011). To reduce this bias, it was stated at the start of each interview that there was no right answer and that we were purely interested in better understanding the local biodiversity from the people who knew it well. It was made clear that we only wanted respondents to report on their own experience. No specific reference to elephants was made at the start of the interview so as to reduce order effect bias (when answers are influenced by what has been previously discussed) and care was taken to use the 'interview funnel' approach to interview design, starting with broad questions and narrowing down towards the end. Respondents were interviewed individually so as to prevent audience effect bias and ensure that the following interviewee responses were not influenced by previous interviewees' responses. Interviews were recorded to ensure that any details were not forgotten. Where permission to record was not granted (<5% of the sample population), notes were taken and transcribed immediately post interview.

The option to say that they did not know was included and questions were phrased neutrally. Interviews lasted on average 10-12 minutes, and much less if the interviewee had never seen signs of elephant. All respondents spoke French, as did the interview team, therefore effective communication was not a problem for this study.

3.5.2.2 Mapping of detection/non-detection data

Approaches were tailored to individual respondent groups to ensure that they could accurately and reliably comment on where signs had been seen. For the TCW's, maps of the UFA's and the AAC's in which they worked were obtained prior to interview, with the AAC's year of exploitation clearly marked on each map. This enabled TCW's to state in which AAC's they had worked, in what year and if they had or had not seen signs of elephant. Authorities were asked to comment only within their area of control. For LV's, participatory mapping was used to identify where LV entered the adjacent UFA, how far they travelled and where they see signs of elephants.

3.5.3 Informal interviews

Informal interviews are normal conversations with individuals or groups of people as they go about their daily lives (Newing, 2011). Informal interviews, composed of open ended questions were conducted on several occasions. The direction of the conversation was led by the interviewee, with some questions asked by the interviewer to either guide conversation or probe an interesting point. As the conversation was informal, notes of key points were taken immediately after the conversation so as not to forget the detail of the conversation.

3.5.4 Pilot study

The pilot (4th-11th May) involved trialling the methodologies and sampling strategy on the 3 respondent groups, aiming to make any necessary adjustments to the approach and assess the reliability of the responses. The pilot study was conducted in 2 villages (Abiere and Medjeuh) and ZSL's partner timber concession Pallisco, who own the adjacent UFA's (10-038, 10-031) where robust data previously collected by ZSL on elephant presence was available. Figure 3.5-1 displays the location of the pilot villages and UFA's.

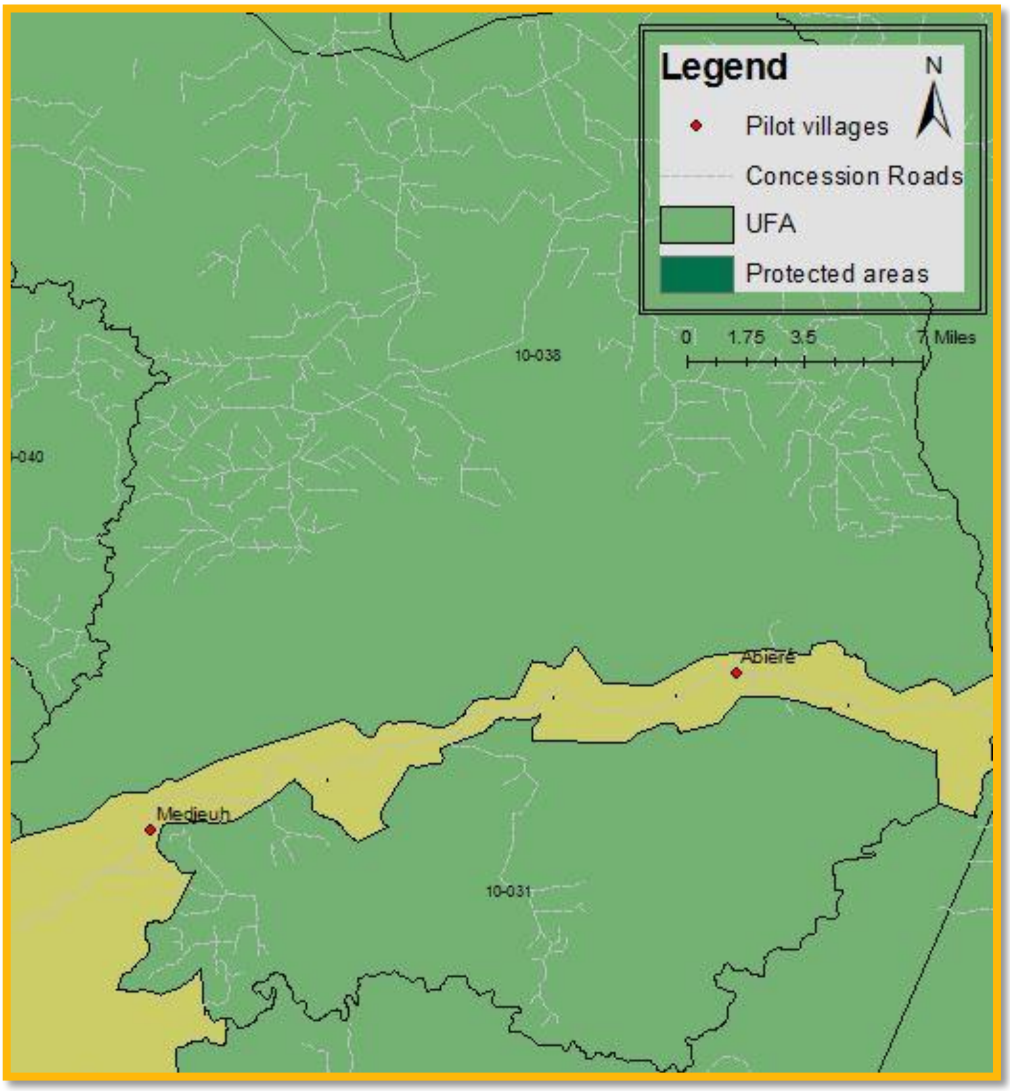

Figure 3.5-1: Map of pilot study location, including study villages and UFA's 10-038 and 10-031.

Detection/non-detection data collected from the respondents were compared to data previously collected by ZSL in the same area (Etoga 2001). The pilot study identified a number of issues, leading to a change in sampling strategy and overall research approach (see table 3.5-2). Following the pilot, no further changes were made and the methodology was deemed appropriate for continued use.

Table 3.5-2: Issues and solutions arising from the pilot study

Issue	Solution
Lack of trust between NGO's and LV. More time was required to gain access to the LV of interest for this study	Unfortunately, for the scope of this study it was decided to eliminate LV from the sampling strategy in favour of a greater focus on the high quality information gathered from TCW's.
Education & Religion demographic questions were not welcomed. In addition, survey took too long.	Removed questions from survey
'"Length of trip" were not appropriately scaled. Many spent more time in the forest than initially thought when designing the survey	Adjusted the bracket options in the interview to be more suitable for timber concession workers
Scale of perceived abundance was confusing	Adjusted the scale and simplified it, adding guidance as to what each option meant

3.5.5 Respondent selection

Due to the nature of this rapid assessment, with the aim to cover as large an area of the eastern region as possible, there was a limited ability for a robust random sampling framework. Therefore, a targeted non-probability sampling strategy was employed, aiming to interview TCW's and authorities across the region. Focus groups were employed to intentionally identify the respondents that were most suitable for this study.

The sampling strategy meant that the sample is not representative of the whole population, therefore attitudes cannot be extrapolated across countries and external validity (i.e. the extent to which the results can be generalized from the sample to a larger population, see Sapsford and Jupp 1996) is low. However, as 60-80% of the land cover in the eastern region of Cameroon is assigned to timber concession, it is of conservation interest to better understand the perceptions, beliefs and attitudes of TCW's and this sampling strategy allowed the coverage of a large proportion of the region. Additionally, in order to effectively gather detection/non-detection data for forest elephants, the pilot found that TCW's and authorities were the most effective and reliable groups and targeting them made sense considering the logistical limitations on this research (time, financial).

3.5.5.1 Timber Concession Worker's

For each participating TC, an initial meeting was held with the site manager who helped us to identify what teams entered the forest on foot and did not operate machinery as otherwise they would have minimal chance of spotting and correctly identifying signs of elephant presence. In order to select a subset of the most reliable UFA workers from within the identified teams, focus groups comprising of a series of short questions were used to eliminate unsuitable respondents (see figure 3.5-2).

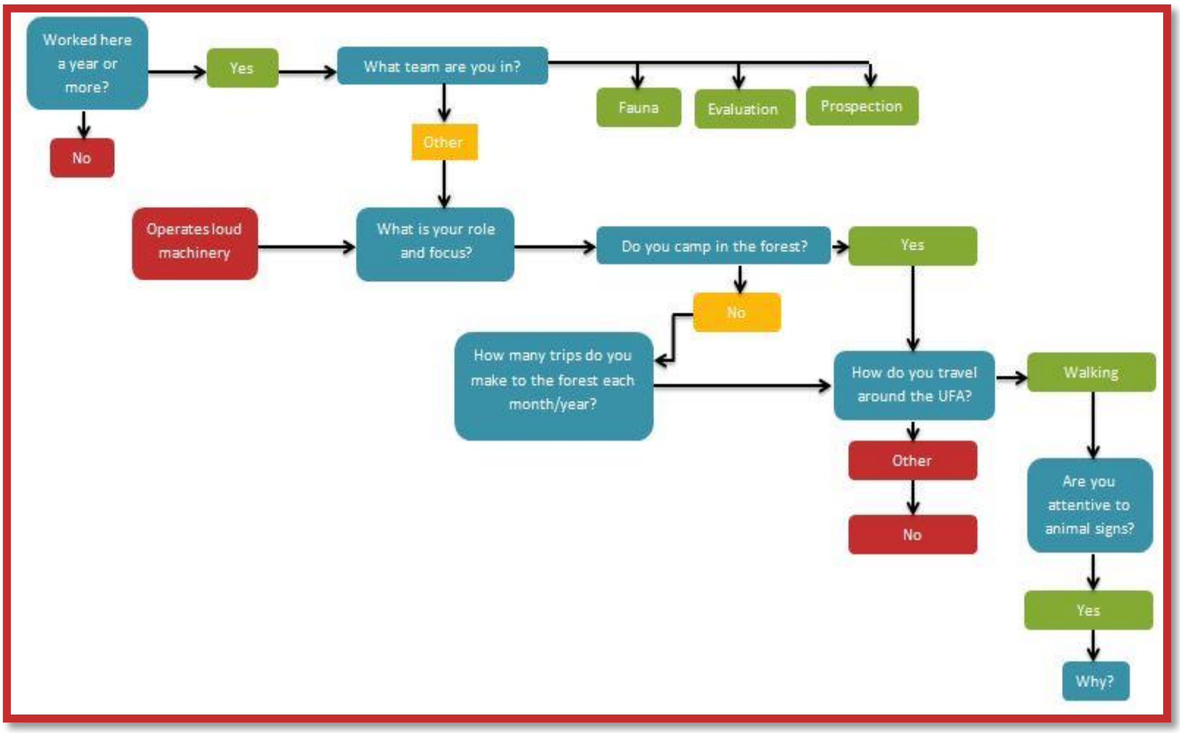

Figure 3.5-2: Flow chart displaying the focus group key questions and selection process.

Blue box=question, Red=inappropriate response for the study requirements and therefore immediately removed from the selection process. Green=desirable response for the selection process and yellow=further questions are required to determine the respondent suitability

3.5.5.2 Authorities

Key informants such as authorities and researchers were interviewed in order to gather data for questions 3a-c, gain a different perspective on the research questions and triangulate the information gathered from the TCW's and local LV. Chefs de poste (CDP) are theoretically aware of any reported poaching and organise anti-poaching activities within their vicinity. We aimed to interview all of the Head of Departments and CDP's in the region. For a full list of interviewees, please see appendix 1.

3.5.6 Sample size

Sample size was determined both by time and logistical constraints and by the need to achieve a balance between area coverage and sufficient repeat surveys for analysis. Additionally, the availability of respondents varied greatly between concessions, meaning that we were not always able to dictate exactly the number of respondents we required. Where repeat surveys did not meet the minimum required amount (3-4 per site), they were noted but still included in the sample as sites with little or no replication can still provide valuable information on occupancy. Although occupancy analysis accounts for missing data, the results of the perceptions and threats were treated with caution for UFA's with few respondents. For a full table of the survey effort across sites and years, see appendix 3.

In terms of qualitative data collection, the principle of saturation, which is when data is collected until no new themes emerge from the interviews (Bryman 2012), was employed.

3.5.7 Ethics

- Confidentiality was guaranteed to all informants
- Permission was always obtained prior to recording (>95% of respondents agreed).
- Due to the sensitive nature of the topic, no-one was asked if they had taken part in any illegal activity regarding elephant poaching, or if they knew anyone that had

3.6 Data analysis

3.6.1 Arc GIS

Prior to conducting any analysis, the values for my site covariates were ascertained using ArcGIS 10.0 (ESRI 2011). All raw covariate data for use in ArcGIS was supplied by ZSL, with the exception of the topography raster file which was obtained from http://srtm.csi.cgiar.org. All layers were projected to GCS_WGS_1984 (Geographic Coordinate System_ World Geodetic System 1984), then the centre point of each site was identified using the centroid tool. Slope and elevation of that point, or the distance from that point to the selected covariate variable was calculated by extracting values to points, then using the Euclidean distance tool. Covariate value or distance from covariate to site centre point was then exported to a .csv file in Excel, ready for analysis in R statistical package (See Appendix 16).

3.6.2 Data preparation & covariate selection

Post data collection, it was noticed that the spread of respondent responses for the detectability covariates was unbalanced, which could have negative implications for the stability of the occupancy models. For example, where Age had five brackets, the results were heavily stacked in two of the five brackets. Therefore, the covariates were recoded in order to pool some of the categories together and get a more balanced spread of data (see table appendix 17).

Table 3.6-2 displays all the detectability and occupancy covariates included in the initial occupancy analysis, including their abbreviated terms.

Table 3.6-1: Detectability and occupancy covariates and their abbreviations

DETECTABILITY COVARIATES								
Age (A)	**Gender** (Ge)	**Rural/Urban** (RuUr)	**Years Worked** (YW)	**Camped** (C)	**Trip** (T)	**Knowledge** (K)	**Year** (Y)	**UFA Group** (G)
OCCUPANCY COVARIATES								
Slope (S)	**Elevation** (E)	**Distance river** (D_Ri)	**Distance Road** (D_R)	**Distance Town** (D_T)	**Distance Village** (D_V)	**Year** (Y)	**UFA Group** (G)	

Having analysed data at the site and UFA level, data was analysed per UFA group (four distinct groups of UFA's separated by well used roads and villages). This allowed for comparisons in occupancy and detectability, as well as perceptions, at the regional scale. Year and UFA group were included as covariates for both occupancy and detectability because in order to extract the "true" occupancy pattern, site-level variation in detectability needs to be controlled. Additionally, if it is assumed that the detectability of sign is constant across sites, any variation in estimated detection probability at the site level may be assumed to correlate with abundance in occupied sites. By looking at site level detectability, it may be possible to draw additional inference regarding the relative abundance in occupied sites.

Pairwise correlations between covariates were conducted to examine independence of variables. If a strong correlation was found between two or more variables, the effects of each variable within the model would be unclear and therefore cannot be modelled simultaneously. The ordinal nature of the respondent data allowed for a spearman's correlation coefficient to be applied. To check for normal distribution of the continuous geographic variables, data was plotted in histograms and qqplots, then checked using Shapiro-Wilk normality test in R. Variables d_Ri and d_R were not normally distributed; therefore spearman's correlation coefficient was used to test the relationship between the two variables. The remaining normally distributed variables were tested using Pearson's correlation coefficient for parametric data. Results displaying either a weak (0.6-0.79) or strong (0.8-1) correlation were discarded from analysis. Table 3.6-3 displays the covariates that were eliminated from analysis.

Table 3.6-2: Covariates removed from further analysis

Variable removed	Why
Gender	Lack of variation for analysis (all respondents were male).
Rural/Urban upbringing	Lack of variation for analysis (over 95% of respondents were raised in a rural area)
Knowledge	Information was used to add understanding to how and why respondents are suitable and reliable elephant detectors.
Number of trips per year	Both "age" and "years worked" were found to be very highly correlated with this variable (>0.9). Therefore it was deemed appropriate to remove it from the analysis.

3.6.3 Occupancy analysis

The first step in the occupancy analysis was to build up a detection history for each site, assigning a '1' for presence and '0' for absence. Data on reported elephant tracks, broken branches, dung and direct sightings were included in analysis. Due to the familiarity of respondents to the sample site used, respondents were able to recall detection/ non-detection further in the past than initially anticipated. This is because each AAC is exploited in a set year; therefore respondents could associate where they saw a sign of elephant with the correct year of sighting. The reliability of reported detections was further tested by asking respondents to repeat both detection and non-detection responses provided at the end of the interview. If the respondent appeared unsure or gave different responses, the response was removed from analysis. Although respondent recall should be considered throughout, the volume of reliable data was found to drop off prior to 2008, and was therefore deemed insufficient and omitted from this study. Due to the rotational nature of exploitation within UFA's, repeat data from the same AAC within a UFA was not collected frequently enough to conduct multi-season occupancy analysis (MacKenzie et al, 2003), therefore data was prepared for single season occupancy analysis, using year as an additional covariate to examine differences in occupancy and detection over 6 years.

Modelling frameworks were developed to allow the selection of candidate models through the systematic modelling of detectability and occupancy covariates (appendix6-8). Akaike Information Criteria (AIC) was used to rank and identify the best fit models (Burnham& Anderson, 2002). The best fit model was examined to understand what the effect of the covariates is on detection and occupancy. Using the best fit model, occupancy estimates were obtained across all sites post-hoc and presented using ArcGIS. All occupancy analysis was conducted in R statistics 'unmarked' package (Fiske & Chandler 2011).

3.6.4 Geographical variation in perceptions and threats

Perceptions and threats data was collected with the intention of adding additional value and understanding of the occupancy data, and better understand what the threats to elephant populations are across the region and to gather information on the perceived rate of population change in UFA's. To assess the perceived change in population, abundance and threats across the region, each response category was assigned a value (e.g. for perceived population change, increased equated to +1, decreased to -1 and same to 0). The mean value of the total score per were used to produce heat maps using ArcGIS in order to present the data spatially. This data was used to show patterns of change across the region, potential relationships between occupancy and the perceived threats across the region.

3.6.5 Qualitative analysis

Qualitative information was collected from open ended questions in order to gain in depth understanding regarding the threats to elephants, attitudes and rates of population change. Themes were identified and key quotes were presented in the results.

4 RESULTS

4.1 Survey summary

Data was collected from 196 respondents over the course of 10 weeks. Of the 196 respondents, 154 were TCW's, 21 were administration and 21 were LV. 100% of the TCW's were male, 96% were raised in rural villages and 76% felt they owed their knowledge of animal signs to their fathers and upbringing. 30% were aged 27-37 and 38% were aged 38-48; only 2% were aged 60+ and 4% aged between 16-26. 100% of authorities were male and none had worked any longer than 2 years in that post due to a shift in government structure (See appendix 1 for a full list of respondents). Detection/non-detection data was collected from a total of 342 sites within 34 UFA's. Figure 4.1-1 highlights the UFA's visited across the region, and the UFA group they fall within.

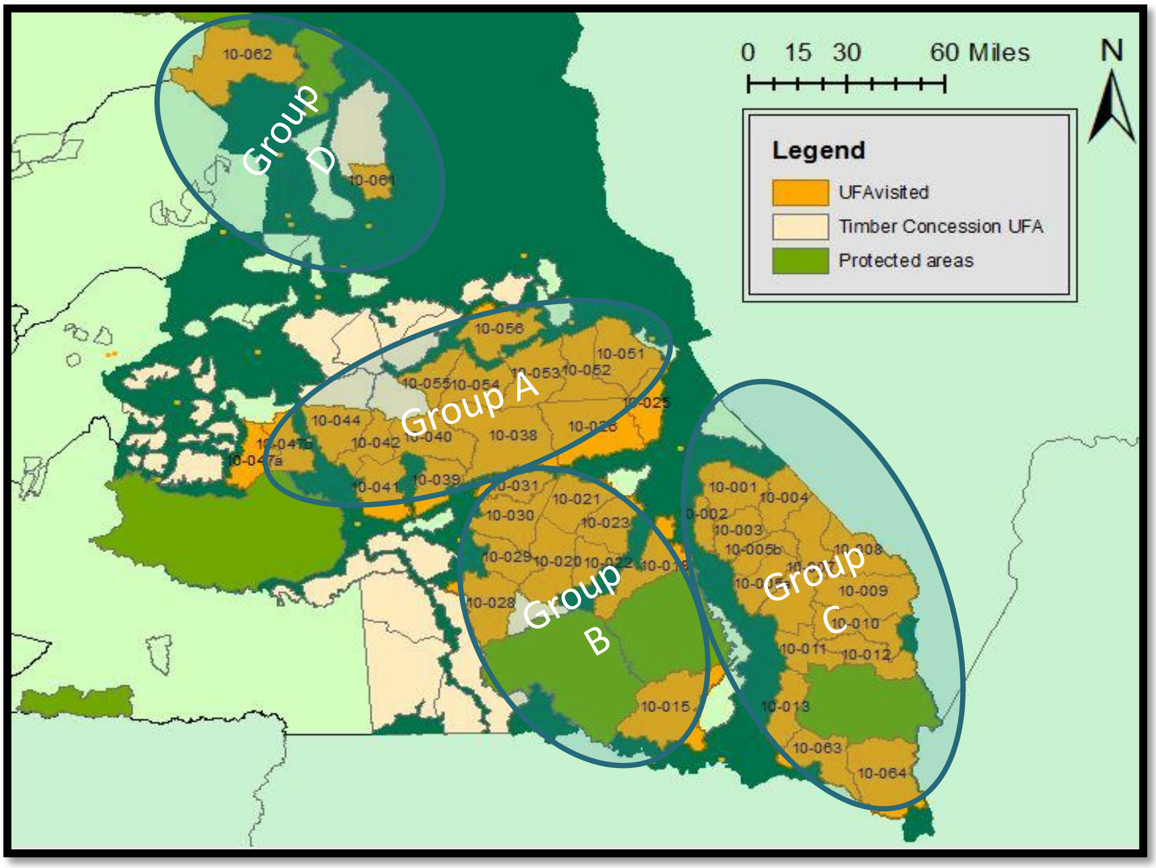

Figure 4.1-1: Map displaying the UFA's and UFA groups

4.2 Detection, non-detection and initial exploration of the data

Figure 4.2-1 shows the naïve detection/non-detection data across the region from 2008-2013. Note that the west of group A has underrepresentation in data.

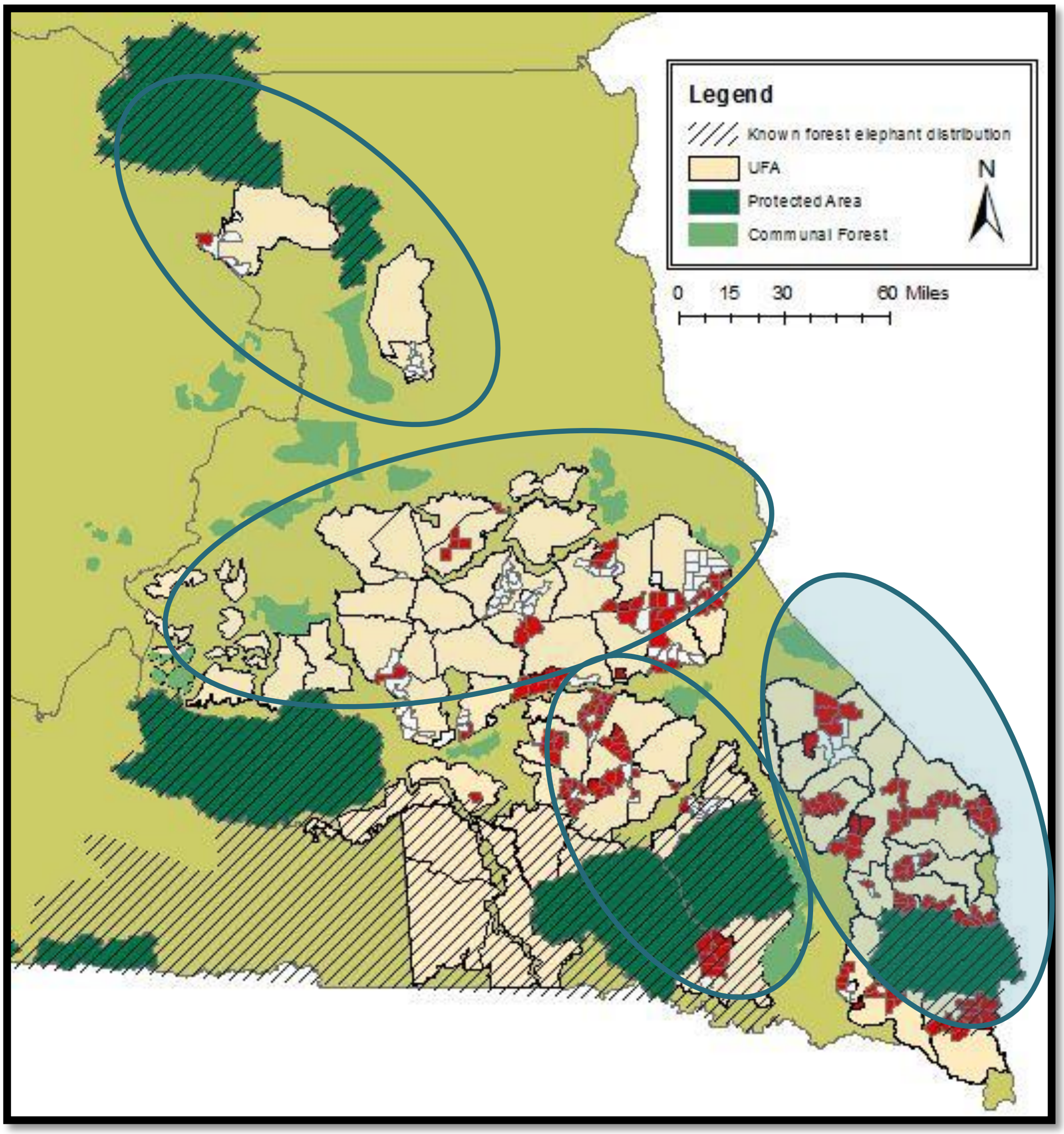

Figure 4.2-1: Naïve detection/non-detection across sample sites.

Sample sites are shown as AAC's (red site= species detected; white site = species not detected). Naïve detection/non-detection data shows higher concentration of detections in the south east (Group C). Of the 81 sites in group C, 73 have reported detection (90%). 45 of the 54 sites in group B had reported detection (83%). In contrast, 38 of the 85 sites in group A (37%) and 1 of the 11(9%) in group D have reported detection.

4.3 Occupancy modelling

4.3.1 Fixed model

Table 4.3-1 displays the summary of the back transformed (psi) occupancy and detectability estimates from the fixed model, which assumes constant occupancy and detectability and does not incorporate any covariates.

Table 4.3-1: Occupancy (Ψ) and detectability (p) estimation for the fixed model

	Estimate	SE	z	P(>|z|)	Confidence interval		AIC
					0.025	**0.975**	
P	0.585	0.0148	5.64	1.66e-08	0.2247218	0.4637965	1931.772
Ψ	0.76	0.0293	7.18	6.78e-13	0.838186	1.467158	

The estimates obtained for the back transformed detectability (p) and occupancy (psi) were 0.585 and 0.76 respectively.

4.3.2 Covariate correlation tests

Results of the Spearman's correlation coefficients (appendix 5) showed a strong positive correlation between the detectability variables Age and Number of Trips (P=0.9759) and Years and Number of Trips (P=0.909) and was therefore eliminated. The Person's correlation coefficient conducted on the occupancy variables found no significant correlations, therefore none were eliminated from the modelling process at this stage.

4.3.3 Covariate model

The results of the best fitting detectability modelling are presented in table 4.3-2. (P(C+YW) Ψ (·)) was the best fitting model at this stage, with the lowest AIC value of 1727.91.

Table 4.3-2: Table of best fitting detectability results

Model	Covariates	AIC	ΔAIC
8	(P(C+YW) Ψ (·))	1727.91	0.00
7	P(A+C+YW)Ψ (·)	1729.46	1.55
3	p (C) Ψ (·)	1731.91	4
4	p (A+C) Ψ (·)	1734.74	6.83
2	p(A) Ψ (·)	1931.06	203.15
6	P(A+YW) Ψ (·)	1932.94	205.03
5	p (YW) Ψ (·)	1933.62	205.71

Conservation related covariates were then added (G & Y), reducing the AIC of the best fit model by 213.21 (from 1727.91 to 1514.7). P(C+YW +G+Y) Ψ (·) was found to best account for detectability. Results are displayed in table 4.3-3 below;

Table 4.3-3: Table of detectability and conservation related detectability covariates

Model	Covariates	AIC	ΔAIC
9	P(C+YW +G+Y) Ψ (·)	1514.7	0.00
11	P(C+YW+G) Ψ (·)	1517.208	3.1
10	P(C+YW + Y) Ψ (·)	1720.823	206.663

KEY OF SYMBOLS

P=Detectability
Ψ= Occupancy
C= nights camped
YW=Years Worked
A =Age
G=UFA Group
Y= Year
AIC= Akaike Information Criterion

Occupancy (Ψ) covariates were then added to the current best fitting model (P(C+YW +G+Y) Ψ(·). Appendix 6 presents the AIC values derived from the 63 possible combinations of occupancy variables occupancy ("Town", "Village", "Road", "River", "Elevation" and "Slope"). Table 4-3.4 displays the top ranking models from this stage of the modelling process.

Table 4.3-4 AIC values of detectability and conservation related detectability covariates modelled with occupancy covariates

Model	Covariates	AIC	ΔAIC
3 (74)	p(C+YW+G+Y) Ψ(V+Ri+Ro+E+S)	1350.16	0.96
4 (42)	p(C+YW+G+Y) Ψ (V+Ri+Ro+E)	1350.24	1.04
5 (58)	p(C+YW+G+Y) Ψ(V+Ri+Ro+S)	1350.29	1.09
6 (59)	p(C+YW+G+Y) Ψ(T+V+Ri+Ro+S)	1350.34	1.14
KEY OF SYMBOLS			
AIC: Akaike Information Criterion			
ΔAIC: Akaike difference			
Ψ: probability of occupancy, p: probability of detection			
C: Nights Camped, YW: Years Worked, G: UFA Group, Y: Year			
T:Distance from Towns, V:Distance from Village, Ri: Distance from River, Ro: Distance from Road, E:Elevation, S:Slope			

As can be seen, the top four models all had an ΔAIC of <4, therefore all four were modelled with all combinations of the conservation related occupancy covariates (“UFA Group” and “Year”) (See appendix 7 for the modelling framework used at this stage).

4.3.4 Model ranking

Table 4.3-5 displays the top ranking models from the combined detectability and occupancy covariate modelling, selected because their ΔAIC values are less than 4, following Burnham & Anderson (2002).

Table 4.3-5 Top ranking covariate models taking into account detectability, occupancy and conservation related covariates (continued on next page)

RANK	MODEL	AIC	ΔAIC	N	Wi
1	p(C+YW+G+Y) Ψ (V+Ri+Ro+E+G)	1349.16	0.00	19	24%
2	p(C+YW+G+Y) Ψ(V+Ri+Ro+E+S+G)	1349.57	0.41	20	20%
3	p(C+YW+G+Y) Ψ(V+Ri+Ro+E+S)	1350.16	1.00	17	15%
4	p(C+YW+G+Y) Ψ (V+Ri+Ro+E)	1350.24	1.08	16	14%
5	p(C+YW+G+Y) Ψ(V+Ri+Ro+S)	1350.29	1.14	16	14%
6	p(C+YW+G+Y) Ψ(T+V+Ri+Ro+S)	1350.34	1.19	17	13%
KEY OF SYMBOLS					
AIC: Akaike Information Criterion					
ΔAIC: Akaike difference					
Ψ: probability of occupancy, p: probability of detection					

C: Nights Camped, YW: Years Worked, G: UFA Group, Y: Year
T:Distance from Towns, V:Distance from Village, Ri: Distance from River, Ro: Distance from Road, E:Elevation, S:Slope
N: Number of parameters in the model
Wi: Akaike weight

A closer examination of the model summaries showed that the "slope" covariate was not significant in the models and therefore did not appear to support any gain in the likelihood compared to the corresponding models. Therefore, models with "slope" incorporated as a covariate were eliminated and p(C+YW+G+Y) Ψ (V+Ri+Ro+E+G) was identified as the best fitting model with the smallest AIC value.

4.3.5 Analysis of the best fit model

The Mackenzie and Bailey goodness-of-fit bootstrap test was run for the best fit model in order to evaluate the fit. The results found that there is no significant lack of fit (p=0.8), therefore following Burnham & Anderson (2002), there is no need to make adjustments to the AIC or the standard errors of parameter estimates. The detectability and occupancy summaries of the best fit model are shown in Table 4.3-6.

Table 4.3-6: Summary of best fitting model p(C+YW+G+Y) Ψ (V+Ri+Ro+E+G) with detectability and occupancy covariates (continued on next page)

OCCUPANCY	Estimate	SE	Z	P(>|z|)
Intercept	2.473	0.648	3.82	0.000134
V	0.796	0.292	2.73	0.006319
Ro	0.944	0.425	2.22	0.026431
Ri	-0.480	0.223	-2.15	0.031651
E	-1.058	0.466	-2.27	0.023127
Group B	0.735	0.720	1.02	0.307193
Group C	-1.400	1.031	-1.36	0.174779
Group D	-3.753	2.039	-1.84	0.065698
DETECTION	**Estimate**	**SE**	**Z**	**P(>|z|)**
Intercept	0.9885	0.361	2.735	6.23e-03
camped2	-1.1602	0.158	-7.360	1.84e-13
years2	-0.0969	0.160	-0.606	5.44e-01

Groupb	0.7459	0.197	3.785	1.53e-04
Groupc	2.3390	0.183	12.772	2.34e-37
Groupd	-0.8364	1.674	-0.500	6.17e-01
year2	-0.7741	0.413	-1.875	6.08e-02
year3	-0.8585	0.380	-2.256	2.40e-02
year4	-1.0155	0.366	-2.772	5.57e-03
year5	-1.2816	0.354	-3.616	2.99e-04
year6	-1.0707	0.363	-2.952	3.15e-03
AIC: 1349.158				

Table 4.3-6 indicates that there is a reduction in the ability for elephants to be detected from year 1 to year 5 (2008-2012) reflected by the increasingly negative estimate values, with a slight increase at year 6 (see light blue boxes). This pattern is consistent with decreasing abundance over time, despite the lack of evidence for a trend in occupancy. The summary shows that there is no significant relationship between the predicted occupancy of the different UFA groups.

Group B has the highest detection and occupancy estimate, whereas Group D has the lowest. Group A comes second, whereas Group C has an ambiguous result of a low occupancy estimate (-1.4) in contrast to the highest detectability estimate (2.34), suggesting lower probability of occupancy, all else being equal, but higher abundance in occupied sites. Group B has a higher estimated occupancy than Group A (Intercept), whereas Group C and D have lower estimated occupancies indicated by their negative estimate values (-1.4 and -3.7 respectively) (see light yellow boxes).

A full summary of the back transformed parameter estimates based on the logit link parameters can be seen in appendix 8. Results indicate that the likelihood of a forest elephant using a particular site decreases with high elevation, proximity to villages and to roads, and increases with proximity to rivers.

4.4 Occupancy and distribution

With the best fit model for occupancy and detectability selected, patterns in occupancy and distribution across the region can be inferred. The box plots in figure 4.4-1 display the distribution of predicted occupancy per UFA group. Boxes display 25-75% interquartile range, and thick line shows the medium value of occupancy. Whiskers display total range and points show outliers 3/2 times the lower quartile.

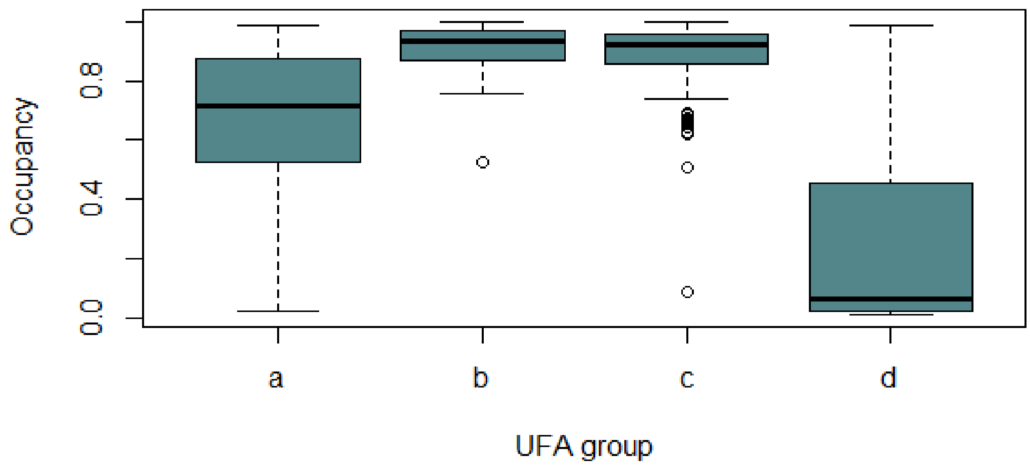

Figure 4.4-1: Box plot of the distributions of predicted elephant occupancy per UFA group.

Figure 4.4-1 shows that groups A and D have the widest spread of predicted occupancy within their groups, although group A has a much higher median occupancy (0.7) than group D (< 0.1). Groups B and C both have consistently high predicted occupancy (median c. 0.95, lower approximate confidence limit c. 0.75), although group C has a substantial number of outlier AACs with lower predicted occupancy.

These results indicate that elephants likely use the vast majority of the UFA area in groups B and C, have a more patchy presence in group A, and are mostly absent from group D. This pattern is illustrated in Figure 4.4-2. The naïve detection/non-detection map (figure 4.2-1) shows the areas in which data was and was not obtained and should be used for reference in understanding areas of underrepresentation.

Figure 4.4-2 shows some interesting patterns of occupancy. Elephants are mostly absent from the western section of group A, with the remainder displaying a medium likelihood of occupancy. In group D, the only areas likely to be used are adjacent to the Mbam et Djerem reserve and there is a lower likelihood of occupancy along the southern boundary of Boumba Bek NP in contrast to surrounding sites. It should be re-emphasised that although interesting, these are predictions and in some cases, presence was reported in sites with low occupancy. For example, the occupancy model predicted high occupancy to the north of Boumba Bek NP, whereas the naïve detection/non-detection in figure 4.2-1shows that no detections were recorded in those sites.

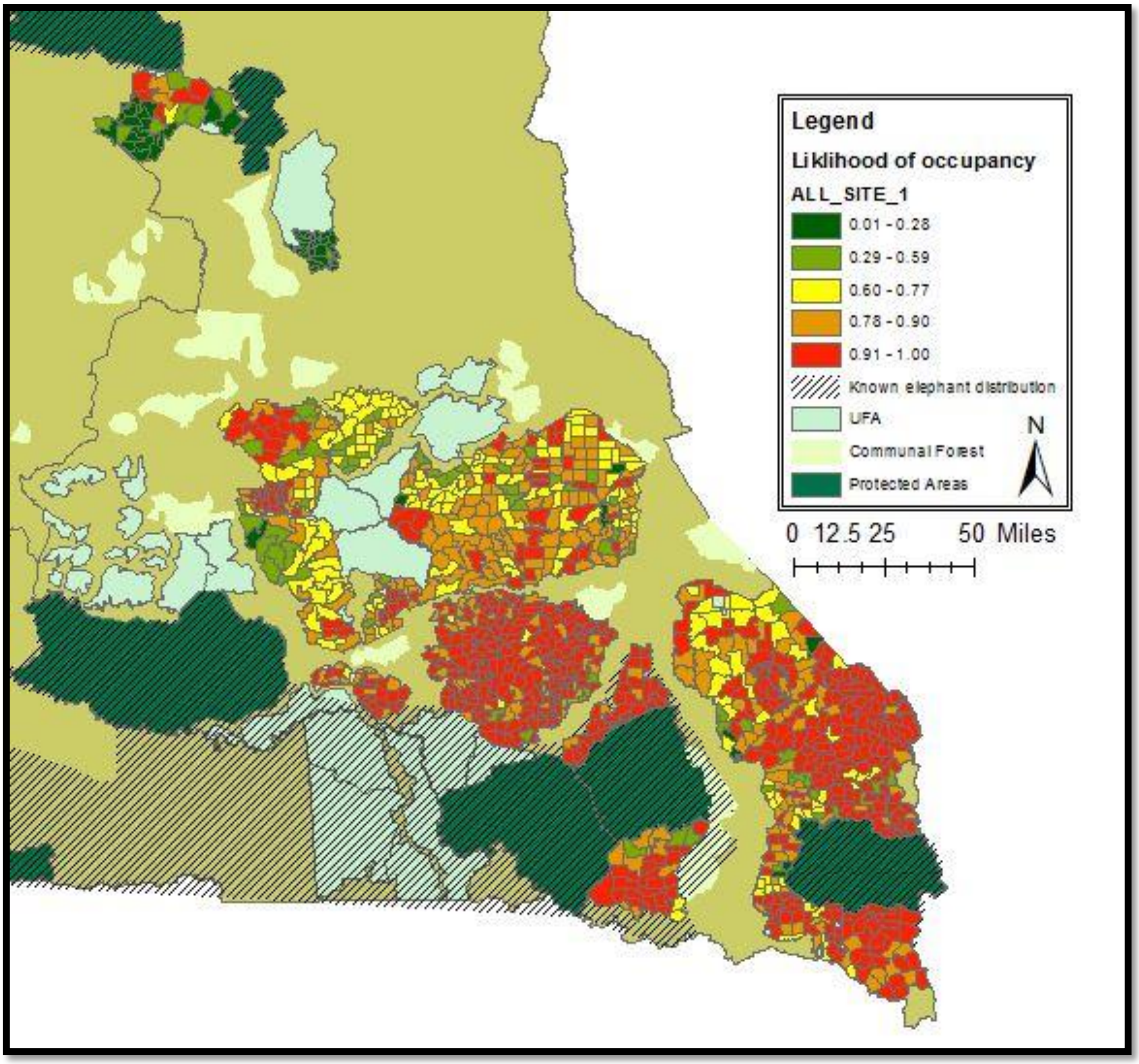

Figure 4.4-2: Likelihood of occupancy across the region based on the best fit model

4.5 Perceived abundance

Figure 4.5-1 displays the mean perceived abundance within each UFA. Bar graphs display mean perceived abundance per UFA, within each UFA group. Where-1 equates to "zero" perceived abundance, and 2 equates to "lots".

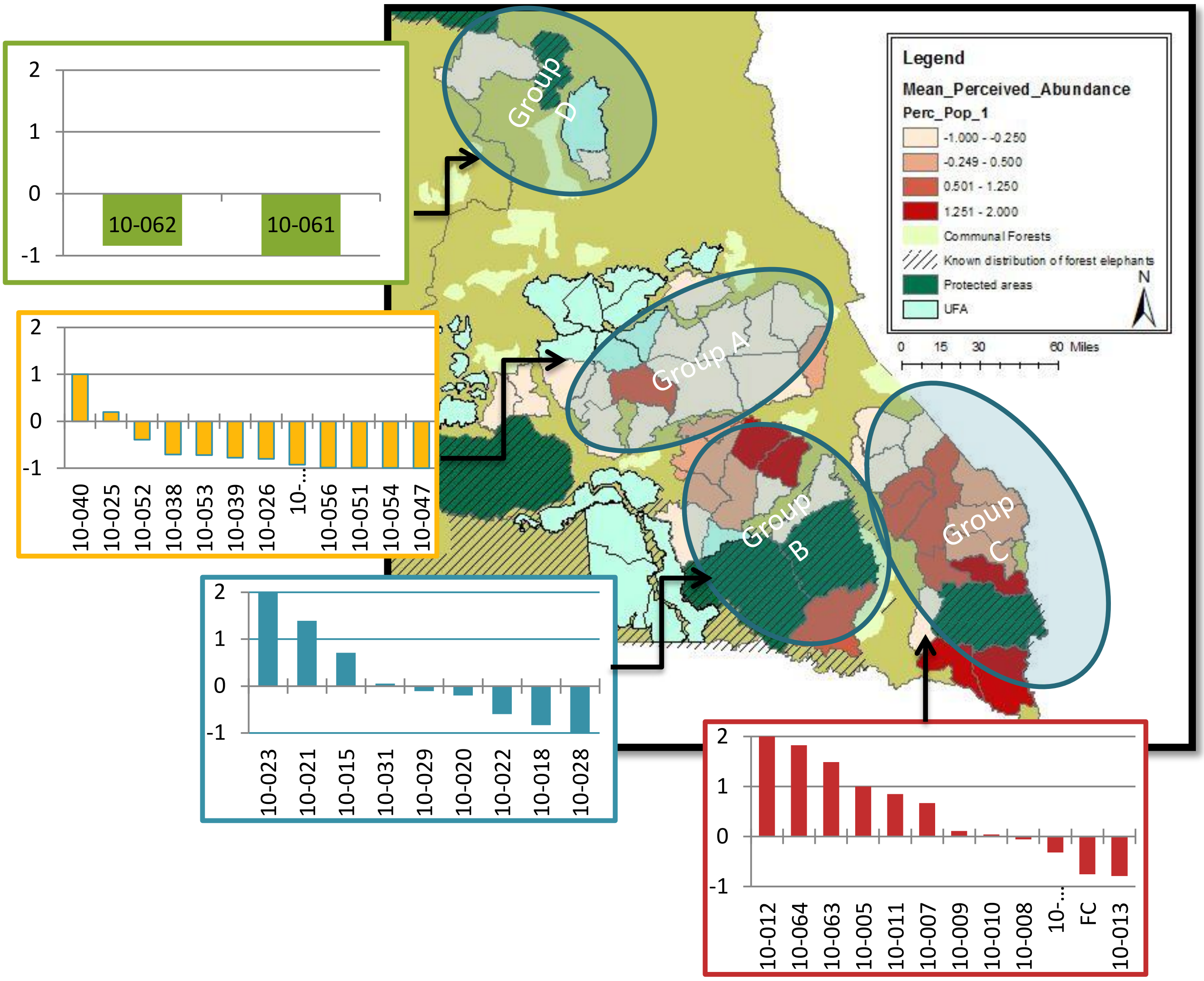

Figure 4.5-1: Perceived abundance of elephant signs across the eastern region

Figure 4.5-1 shows that the perceived abundance is lowest in the north west of the region and increases to the south east, with high perceived abundance in sites adjacent to the Nki, Boumba suggesting that there is almost zero abundance in the group. In contrast, groups B and C both have positive perceived abundance. Group C has the highest perceived abundance of the UFA groups, with the mean of half the total UFA's laying between 0.5 and 2. This pattern of perceived abundance across UFA sites is consistent with the estimated detectability result from the best fit model summary (table 4.3-6).

4.6 Perceived population change

Figure 4.6-1 displays the mean perceived population change within each UFA. Bar graphs display the mean perceived population change per UFA, within each UFA group. Where 1 relates to an increase in population, -1 related to a perceived decrease and 0, no change.

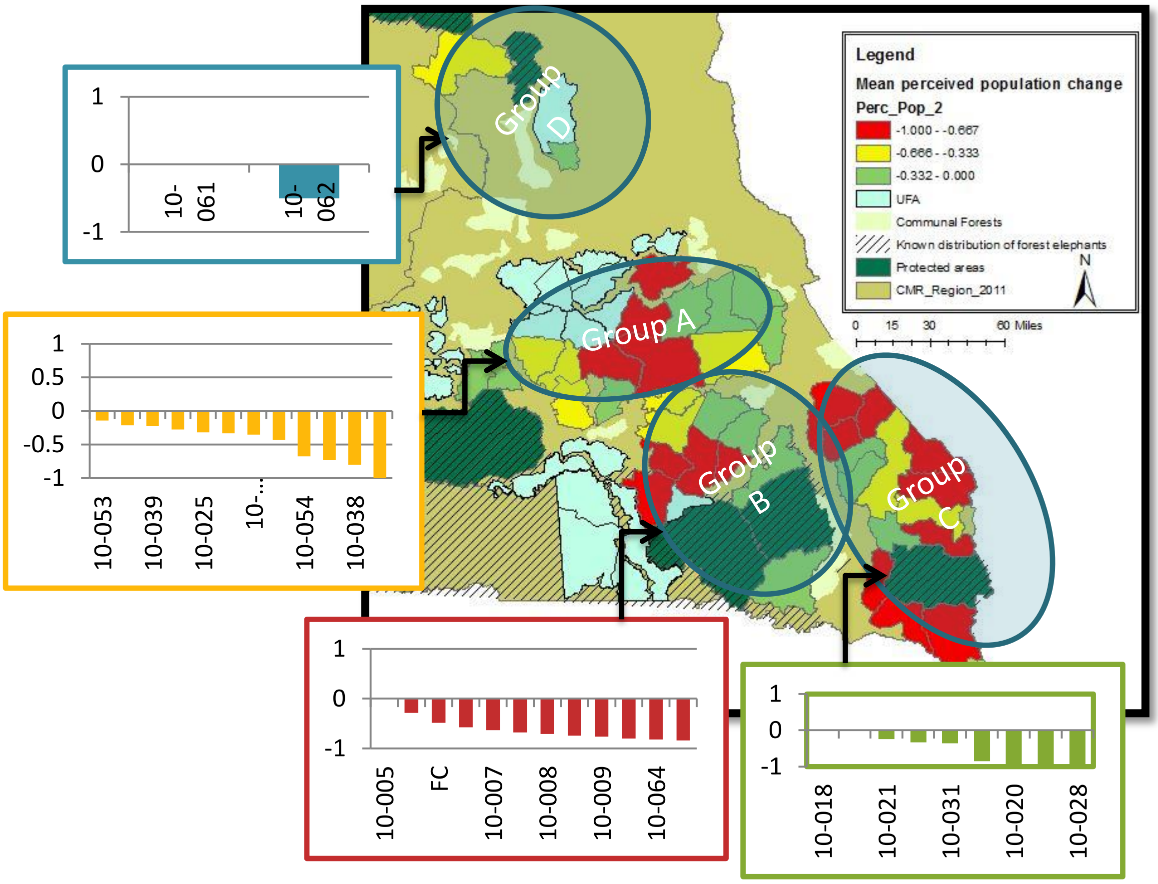

Figure 4.6-1: Perceived population change across the eastern region

An initial remark on the perceived population change is that the mean values of each UFA are negative, indicating a general perception of population decline across the region, which is consistent with the declining detectability trend reported. The greatest population decline is shown across group C, namely in sites adjacent or in close proximity to the borders of the CAR to the East, and The Congo to the South. Interestingly, there is a perceived stable population in sites adjacent to Boumba Bek NP in group C and north of Lobeke NP in group D; sites in the north east of group A are perceived to be stable. There appears to be a positive relationship between the pattern of perceived abundance and perceived population decline, notably in group C. Perceived population decline is smallest in the north west of the region, where perceived abundance is also low.

4.7 Threats

The following figures display the results of the qualitative data collected for the perception of threats across the region. The map can be interpreted in that 1 (dark red) is “strongly believe the factor to be a threat”, -1 is (cream) “strongly believe the factor is not a threat” and 0 (pink) is “neutral”. All other light blue UFA’s represent UFA’s with no data.

4.7.1 Roads

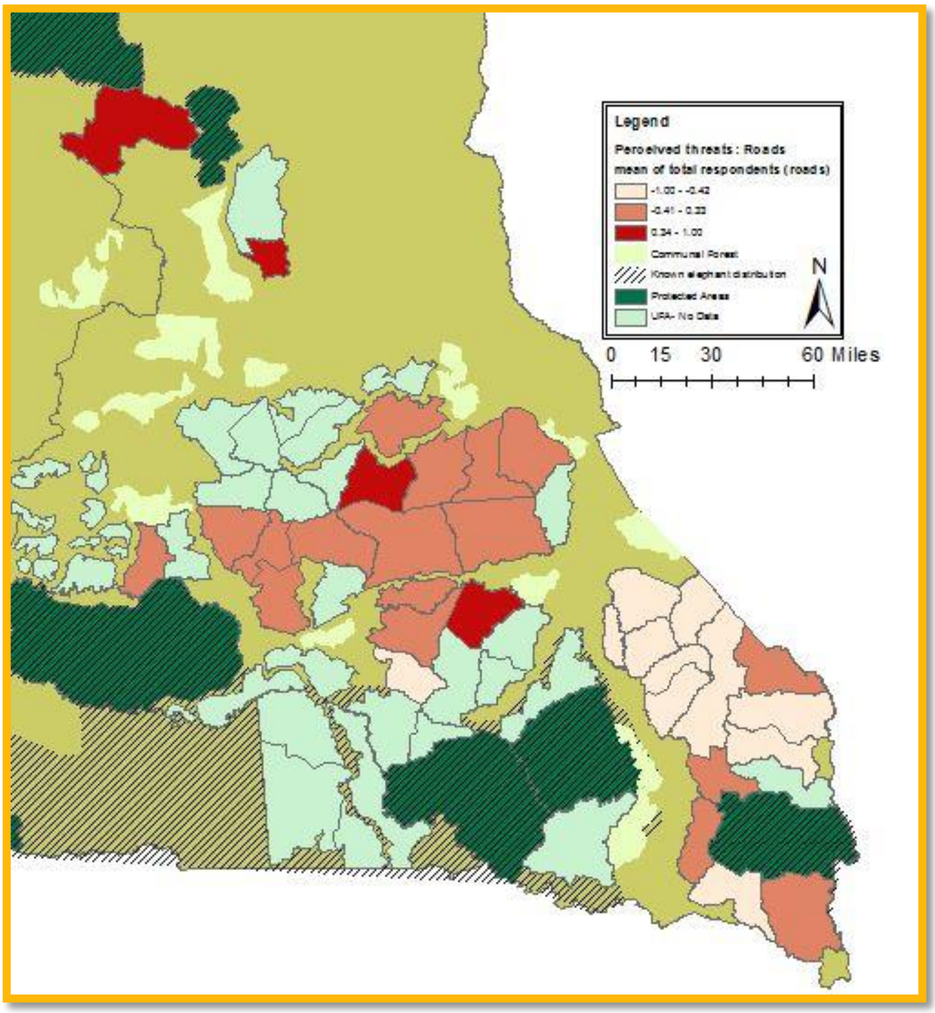

Figure 4.7-1: Map displaying the mean perceived threat to elephants from roads per UFA

Of the total 161 respondents, 56 think roads are a threat, 69 do not think they are a threat and 37 do not know. There is a perceived threat from roads in group D. The majority of UFA’s in group C do not perceive roads to be a risk, whereas the majority of UFA's in group A and B are not sure if they are a risk or not.

4.7.2 Bush meat

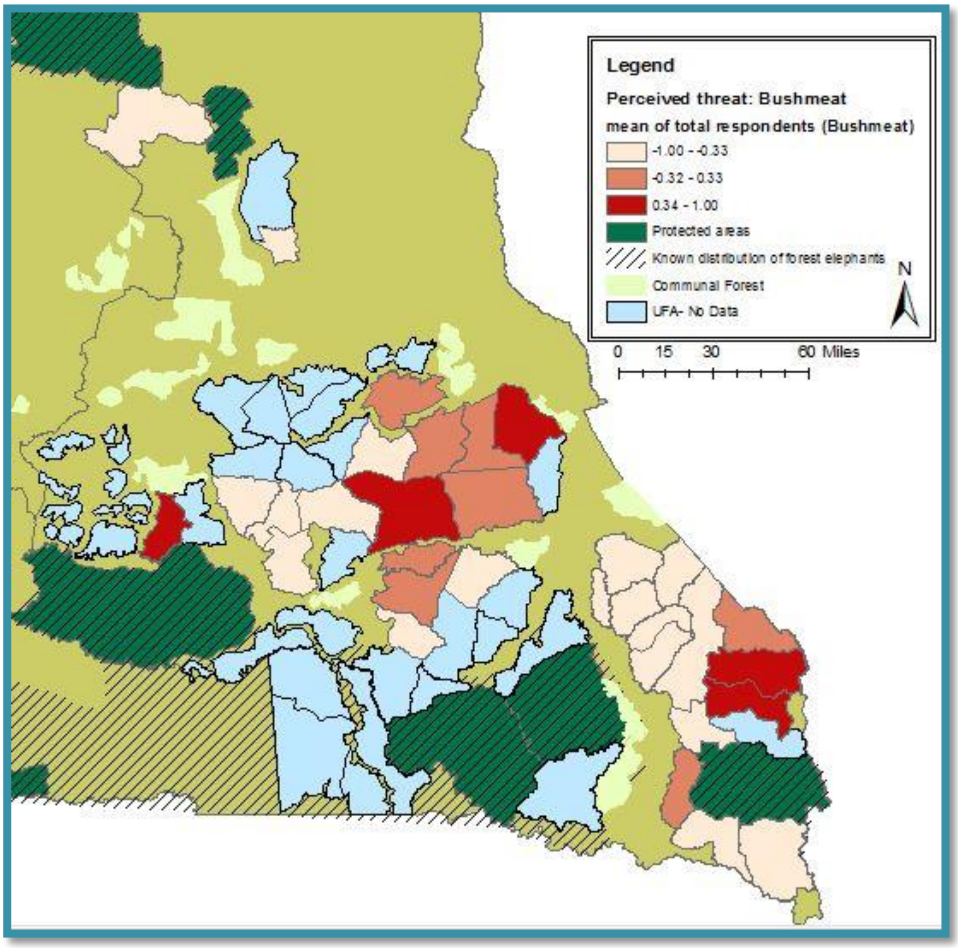

Figure 4.7-2: Map displaying the mean perceived threat to elephants from poaching for bush meat per UFA

Of the 161 respondents, 36 agreed that poaching of elephants for bush meat is a problem, 75 disagreed and 51 did not know. Most UFA's do not consider poaching for bush meat to be a threat to elephants. However there is a perceived threat in the west of UFA group A and in the UFA's north of the Lobeke NP in group C.

4.7.3 Ivory

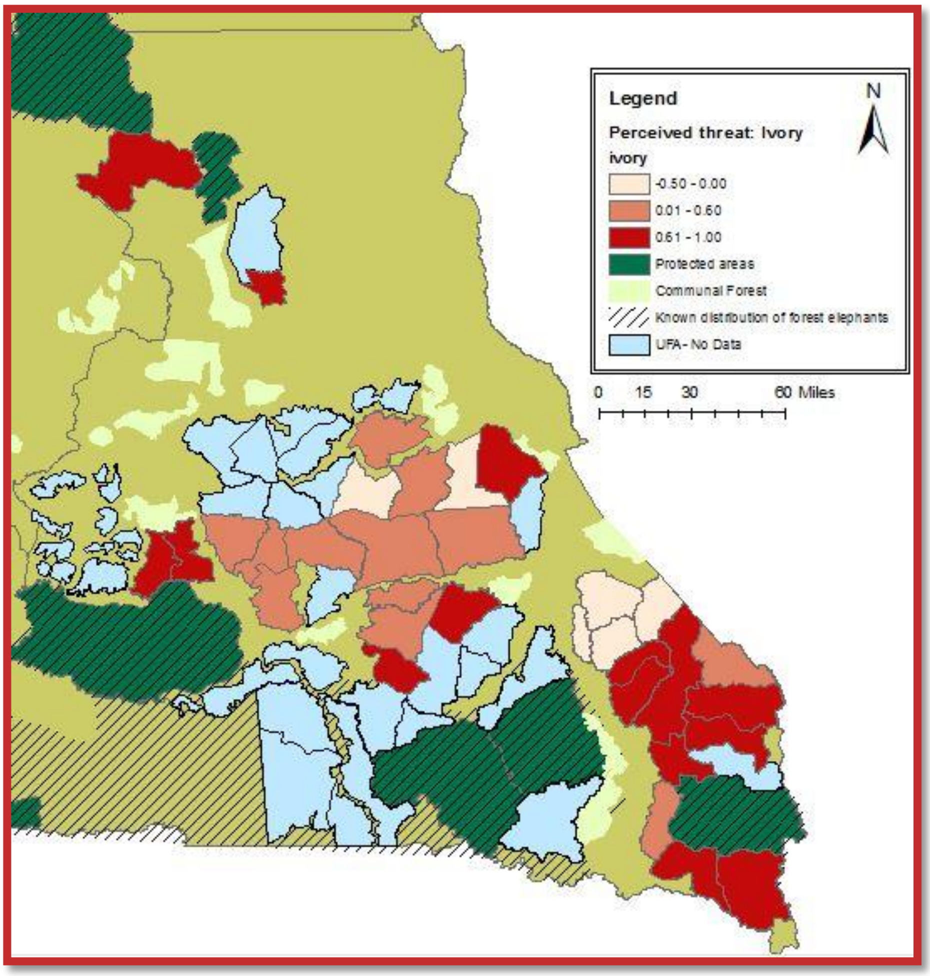

Figure 4.7-3: Map displaying the mean perceived threat to elephants from poaching for ivory per UFA

Poaching for ivory is the biggest perceived threat to elephants, with 93 of the 161 respondents stating that they thought it was a problem. Only 25 disagreed and 44 did not know. The perceived threat of poaching for ivory is more concentrated in UFA group C and D

4.7.4 Timber exploitation

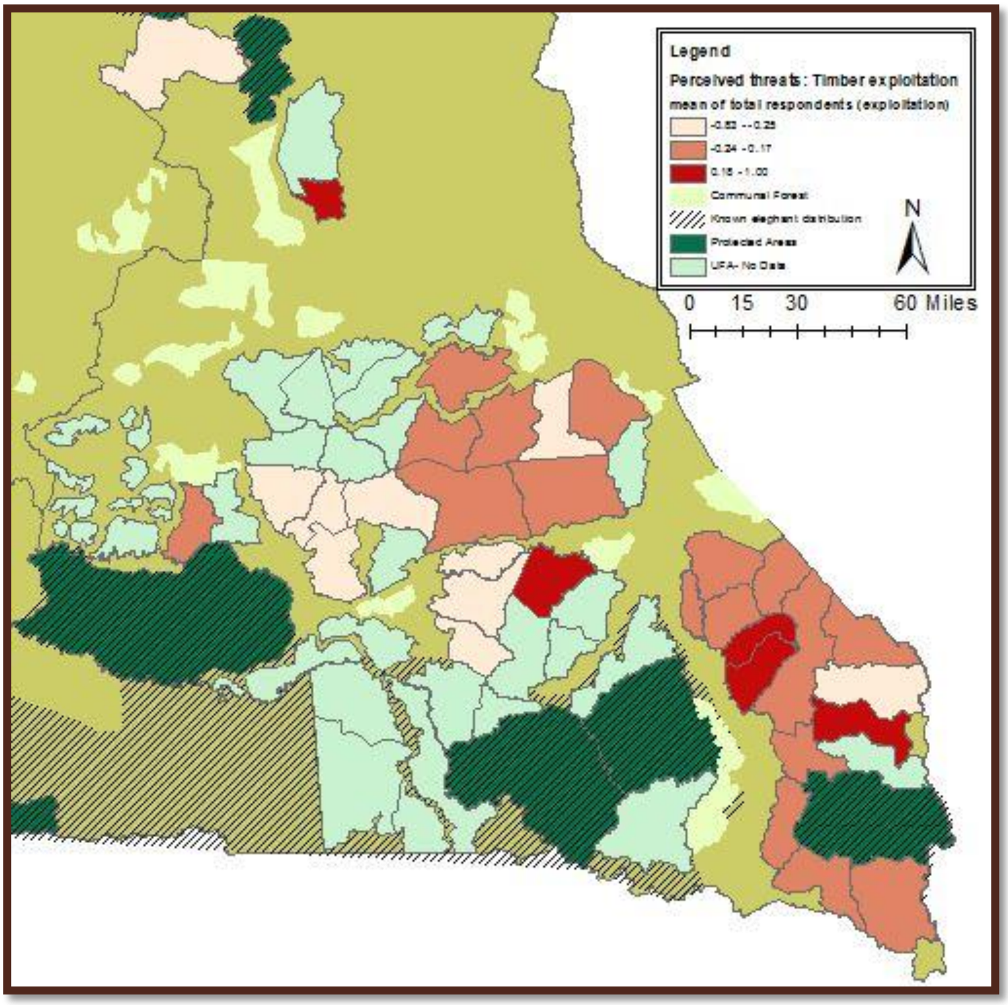

Figure 4.7-4: Map displaying the mean perceived threat to elephants from timber exploitation per UFA

Timber exploitation gave the most ambiguous results of all the threats, signified by the relatively similar range of results. 60 of the 161 respondents did not think that exploitation was a threat to elephants. 44 thought that it was and 58 did not know.

4.8 Qualitative data

Open ended questions with the aim of gathering in-depth understanding of population change, attitudes towards elephants and the threats they face brought up some interesting issues.

4.8.1 Poaching

Despite awareness of the laws, the qualitative data suggests that the financial reward of elephant poaching outweighs the risk for many in the eastern region of Cameroon.

"Elephant poaching has become harder, but they do it anyway. You have to be secretive or get arrested. All of the elephant is worth money, the meat, the skin, and the tusk" (Anon, TC)

The price of ivory and the level of poverty in the region mean that alternatives to poaching are perceived to be lacking;

"Alternatives how? People look to get rich quick Even 30 days of work doesn't match the price of ivory…alternatives don't work " **(#10, Authority)**

"I like my work… I have 13 kids, this allows them all to go to school. Panagiotis Marielis offered me work but for how much? I prefer poaching" (Poacher, UFA 10-061)

A lack of desire to protect elephants further reflects the above sentiment. Although some don't want to lose the species for future generations, overall the feeling was that elephants are of financial worth, and they can make you rich quick.

"People like elephants because their tusks are worth something. There s no emotional attachment to elephants. If there are no more elephants, people will be sad because there is no more ivory" (#6, Authority)

"I like elephants, but we can't kill them anymore. People have stopped killing them only because it is illegal…If elephants disappear, people will be a bit sad But, as elephant meat is illegal I don't see why people will regret the loss of the species,"

Interestingly, an increased understanding of the importance of elephants for the survival of the forests seems to improve overall attitudes towards the need for conservation amongst TCW's;

"We need to protect elephants for our forests. Elephants are important for other animals too… and move seeds around the forest… Without them our forests wouldn't be the same"

Conversely, attitudes towards elephants are negatively influenced by HEC, which is an issue in the very south eastern UFA's of Group C and is apparently on the increase;

"… When we go to the CDP, he says no to culling People are frustrated… opinions of elephants have gone down because of this"

The influence of international markets was regularly cited by authorities as a key force behind poaching across the region;

"… opening up of Africa to the Asian market, the price of Ivory has gone up and led to an increase in poaching. They say they are doing research for mineral exploitation, or they are here for pangolin scales… they hide behind that to illegally trade Ivory " (#3, Authority)

"…I remember in 2008/2010 a kilo of ivory cost 40,000…But in 2011-2013 it rose to 120-140,000 the kilo… At first, it was people within the Cameroonian administration…Since then it's the Asians who lead it, who say, 'we are in need of ivory, import as much as you can'…(#10 Authority)

Corruption was identified by both authorities and TCW's as one of the key barriers to elephant conservation. Corruption is well known, and combined with a lack of law enforcement, reduces the fear of getting caught and further encourages people to get involved in poaching as a 'quick fix' to poverty.

"Gendarmes are involved, the CDP is implicated, everyone is implicated " (#3, Authority)

"It's always the generals, the ministers, the CDP that are behind it and involved It's them that are behind the poaching There are road blocks and yet no one gets stopped There is a lot of money to be made from it…" (Anon, TCW 10-030)

Interviews with authorities demonstrated a lack of capacity to protect elephants in the region, highlighted by their statements and also by the lack of internal organisation as poaching reports were mostly unavailable and/or non-existent. Therefore, even with the will to work, taking action is difficult and dangerous;

"Elephant poaching exists...But we don't we don't have weapons. It's dangerous. We can't really reduce it. We don't have the poaching reports, they are somewhere else. " (#9 Authority)

However, if anyone does get caught, it is the local who was used to find the species and not the main contact. Therefore, no matter how many local poachers get caught, those driving the market are still there;

"…the authorities use local people, Baka's especially, to go and find them elephants and poach them… What can I say…people capitalise on their positions of power to their advantage. On top of their salary, they can make a lot more by poaching elephants (#8, Authority)"

The presence of roads was widely understood to be used by poachers, although this did not come out in the quantitative data. This is because a distinction was not always made between elephants using a road, and the road posing a threat to elephants. It is reported that poachers take advantage of the increasing fragmentation of forests by the UFA's and ZIC roads, to access areas of high elephant density in order to poach more effectively.

"If there is a ZIC, it's because the UFA create roads… It's the same for poachers; they follow the roads to poach…It's in these UFA's and ZIC's that there are always poachers" (#10 Authorities)

"Roads are a problem…we do what we can after exploiting the area, close off the roads, break bridges, but still they manage to get through…" (Anon, TCW, UFA 10-01, 2,3,4)"

Additionally, interviewees made a distinction between well used and quiet roads, indicating that elephant behaviour may be influenced by road use levels;

"Roads aren't a problem here for elephants. The only traffic here is from timber workers here and the safari, it's not a lot at all" (Anon, TCW UFA 10-007)

Finally, civil unrest in neighbouring countries of The Congo and the Central African Republic (CAR) were highlighted as additional key causes of the elevated risk of poaching in group C by both authorities and TCW's;

"When I was working over East, there were a lot of Congolese coming over the border to poach …We are surrounded by instable countries …our neighbouring countries sell these weapons AK47's, to Cameroonians…" (#10, Authority)

Figure 4.8-1: Left: Home-made ammunition for killing elephants. Middle: Elephant tusk seized near Yokodouma. Right: Motorbike, ammunition and elephant tusks seized. Photo credits Madeleine Ngo Bata, Stephane Brittain, Madeleine Ngo Bata

5 DISCUSSION

5.1 Summary of key findings;

- p(C+YW+G+Y) Ψ (V+Ri+Ro+E+G) is the best model for occupancy and detectability.
- Detectability has decreased over 6 years, consistent with declining perceived abundance in occupied sites.
- Overall, there is a positive relationship between perceived population decline and perceived abundance. The higher the perceived abundance, the greater the perceived decline.
- There is a positive relationship between the perceived threat of ivory poaching and perceived population decline, predominantly in Group C.
- Attitudes towards elephants are negatively influenced by HEC and positively influenced by an understanding of their role in the forest. People are more aware of their financial than their intrinsic worth.
- Qualitative data has provided in-depth information on the effect of conflict, corruption, capacity and international markets on poaching and population decline across the region.

This study has used interview-based occupancy analysis to provide a rapid assessment of the occupancy, distribution and threats to the forest elephant across the eastern region of Cameroon. Detection/non-detection data was collected and models were used with the intent of providing further insights into what determines the occupancy and distribution of forest elephants. Additionally, socio-demographic data was collected with the aim of setting the occupancy data in a context that would be both relevant and useful for guiding further conservation action.

Key findings and limitations of the results which respond to research questions 1a to 4a will be discussed in the context of the wider literature. A critical discussion of the findings allow for the reliability and suitability of this method to be assessed (RQ 5), before making recommendations for conservation action and future work.

5.2 To determine the distribution, occupancy and status of forest elephants in the eastern region of Cameroon

Whilst detectability covariates regard the ability of the respondent to notice and recall signs of elephant, Group and Year can be used as an index of abundance in occupied sites. In theory, occupancy could remain constant while abundance within occupied sites (and UFA group) and through years changes, meaning that scarcer populations are less likely to be detected (MacKenzie et al 2002). In this study, detectability is a reliable surrogate for abundance. All sites share the same forest environment; therefore any variance in the ability to detect the species cannot be explained by a change in habitat type and visibility.   The competence of the individual to detect signs are controlled for in the model, therefore, variation in the detectability of forest elephants is correlated with variation in abundance across sites, rather than variation in an ability to detect signs of elephant.   Additionally, patterns of detectability are consistent with perceived abundance across the region (See table 4 3-7). The results provide interesting spatial data on the relative abundance of UFA groups, and temporal data on the change in detectability over 6 years.

Although the goodness of fit test (section 4 3-5) shows that the best fit model adequately accounts for occupancy in the region, it should be noted that this model is the most parsimonious model and therefore a simplification of reality. For example, although the model results support that detectability increases with distance from road (Blake et al , 2008; Stokes et al , 2010), the qualitative data suggests a more complex, less linear relationship. Qualitative data suggests that elephant signs are frequently detected near privately owned logging roads.   These findings may support Blake et al (2008) that elephants adopt different behaviours to deal with roads. Another possibility is that some roads may be distributed along more easily accessible paths that elephants like to use, and therefore signs of elephant would be present there.

Although the covariate “slope” did not provide any contribution to the models, respondents reported on a number of occasions that elephants avoided hilly areas in group C. There is a possibility that, rather than an actual lack of effect, the resolution of use with respect to slope may be considerably finer than that at which sites defined.

Estimates produced by the fixed model for occupancy and detectability are Ψ =0 76 p=0 585 (table 4 3-1). Although data in this region is limited (CITES 2013b), the findings are comparable with those of Martinez et al (2011) (Ψ =0 44, p=0 86) in neighbouring Equatorial Guinea. However, whilst occupancy (Ψ) is higher in this study than in Martinez (2011), detectability (p) is lower. One potential explanation for this is that elephants use a greater proportion of sites in this study site, compared to that of Martinez et al (2011), though the smaller detectability estimate points to a smaller abundance of forest elephants within sites used.   The model also showed that detectability has decreased over 6 years, consistent with declining perceived abundance in occupied sites and further supported by qualitative reports of a declining abundance across the region.

A well-used main road separates groups A and D from groups B and C and the current main estimated range, although there are fragments of known range within Mbam & Djerem NP in the north too (see appendix 16). Reports from authorities and TCW's suggest that populations within groups A and D are much more isolated than those present within groups B and C, reporting that elephants migrate around within the UFA's to distance themselves from the noise of exploitation (Bowles et al, 1994; Richardson et al, 1995) and villages (Buji *et al* 2007; De Boer *et al* 2013) but cannot move out of those confined areas. It is also interesting that the only sites of predicted occupancy in group D are adjacent to Mbam & Djerem NP Deng Deng NP (figure 4 4-2). This suggests that elephant populations living in Mbam & Djerem NP may be using the north of the Timber concession (TC) as a corridor perhaps for access to the other NP. The same pattern of elevated likelihood of use in sites can also be seen adjacent to Boumba Bek NP in group B. This adds weight to the findings of Lamb et al (2005) that land adjacent to NP's is valuable for conservation and that it would be of interest to conduct further studies within these sites.

The higher likelihood of occupancy in groups B and C may be owed in part to the lower proportion of sites that are adjacent to villages and in group B, adjacent to roads (see appendix 15). Additionally, sites in the south of group C are of low elevation (appendix 15), favourable to elephant populations (Sukumar, 2003). The patterns of occupancy throughout UFA groups B and C supports that well-managed concession areas can provide refuge to forest elephants in an otherwise insecure landscape (Kolowski, 2010; Clark et al, 2009; Weinbaum et al, 2007; Stokes et al, 2010) and that sites adjacent to NP's in group B, C and D may be good priorities for conservation action (Lamb et al, 2005). However, the emphasis on 'well-managed' means that additional support should be provided to UFA's with a high likelihood of occupancy to improve their sustainability practices and ensure that they can continue to operate in a manner that has a minimal impact on the remaining elephant populations. This is important as despite the high levels of occupancy in some sites, the detectability and therefore relative abundance in comparison to other literature (Martinez 2011) is low.

All UFA groups had relatively consistent occupancy and detectability estimates, except group C that has lower occupancy and higher detectability estimates (table 4 3-1). If this result is interpreted to mean that the area of sites occupied is small, but the abundance (detectability) is high, this could be an indication of compression of the population (Barnes et al 1997; Blake et al

2008). High perceived abundance combined with the reported HEC in the region support this conclusion (Hoare, 2000; Blanc 2007). Furthermore, reports of an influx of elephants that are escaping the threat of poaching from instable neighbouring countries coincide with the increased incidence of HEC in the area, suggesting that conflict in neighbouring countries may also be a factor in the high detectability and HEC. Unfortunately, it is also reported that elephant populations, despite the potential influx from neighbouring countries, are still decreasing, possibly due to poaching.

Very little research has been conducted in the areas outside of PA's in Cameroon (Blake et al, 2008). This research in previously unsurveyed production forest shows that elephant range extends further than the current estimate given in AESR (2007), supporting the results of the initial range estimate provided in the AESR (2003). However, it is worrying that areas with the highest likelihood of occupancy may also be at high risk from fragmentation and ivory poaching.

5.3 Gain a deeper understanding of the threats to elephants

The high perception of threat from ivory poaching in areas of high elephant occupancy and relative abundance supports Blanc et al (2007) that poaching is rife in the region, contradicting the findings of Yackulic et al (2011) who found that hunter access was negatively correlated with elephant density. Qualitative and quantitative data supports that the population declines in UFA group B and C may be in part due to their vulnerable position next to Congo and the CAR, with high levels of reported poaching and an influx of poachers from across the borders.

In this study, a high likelihood of elephant occupancy attracts a higher level of threat from poaching and correlates with a decline in elephant population. Equally, sites of low abundance such as within group A and D are linked to areas of comparatively low perception of threat from poaching and a more stable population. Qualitative findings (section 4.8) confirm that conflict, corruption and lack of capacity are big barriers to effective conservation, and allow the poaching of ivory to continue (Blake et al 2007; CITES, 2008; CITES, 2013a). The findings supports that the financial incentives for poaching are great (section 4.8) and the increasing value of ivory due to the influence of the international markets makes finding alternatives increasingly difficult. The demand for ivory and the involvement of the international market in Cameroon was a strong theme throughout the qualitative data collected.

Although the results suggest that timber exploitation does not negatively impact elephants directly (Clark et al 2009), the potential for respondent bias (Mewing, 2011) should be considered as TCW's may have been wary of providing opinions that incriminate their job in the decline of a protected species. In order to fully investigate the effects of timber exploitation on elephant occupancy, research in sites at different stages of exploitation would be required, following Clark et al (2009).

5.4 Increase understanding on people's perceptions towards elephants

Despite education regarding endangered species throughout the UFA's visited, HEC was found to have a negative impact on the attitudes towards elephants and conservation itself. Additionally, the lack of institutional support for those who loose crops to HEC has implications for the success of anti-poaching drives and education supporting Hoare, (2000) and Blanc (2007). Furthermore, although TCW's were aware that poaching was illegal and are not implicated in poaching of elephants themselves, their attitudes towards elephants ranges from ambivalent to believing that the main worth of an elephant is for financial gain. This highlights that changing attitudes and behaviour requires a more nuanced approach to people motivations and incentives than simple awareness raising and education.

5.5 Assess the reliability and suitability of this method of rapid assessment in the context of forest elephants in Africa

In order to assess the reliability and suitability of this method of rapid assessment, the results drawn from this method need to be evaluated. The occupancy analysis method applied in this study makes certain assumptions that, if not met, can cause bias and thus incorrect inferences. The first assumption relates to the correct identification of the species. It is believed that false positives were very unlikely in this study since the forest elephant is the only elephant species within that range and it and its sign is easy to identify.

The second assumption is the closure of sites to changes in occupancy. In this study, interview data recorded species detections over 1 year, during which considerable random fluxes in the occupancy of a site may have occurred (Martinez et al 2011). The alternative interpretation of occupancy from ''proportion of area occupied'' to ''proportion of area used'' (MacKenzie & Nichols, 2004; Zeller et al , 2011), ensures this assumption is not violated. The third and fourth assumptions relate to heterogeneity in occupancy and detectability. One of the research questions of this study referred to identifying factors that influence the occupancy and detectability of the forest elephant. It is believed that the model presented identified some of the main factors that contribute to the variation in both values.

This paper provides additional evidence that interview based occupancy analysisis a reliable and suitable method for a rapid assessment of forest elephant occupancy across a large scale, forest habitat, as a compliment or first stage in a monitoring process (Meijaard et al 2013). This method has allowed for the whole region to be surveyed within 10 weeks and for qualitative data to be collected in addition to the detection/non-detection data. This additional data provides a socio-demographic context that is often disregarded in surveys, making resources easier to allocate in the subsequent stages of a conservation plan. Conservationists should consider this method for surveying large, remote areas, where little is known of the species to provide information on the relative abundance of easily recognisable species and threats to their survival, as a compliment to other techniques (Meijaard et al 2011).

5.6 Reliability & Limitations

This rapid assessment has provided useful information; however, there are limitations to this study and method which should be considered for future work;

5.6.1 Survey effort

The lack of repeat surveys, made multi-season analysis impossible. Sampling was limited to sites where TCW's are currently prospecting or exploiting, meaning that:

a) The sites changed each year as each site represented an area of annual exploitation

b) The impacts of exploitation could not be explored as a variation in forest type (pre/during/post exploitation) was not available

Furthermore, annual cut moved from one AAC to an adjacent AAC, causing clustering of sites within UFAs. Ideally, data would be gathered from all the AACs within the UFA. Failing that, random sampling of AAC's throughout the UFA would improve the sample strategy. The uneven survey effort means that certain UFA's were underrepresented in the model (see figure 4 2-1); therefore results within those sites had to be treated with caution. This was beyond the control of the research team, as they were not permitted access to all UFA's. An underlying issue with this is that some companies with a lesser interest in conservation or the prevention of poaching may be less likely to be involved in this study, therefore UFA's with potentially lower elephant occupancy may be omitted from the study.

5.6.2 Interview reliability

Measures were taken to ensure the reliability of the respondents and reduce bias (see section 3 5 2-1). However, the use of randomised response techniques (as recommended by Meijaard et al

2011), although not used in this study due to time constraints, may have been useful in further reducing social bias and should be considered for future studies, time permitting.

The interviewing of LV and hunters (following Meijaard et al 2011) had to be removed from the methodology due to time constraints. The inclusion of LV/hunters would be interesting for future studies with less time constraints, where trust and relations could be built with potential key informants. This could prove valuable in providing data for parts of the UFA that are not being prospected by the TC at the time, helping to cover a more even proportion of the UFA and begin to provide data on the effect of timber exploitation on forest elephants. Additionally, it was mentioned throughout that signs of elephant are found close to rivers, however TC's do not operate in this type of marshy land that forest elephants like to use. Information from LV would help in the triangulation of the data provided by different sources, provide an alternative perspective on the issues surrounding poaching and help to fill gaps in the landscape not covered by the authorities and TCW's.

5.6.3 Occupancy and home range

Using occupancy as a proxy in population status assessments has recently been called into question as variations in occupancy may reflect variations in space use or plot size as opposed to true changes in abundance (Efford & Dawson 2012). Although it can be argued that this is less of an issue as plot size increases beyond home range size and that, for the most part, occupancy estimates correlate well with abundance, it is important to note that given the sample unit size relative to elephant home range in this study, occupancy cannot be used as estimator of abundance in this study.

However in this study, occupancy is interpreted as the proportion of area used (Martinez, 2011; MacKenzie & Royle, 2005) and is not used as an indicator of absolute abundance. Rather, change in detectability is used as an indicator of relative abundance. Additionally, the benefits of the sample size at this scale are that interesting fine scale changes in predicted occupancy and detectability in relation to the covariates and other factors can be investigated.

5.6.4 Heterogeneity

In the most part, occupancy estimations fall in line with the observed detection histories and with perceived abundance. However, there are areas where the occupancy predictions are out of kilter with actual observations. Areas of underrepresentation within the detection/non-detection data may be an influencing factor. Alternatively, heterogeneity caused by the differences in overlap between home range and site influences the probability of detecting an individual, as does the number of individuals within each plot. As a result, the sampling strategy and how it relates to the actual elephant home ranges may account for some variation between the naïve estimate and the predicted occupancy (Efford & Dawson, 2012).

The UFA grouping structure is a rather crude way of gathering together although it allowed for four distinct groups of UFA's to be discussed and compared in terms of occupancy and detectability within the time available for this study. Additionally, other important proxies such as the distance to border may influence poaching pressure and therefore occupancy and detectability of elephants. As such, omitted variables should be considered in future research to further understand the influence that poaching has on elephant occupancy.

5.7 Recommendations for future action

Monitoring is an essential part of conservation programmes, however it is often costly and hard to sustain, especially in developing countries where resources are more limited (Danielsen et al, 2005). Although requiring resources for the analysis of data, this interview based occupancy-analysis approach allows for rapid, inexpensive data collection, easy to implement and suitable for projects with low budgets. The findings of this project have allowed for the research objectives and questions to be answered, and recommendations for conservation action and future work to be made, including:

- The current known elephant range (IUCN, 2007) needs to be expanded to incorporate the ground covered in this study, namely groups B and C
- Regular rapid assessments across the newly defined range would be of use to identify any trends in HEC, population change and threats
- Targeted population surveys should be conducted in sites identified as having high abundance (groups B and C), in order to confirm the findings of the rapid assessment and build a database of the abundance Urgent attention should be given to sites in groups B and C, close or adjacent to international borders
- Additional work should be conducted in the region to support timber companies in becoming more sustainable and manage their practices in a manner than takes elephants into consideration. Occupied sites adjacent to NP's could be targeted first as they may prove to be of high conservation value
- The WWP in Cameroon is already working with UFA's in groups A and B. Immediate action is required in the higher risk sites within group C, in light of the potential for

compression, HEC and poaching

- Corruption and a lack of resources are recognised as a key barrier to the protection of elephants in Cameroon. More resources need to be allocated to authorities in the eastern region for them to do their jobs effectively. At the same time, a transparent system of reporting and monitoring needs to be implemented to help reduce corruption (see LAGA, 2013)

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6 APPENDICES

6.1 Appendix 1: Full list of interviews collected during fieldwork

Respondent group	Comments	Number
Head of service for the Department of Fauna and Protected Areas	Délégation régionale de l'Est	1
Head of the Department of Fauna	Délégation départementale du Haut-Nyong	1
	Délégation départementale de la Boumba et Ngoko	1
	Délégation départementale de la Kadey	1
	Délégation départementale du Lom et Djerem	1
Chef d'antenne	Antenne de Lomié du Service la Conservation du Dja	1
Head of Monitoring and Evaluation of Management	SFIL	1
Manager	SFIL	1
Systematic Inventories Team	Sous-traitant (Ets ALCO) pour les inventaires à SIM	6
Monitoring and Evaluation Team	PALLISCO	3
Identification and Marketing Team	PALLISCO RP2	5
	PALLISCO RP1 (Makalaya)	8
Chef de Poste	Mbang	1
	Kika (Adjoint)	1
	Salapoumbe	1
	Ngatto (ecogardes)	2
	Koumela base à Libongo	1
	Mindourou	1
	Lomié	1
	Messok	1
	Zoulabot	1
Site Manager	SFID	1
	Panagiotis Marielis	1
Team Fauna	SFID (pisteurs)	2
	SFID (Responsable équipe faune)	1
	PALLISCO (pisteurs)	3
Prospection Teams	SFID	20
	ALPICAM/GRUMCAM (kika)	13
	SEBC/Groupe VICWOOD	12
	CFC/Groupe VICWOOD	18
	ALPICAM/GRUMCAM(Mindourou)	20
	SFIL	7
	PALLISCO	8
	SEFAC	18
	Panagiotis Marielis	6
Villages	Medjeuh	12
	Abiere	9
Opportunistic interviews	Un monsieur qui fait des inventaires dans la 10 028 à Messok	1
	Propiétaire de ZICGC (Pepe) à Kika	1

	Un braconnier à Dimon	1
Researchers	2 botonists at Yaoundé	2
	TOTAL	**196**

6.2 Appendix 2: Example interview structure for interviews with TCW's

Basic information

Age: 16-26 ☐ 27-37☐ 38-48 ☐ 49-59☐ 60+ ☐

Gender: Male☐ Female☐

Where were you born? Urban ☐ rural ☐
Team :

Job position:

What tasks does that involve? (Chainsaw operator/truck driver etc.)

Detectability

How long have you worked here? < 1year ☐ 1-5 years ☐ 6-10 years ☐ >11 years ☐

How many trips do you make into the forest?

4 trips/week☐ 2-4 trips a week☐ 1-2 trips a week☐ 1-2 trips a month☐

1-2 trips a year☐ 0 trips☐

Do you camp in the forest? Yes ☐ No ☐

How many nights do you spend in the forest when working?

0 ☐ 1-7 ☐ 8-14 ☐ 15+ ☐

Are you attentive to animal signs when you see them? Always ☐ Sometimes☐ Rarely ☐

Occupancy

Have you ever seen an elephant or sign of an elephant? Yes ☐ No ☐

What sign(s) did you see? Describe it to me.

Foot prints ☐ dung ☐ actual sighting ☐ heard one ☐

carcass ☐ reports from others☐ other (please state)

In what AAC did you see it in?

What year was this in?

What time of year did you see this (Wet/Dry season)

Was the AAC; active ☐ being prepared ☐ post evaluation ☐

Abundance and distribution

Do you think that there are zero ☐ a few ☐ or lots ☐ of elephants in the AAC's in which you worked this year?

Do you think that there are zero ☐ a few ☐ or lots ☐ of elephants in the AAC's in which you have ever worked?

In the last 3 years, do you think that the number of elephants has;

increased ☐ decreased ☐ stayed the same☐

Threats

I'm going to name some potential factors that could lead to a change in Elephant. Please state if you think that the factor has an influence on elephant population;

factors	**Yes**	**Neutral**	**No**	**Don't know**	**Additional comments**
Roads					
Hunting for bush meat					
Hunting for Ivory					
Exploitation					
Other?					

In your opinion; is there any human elephant conflict in this area? Yes ☐ No ☐

- If yes; what are the conflicts?

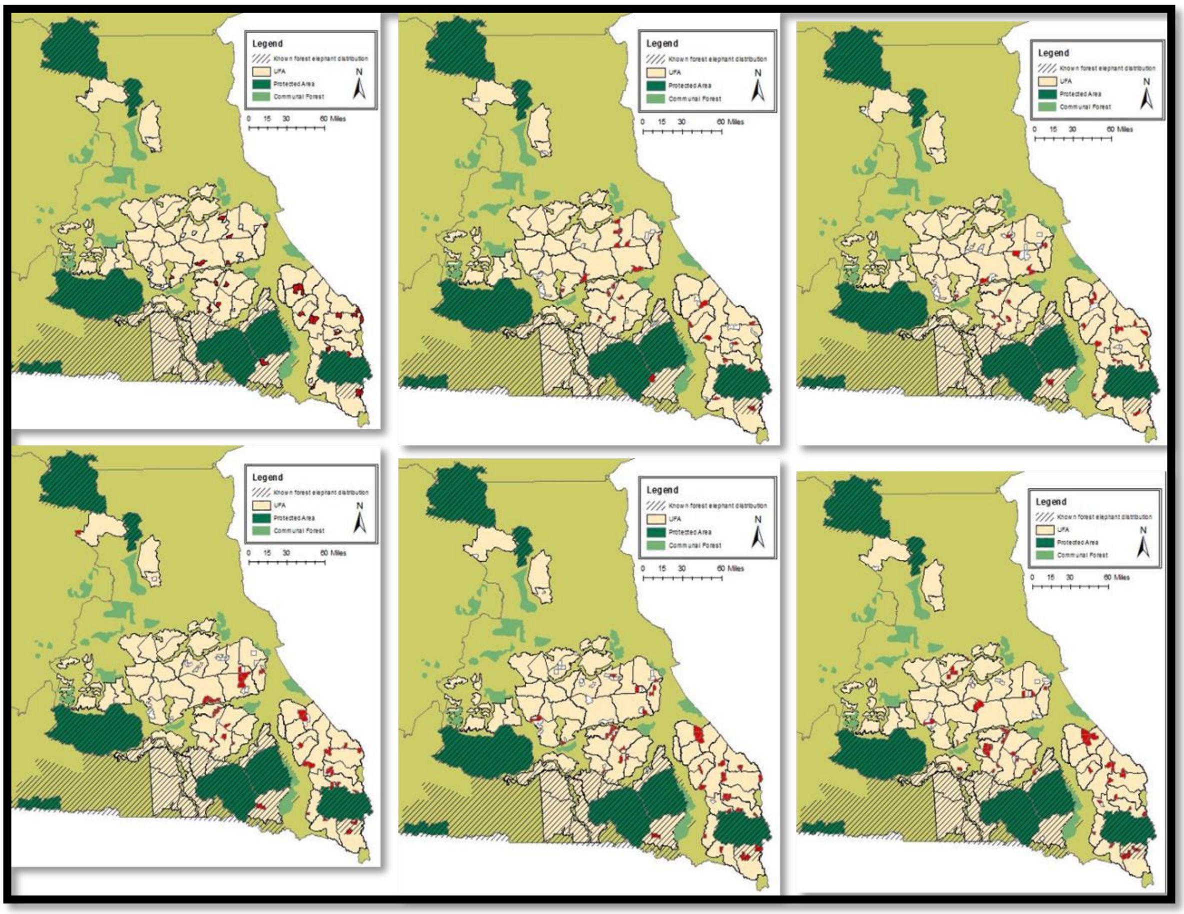
Have you ever seen signs of elephant poaching in the AAC's whilst working here?

6.3 Appendix 3: Table of survey effort per site and per year

Survey effort per year and UFA							
UFA numbers	**2013**	**2012**	**2011**	**2010**	**2009**	**2008**	**TOTAL PER UFA**
10-001	20	20	14	5	4	4	**67**
10-005	1	0	0	1	2	2	**6**
10-007	10	10	10	7	6	7	**50**
10-008	15	18	11	8	7	5	**64**
10-009	18	18	5	6	8	6	**61**
10-010	7	13	10	14	7	5	**56**
10-011	10	10	10	1	6	6	**43**
10-012	8	17	11	8	7	5	**56**
10-013	13	13	11	9	7	7	**60**
10-015	10	10	10	7	6	6	**49**
10-018	1	1	1	1	1	1	**6**
10-020	2	2	2	1	1	1	**9**
10-021	1	6	6	4	5	2	**24**
10-022	2	2	2	1	1	1	**9**
10-023	1	0	0	0	0	0	**1**
10-025	1	6	6	3	3	2	**21**
10-026	19	18	19	12	4	4	**76**
10-028	1	0	0	0	0	0	**1**
10-029	4	2	2	3	1	2	**14**
10-031	26	18	14	5	5	3	**71**
10-038	27	20	26	20	14	15	**122**
10-039	12	16	16	5	6	4	**59**
10-040	0	0	0	0	0	1	**1**
10-041	19	14	8	5	6	4	**56**
10-047	2	1	0	0	0	0	**3**
10-051	11	17	16	12	5	3	**64**
10-052	7	7	7	5	4	2	**32**
10-053	3	17	16	13	6	3	**58**
10-054	25	27	25	21	17	16	**131**

10-056	28	27	23	19	15	15	**127**
10-061	1	0	0	0	1	0	**2**
10-062	5	0	0	0	0	0	**5**
10-063	13	13	11	9	7	7	**60**
10-064	17	17	11	8	7	5	**65**
TOTAL PER YEAR	**340**	**360**	**303**	**213**	**169**	**143**	

6.4 Appendix 4: Naïve detection/non-detection maps for years 2008-2013



6.5 Appendix 5: Analysis of detectability variable relationships using spearman's correlation coefficient

	Age	Years	Camp	Trip
Age	NA	0 00247	0 1803	0 9759
Years	NA	NA	0 3559	0 909
Camp	NA	NA	NA	2 368e-16
Trip	NA	NA	NA	NA

6.6 Appendix 5b: Analysis of occupancy variable relationships using Pearson's correlation coefficient (for parametric data)

	D_Towns	**D_Road**	**Elevation**	**Slope**	**D_Villages**	**D_River**
D_Towns	1 00000000	-0 01645785	-0 41092075	-0 04139501	0 3473485	-0 13796216
D_Road	-0 01645785	1 00000000	0 08348724	0 16099319	-0 1161738	0 10285239
Elevation	-0 41092075	0 08348724	1 00000000	0 15301984	-0 2881728	0 17528427
Slope	-0 04139501	0 16099319	0 15301984	1 00000000	0 1321780	0 07367539
D_Vilages	0 34734853	-0 11617376	-0 28817276	0 13217795	1 0000000	-0 16007298
D_River	-0 13796216	-0 04189356	0 17528427	0 07367539	-0 1600730	1 00000000

6.7 Appendix 6: Modelling framework 1: Best fitting detectability model with all occupancy covariate combinations

environmental occupancy covariates							
Model ID	**D_T**	**D_V**	**D_Ri**	**D_Ro**	**Elev**	**Sl**	**AIC VALUE**
12	0	0	0	0	0	0	**1514 66**
13	1	0	0	0	0	0	1363 4
14	0	1	0	0	0	0	1364 319
15	1	1	0	0	0	0	1361 292
16	0	0	1	0	0	0	1363 13
17	1	0	1	0	0	0	1358 282
18	0	1	1	0	0	0	1359 327
19	1	1	1	0	0	0	1357 001
20	0	0	0	1	0	0	1364 198
21	1	0	0	1	0	0	1357 936
22	0	1	0	1	0	0	1356 042
23	1	1	0	1	0	0	1354 936
24	0	0	1	1	0	0	1358 604
25	1	0	1	1	0	0	1354 108
26	0	1	1	1	0	0	1351 985
27	1	1	1	1	0	0	1351 575
28	0	0	0	0	1	0	1365 297
29	1	0	0	0	1	0	1362 012
30	0	1	0	0	1	0	1360 925
31	1	1	0	0	1	0	1360 062
32	0	0	1	0	1	0	1359 992
33	1	0	1	0	1	0	1357 849
34	0	1	1	0	1	0	1357
35	1	1	1	0	1	0	1356 568
36	0	0	0	1	1	0	1359 159
37	1	0	0	1	1	0	1356 937
38	0	1	0	1	1	0	1353 292
39	1	1	0	1	1	0	1354 021
40	0	0	1	1	1	0	1355 116
41	1	0	1	1	1	0	1353 918
42	0	1	1	1	1	0	1350 235
43	1	1	1	1	1	0	1351 362
44	0	0	0	0	0	1	1371 783
45	1	0	0	0	0	1	1365 239
46	0	1	0	0	0	1	1365 405
47	1	1	0	0	0	1	1362 825

48	0	0	1	0	0	1	1364 893
49	1	0	1	0	0	1	1360 162
50	0	1	1	0	0	1	1360 676
51	1	1	1	0	0	1	1358 678
52	0	0	0	1	0	1	1364 956
53	1	0	0	1	0	1	1357 818
54	0	1	0	1	0	1	1353 521
55	1	1	0	1	0	1	1352 884
56	0	0	1	1	0	1	1359 51
57	1	0	1	1	0	1	1354 478
58	0	1	1	1	0	1	1350 294
59	1	1	1	1	0	1	1350 343
60	0	0	0	0	1	1	1367 293
61	1	0	0	0	1	1	1364 006
62	0	1	0	0	1	1	1362 739
63	1	1	0	0	1	1	1361 932
64	0	0	1	0	1	1	1361 989
65	1	0	1	0	1	1	1359 846
66	0	1	1	0	1	1	1358 881
67	1	1	1	0	1	1	1358 48
68	0	0	0	1	1	1	1360 766
69	1	0	0	1	1	1	1357 854
70	0	1	0	1	1	1	1352 711
71	1	1	0	1	1	1	1353 401
72	0	0	1	1	1	1	1356 805
73	1	0	1	1	1	1	1355 098
74	0	1	1	1	1	1	1350 159
75	1	1	1	1	1	1	1351 257

Camped	1
YW	1
UFA Group	1
Year	1

6.8 Appendix 7: Modelling framework 2: Detectability and occupancy best fit shortlist

	environmental occupancy covariates						conservation-related occupancy covariates		
Model ID	**D_T**	**D_V**	**D_Ri**	**D_Ro**	**Elev**	**Sl**	**Group**	**year**	AIC
75	0	1	1	1	1	1	0	0	1350 16
76	0	1	1	1	1	1	1	1	1354 66
77	0	1	1	1	1	1	1	0	1349 57
78	0	1	1	1	1	1	0	1	1355 26
79	0	1	1	1	1	0	0	0	1350 24
80	0	1	1	1	1	0	1	1	1353 83
81	**0**	**1**	**1**	**1**	**1**	**0**	**1**	**0**	**1349 2**
82	0	1	1	1	1	0	0	1	1354 64
83	0	1	1	1	0	1	0	0	1350 29
84	0	1	1	1	0	1	1	1	1356 22
85	0	1	1	1	0	1	1	0	1351 14
86	0	1	1	1	0	1	0	1	1355 21
87	1	1	1	1	0	1	0	0	1350 34
88	1	1	1	1	0	1	1	1	1357 31
89	1	1	1	1	0	1	1	0	1357 28
90	1	1	1	1	0	1	0	1	1355 25

6.9 Appendix 8: Modelling framework 4: Back transformed parameter estimates for best fit covariate model

Estimate	SE	Intercept	V	R	Ri	E	Group B	Group C	Group D
0 5	0	0	0	0	0	0	0	0	0
0 922	0 0464	1	0	0	0	0	0	0	0
0 0778	0 0464	-1	0	0	0	0	0	0	0
0 689	0 0625	0	1	0	0	0	0	0	0

0 311	0 0625	0	-1	0	0	0	0	0	0
0 72	0 0857	0	0	1	0	0	0	0	0
0 28	0 0857	0	0	-1	0	0	0	0	0
0 382	0 0528	0	0	0	1	0	0	0	0
0 618	0 0528	0	0	0	-1	0	0	0	0
0 258	0 0891	0	0	0	0	1	0	0	0
0 742	0 0891	0	0	0	0	-1	0	0	0
0 676	0 158	0	0	0	0	0	1	0	0
0 324	0 158	0	0	0	0	0	-1	0	0
0 198	0 164	0	0	0	0	0	0	1	0
0 802	0 164	0	0	0	0	0	0	-1	0
0 0229	0 0457	0	0	0	0	0	0	0	1
0 977	0 0457	0	0	0	0	0	0	0	-1

6.10 Appendix 9: UFA level perception of threats: Group A

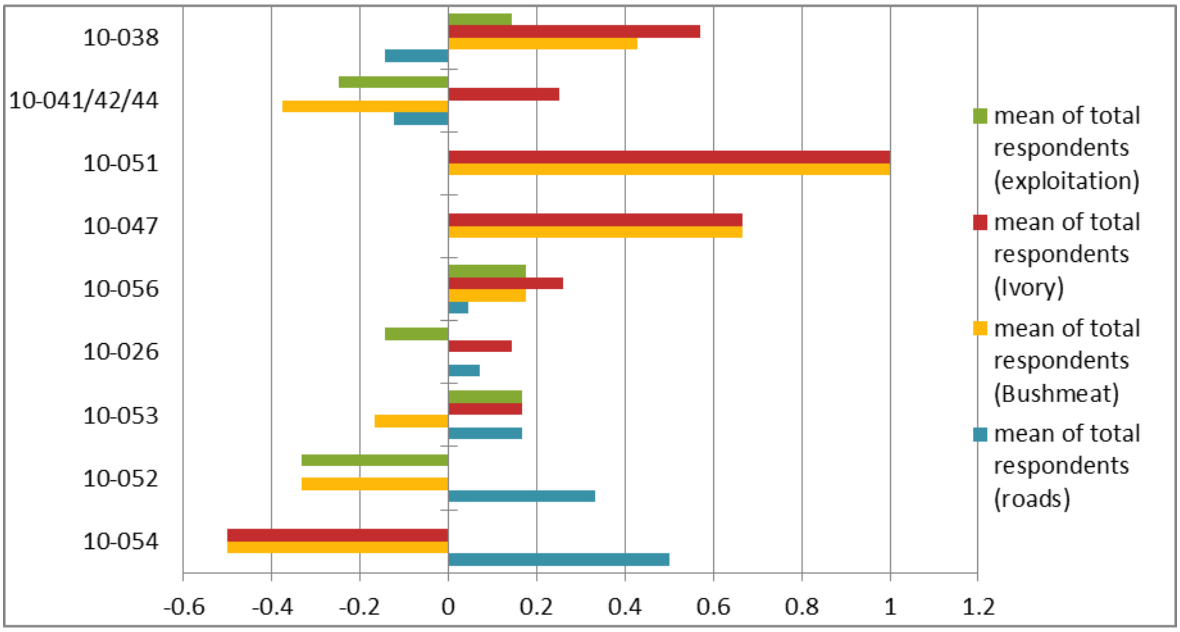


Figure : Group A mean perceived threats per UFA (where +1= agree 0=don't know -1=disagree)

Figure 6 10-1 shows the mean scores for threats in each UFA within group A 10-054 is the only UFA where ivory is not perceived as a threat 51 and 47 both have a high perceived risk of poaching for ivory Roads are perceived to be the biggest risk in 54, but in contrast are not a perceived threat in 38 and 41 Poaching for bush meat is perceived as a threat in UFA's 38, 51, 47 and 56 Overall, UFA 51 has the highest perceived risk of poaching for ivory and bushmeat.

6.11 Appendix 10: UFA level perception of threats: Group B

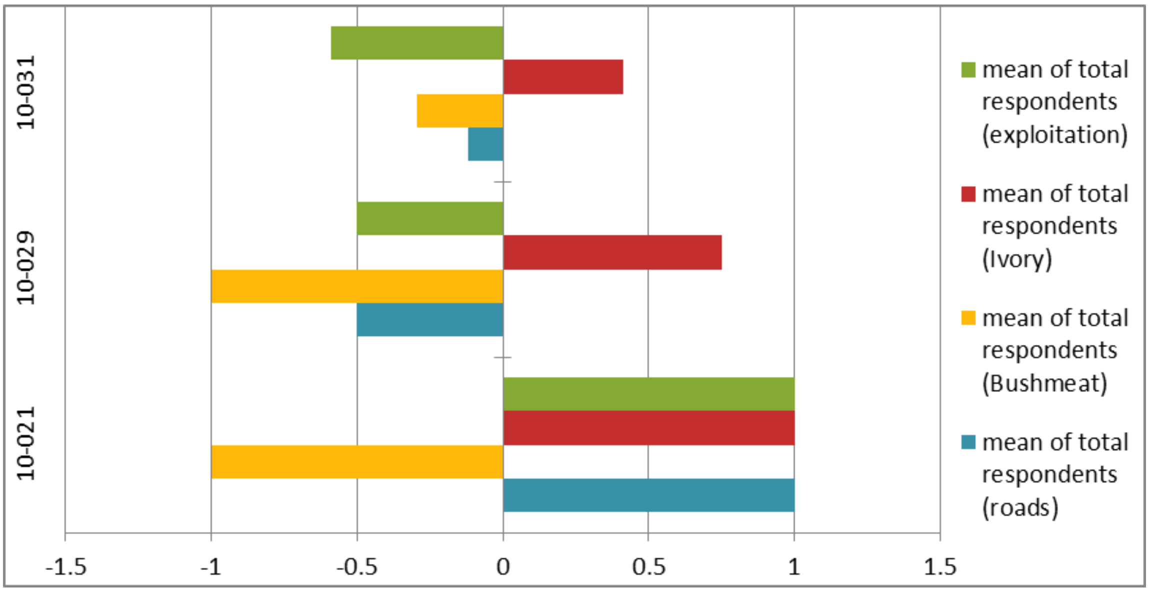


Figure 6.11-1:Group B mean perceived threats per UFA (where +1= agree 0=don't know -1=disagree)

Figure 6 11-1 shows the mean scores for threats in each UFA within group B   Bush meat is not perceived as a threat throughout group B   In contrast, poaching for ivory scored a consistently high score, suggesting that poaching for ivory is a perceived problem in the region, namely in UFA 21   Again, exploitation and roads gave mixed responses

6.12 Appendix 11: UFA level perception of threats: Group C

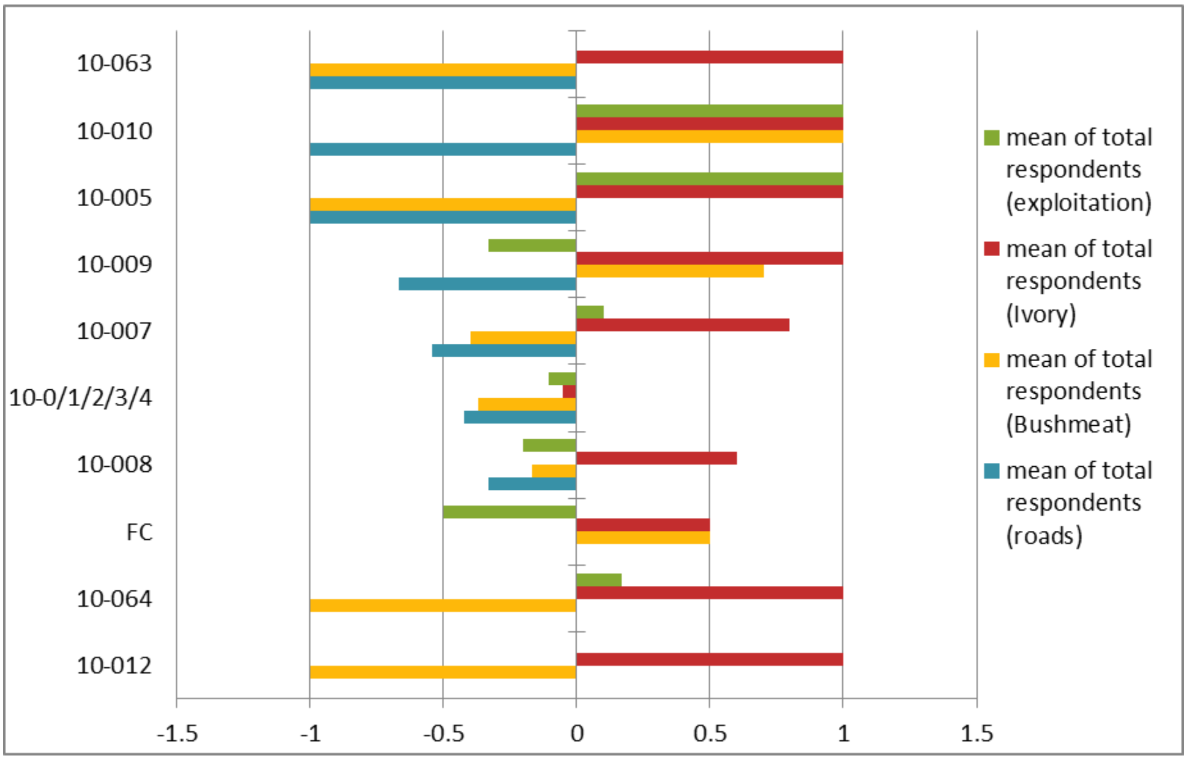


Figure 6.12-1: Group C mean perceived threats per UFA (where +1= agree 0=don’t know -1=disagree)

Figure 6 12-1 shows the mean scores for threats in each UFA within group C   There is a very high perceived threat of ivory poaching across all UFA’s in group C, with 6 of the 10 scoring a mean of +1 In contrast, poaching for bush meat was not perceived as a threat in UFA’s 12, 64, 5 and 63, whereas in UFA’s 10 and 9 there is a perceived threat from poaching for bush meat Of all the UFA groups, group C has the smallest perception of threat from roads, especially in UFA’s 5, 10 and 63 Additionally, the perceived threat from exploitation is the highest in group C than any other group, namely in UFA’s 10 and 5

6.13 Appendix 12: UFA level perception of threats: Group D

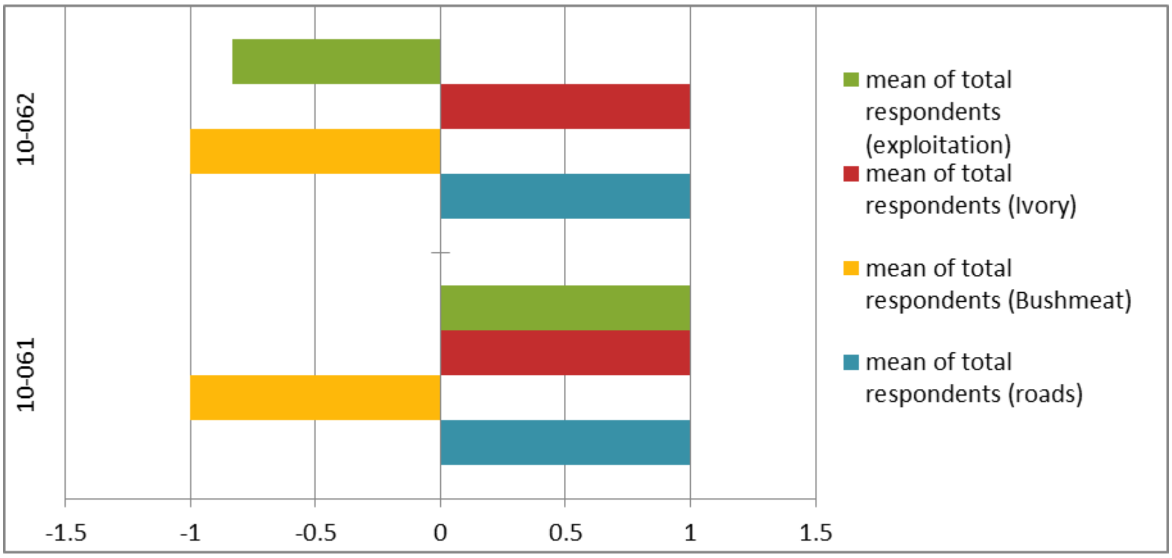


Figure 6.13-1: Group D mean perceived threats per UFA (where +1= agree 0=don't know -1=disagree)

Figure 6 13-1 shows the mean scores for threats in each UFA within group D Roads and poaching for ivory are highly perceived as threats in group D, whereas bush meat is not Again, exploitation provides mixed results

6.14 Appendix 13: UFA Level description of results: Perceived abundance

Of the group A UFA's in figure 11, only 10-040 and 10-025 have mean positive perceived abundance values All other UFA's have negative mean perceived abundance values, lying between 0 and -1 The negative perceived abundance is most pronounced in UFA's 56,51,64 and 47, whose mean perceived abundance lies at -1 (perceived "zero") Of group B, UFA 23 and 21 both have positive mean values of >1 In contrast, UFA 28 has the smallest mean perceived abundance at -1

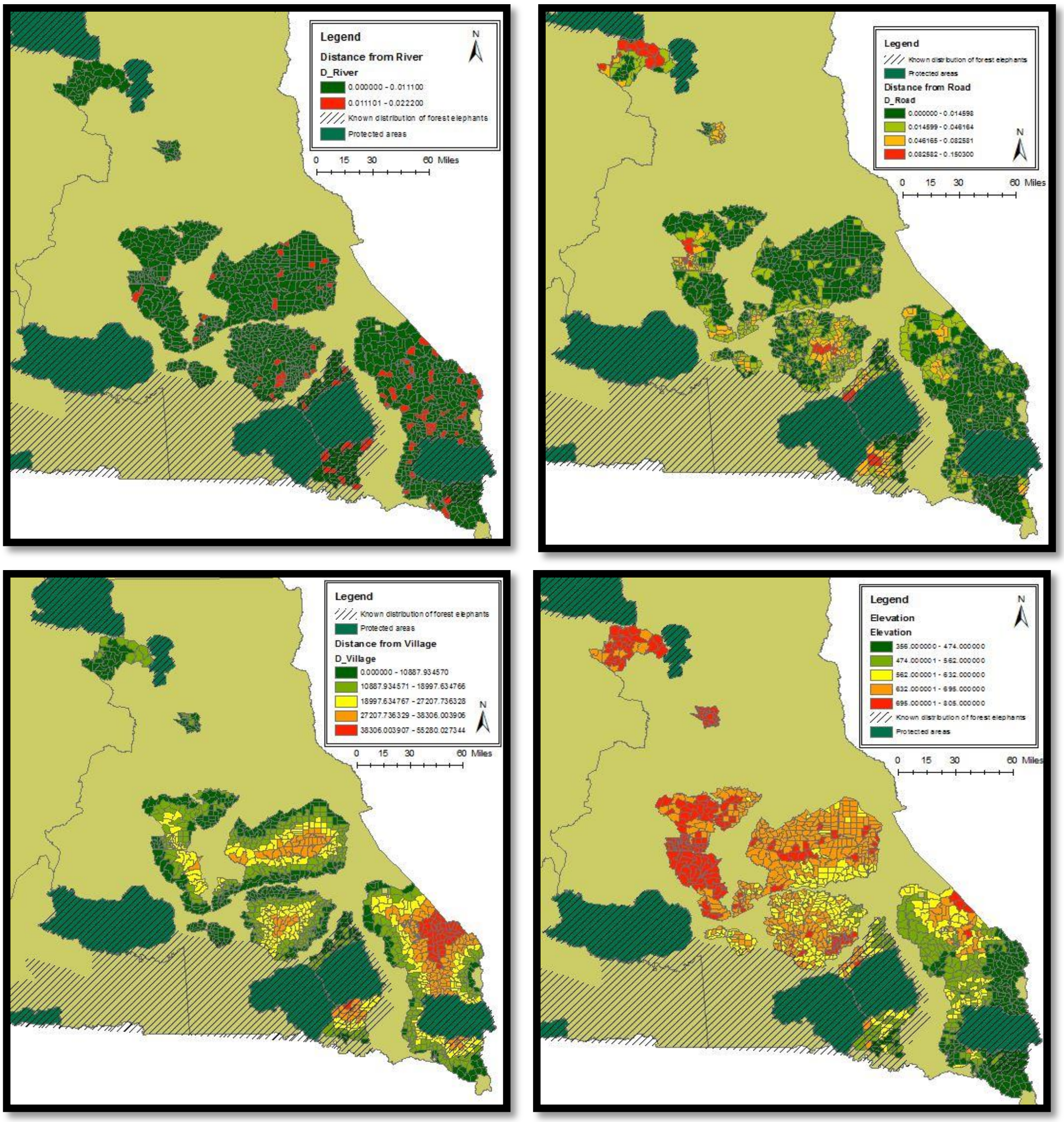
Group C has the highest perceived abundance of the UFA groups, with the mean of half the total UFA's laying between 0 5 and 2 This is consistent with the estimated detectability result from the best fit model None of the mean values reach -1 (perceived "zero"), whereas both UFA's within group D have a perceived mean abundance of close to -1

6.15 Appendix 14: UFA Level description of results: Population change

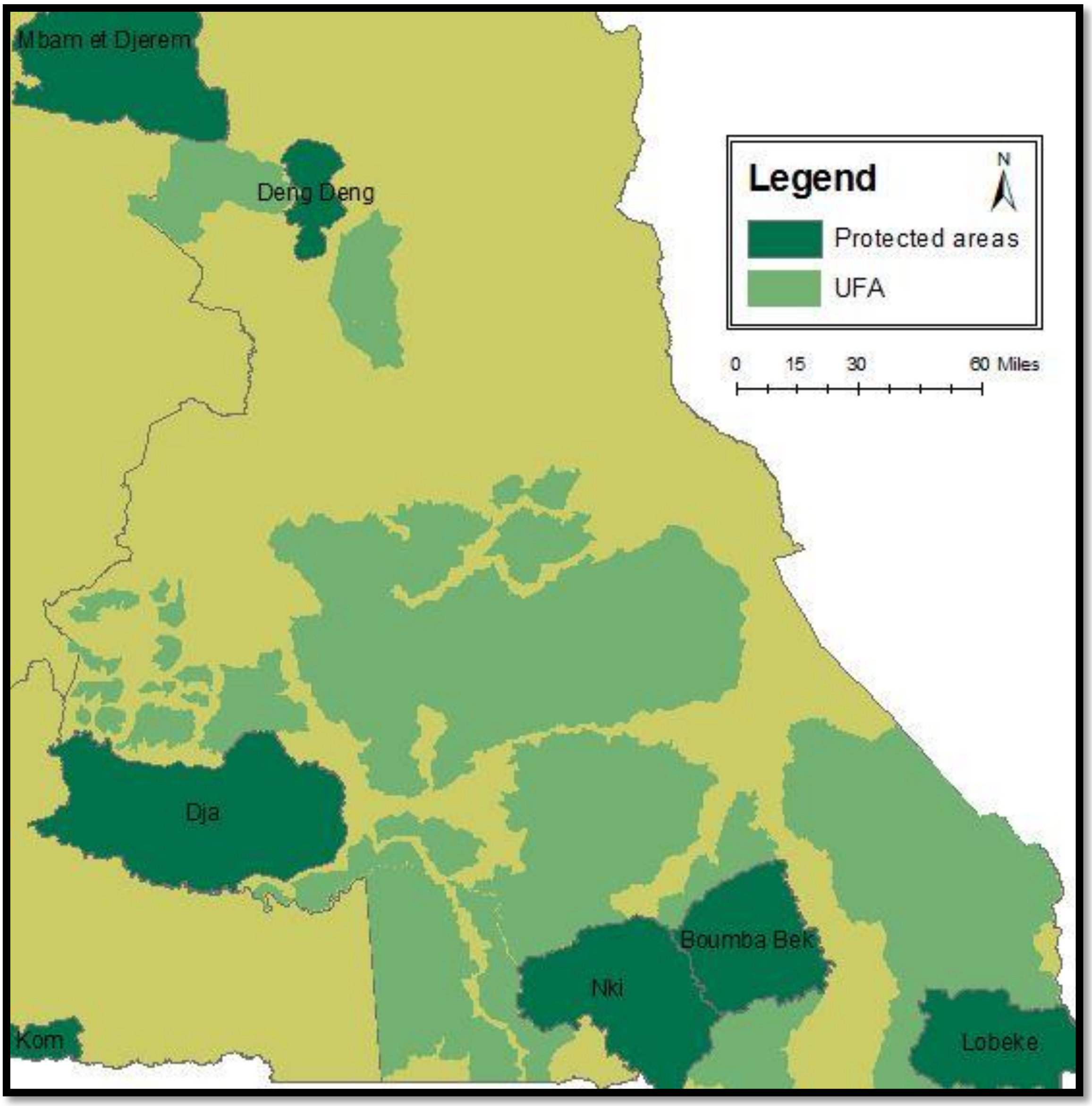
Of the group A UFA's in figure 12, the mean perceived population decrease is greatest in 10-040, and smallest in UFA 53 Of the 12 UFA's in this sample, 8 have a mean perceived population change close to '0', suggesting that the rate of population decline is not as marked there than in the remaining UFA's, where the perception of decline is greater   In UFA group B, the perceived population decline is more marked in UFA's 20-28, each with a mean of -1; the population of UFA 18 and 21 is perceived to be stable   Although none of the UFA's in group C received a full "-1" mean score, the overall perception of decline is greater than it is in group A Finally UFA 61 in group D is perceived to have a stable population and the mean score for UFA 62 is 0 5   Mean perceived population decline is greatest in group C

6.16 Appendix 15: Maps showing the elevation and distance of each site from perceived threats

Top left: Distance from River; Top right: Distance from Road; Bottom left; Distance from village; Bottom right: Elevation



6.17 Appendix 16: Maps displaying the names of all national parks in the eastern region



6.18 Appendix 17: Table of covariates and pooled responses post interview.

Covariate	Age	Years Worked	Nights Camped	Number of Trip	Source of signs knowledge
Before	(1)16-26, (2)27-37, (3)38-48, (4)49-59, (5)60+	(0)=1-5; (1)= 6-10; >(2)=11	(0)=0; (1)=1-7; (2)=8-14; (3)=15+	(1) +5/week (2) 3-4/week (3) 1-2/week (4) 1-2/month (5) 1-2/year (6) none	(0)=Job, (1)= safety, (2)=directions, (3)=upbringing
After	(1+2) young, (3) middle aged (4+5) old	(0+1)= <10 years (2)=>11 years	(0+1)=1 (2+3)=2	(1-3)= 1 (4-6)= 2	(0+1)=1 (2+3)=2