NOTTINGHAM TRENT UNIVERSITY

STATUS AND DETERMINANTS OF LARGE MAMMAL OCCUPANCY IN A NIGERIAN PROTECTED AREA.

OLUSEUN ADESOLA AKINSOROTAN

A thesis submitted in partial fulfilment of the requirements of Nottingham Trent University for the degree of Doctor of Philosophy

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Copyright statement

Declaration

I hereby, declare that this dissertation has not been submitted in part or in whole as paperwork for a degree at any other university. I hereby declare that this dissertation is entirely my own work and that all parts and thoughts which have been taken from other persons are marked and identified by reference.

Signature:………………………….

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Abstract

Global declines in large mammals are well recognised and threaten the well-being of ecological and human communities. Most African large mammals are endemic to Africa with many listed as either endangered and/or vulnerable by the International Union for Conservation of Nature (IUCN) due to declines across their range owed in part to anthropogenic activities. In view of the effect of anthropogenic threats on large mammal populations, research was conducted in the Old Oyo National Park (OONP), the third largest national park in Nigeria, with the aim to investigate the status of large mammals and to examine the types and the extent of the threats associated with the large mammal populations in the park.

In this thesis, the species composition and the first baseline estimates of large mammals within the OONP are provided to inform future management. A multidisciplinary approach that combines camera trapping, distance sampling line transects and questionnaire surveys of local villagers and Rangers (stakeholders) were applied to derive data on the status of large mammals in the park. The camera trap survey covers 199 stations deployed for 2,786 trap-nights. The distance sampling comprised 45 line transects totalling 306Km across the park. A total of 800 villagers neighbouring the park and 100 Rangers in the protection unit of the park was surveyed between January 2015 and August 2015. Important is the estimate of illegal activities provided for the first time in the park, emphasizing the need for effective conservation planning using the data from the camera trap and the villagers questionnaire (Randomized Response Techniques (RRT) and direct questioning) and identify the predictors of the highest occurring illegal activities in the park.

Twenty four out of 28 historical occurring large mammal species were detected using field based surveys (cameras and transects). Apart from the top predators, elephant buffalo and oribi, the evidence of other wild species occurrence was provided across the field based surveys and the perception of the stakeholders (Villagers and Rangers). There are similarities in the perception of Villagers and Rangers to mammal declines and the low occupancy estimates of large mammals derived from the camera trapping survey. Over 70% of the stakeholders (Villagers and Rangers) perceived that most species have declined in the park. Similarly, a single species occupancy model applied to camera trap data indicated a low probability of occurrence for most species. An estimate of site occupancy as low as ψ 0.18 for rodents such as grasscutter *(Thryonomys gregorianus)* while higher estimates ($\psi \geq 0.79$) were derived only for bush buck *(Tragelaphus scriptus)*, civet (*Civettictis civetta)*, giant rat (*Cricetomys*) and kob *(Kobus kob)*. However, the occupancy estimates for illegal activities are higher than any of the wild animal species. Results from the field based surveys and perception of the stakeholders supported the conclusion that many species have declined and six are extirpated from the park. The field studies recorded four new species never previously detected in the Park.

All methods detected evidence of illegal anthropogenic activities in the park, principally in the form of poaching and illegal grazing. The highest occurring activity identified was the illegal hunting of wild animals with an estimate of site occupancy of ψ 0.97, followed by the illegal grazing ($\psi = 0.68$). The density of illegal grazing (85.3 cattle/Km^2) was higher compared to any other wild species in the park

The drivers of illegal hunting activity (the highest occurring activity) of the villagers show that occupation was the key factor that could influence illegal hunting activities. The individuals who engaged in seasonal employment such as crop farming, mixed

farming and other types of occupation tended to engage in illegal hunting activity. Although, bushmeat consumption did not significantly predict illegal hunting activities, it was significantly associated with illegal hunting. Moreover, the bushmeat consumption is influenced by education and occupation. These two factors influenced consumption of bushmeat among the villagers, leading to a high level of illegal hunting and placing the large mammals in the park under threat.

This study provides the first empirical evidence of low occupancy of native large mammal species, high levels of illegal activity and low abilities to persecute and apprehend the offenders. The data serve as a baseline for the park authorities to monitor the species protected and the effectiveness of conservation efforts deployed. The findings imply that the threat of illegal hunting and domestic cattle grazing activities to large mammals should be highly considered when planning future conservation measures. This research has confirmed the ability of camera trapping methods to detect species of different traits and illegal activities, and the RRT to elucidate information on the rule breaking behaviour of local villagers which are important for the designing and implementation of management strategies.

Dedication

This thesis is dedicated to God Almighty, my help in ages past and my hope for years to come. He has been the source of my strength throughout this program and on His wings only have I soared. I also dedicate this work to my husband Dr. Ademola Micheal Akinsorotan and my Children, Comfort, Catherine, Caroline and Christiana (Babe) who have been affected in every way possible by this quest. I give my deepest expression of love and appreciation for the encouragement that you gave and sacrifices you made. God bless you.

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Acronyms

ER: Encounter Rate

IUCN: International Union for Conservation of Nature

NGO: Non Governmental Organization

OONP: Old Oyo National Park

RIA: Relative Index of Abundance

RRT: Randomized Response Technique

WPC: World Parks Congress

Chapter 1: Introduction

The global human population is increasing and was recently estimated to be 7 billion (Haub, Gribble and Jacobsen 2011, UNFPA 2011, Wang, *et al*. 2013), which in turn is placing tremendous strain on the planets natural resources. Predictions suggest the human population could achieve 10 billion individuals by the end of the 21st century with Africa's population expected to claim over one third of the world's population (UNFPA 2011, UNDESA 2015). Currently Africa has a population of 1.2 billion people reaching 4.1 billion by 2100 (WIWP 2017). The rapid population growth can lead to an undesirable condition (e.g biodiversity decline, economic hardship and extreme poverty) as the number of existing human population exceeds the carrying capacity of Earth. As the world's human population increases, there is an increased demand for space and resources resulting in increased transformation of natural habitat. Such landscape modification and the resultant human-dominated environments are the primary drivers of species extinction on a global scale (Dale and Polasky 2007, Didham, *et al*. 2007, Bellard, *et al*. 2012).

Five mass extinction events have been documented throughout the history of the Earth, resulting in the extinction of over 90% of all species (Gaston and Spicer 2004). The causes of these events are believed to be largely due to a change in global climate or extra-terrestrial impact (Erwin 2001). Many scientists believe the Earth is experiencing a sixth mass extinction (Kolbert 2014) as the current rate of extinction is 1,000 - 10,000 times the natural level of extinction (Woodroffe 2000, Raven 2002, Fischer and Linsenmair 2007). Consequently, many species have been reported in decline (Craigie, *et al*. 2010, Hoffmann, *et al*. 2011, Woinarski, *et al*. 2011, Woinarski, Burbidge and Harrison 2015). In addition, the current mass extinction is very different from all others so far as human activity is directly implicated in the continuous adverse impacts on biodiversity (Pullin 2002). The main drivers of biodiversity loss today include overexploitation by humans (Mora, *et al*. 2007, Butchart, *et al*. 2010, Nuwer and Bell 2014), resource consumption (the rise in non-renewable resource use by the growing human population) (Liu, et al. 2003, Golden, et al. 2011), habitat destruction/disturbance (Brooks, et al. 2002, Didham, et al. 2007, Titeux, et al. 2016), pollution and the impact of climate change(Bickham, et al. 2000, Bellard, et al. 2012, Pandit, et al. 2017, Slingsby, et al. 2017), all of which are due to anthropogenic factors.

1.1 Biodiversity Conservation

Habitat destruction and overexploitation are the factors driving much of the current global biodiversity extinction crisis and threatening the essential benefits, or ecosystem services, that humans derive from the functioning ecosystems (Hoekstra, *et al*. 2005, Brooks, *et al*. 2006, Turner, *et al*. 2007). Natural functioning ecosystems provide people with clean air, fresh water, food, medicine and raw building materials. Ecosystem services also include the regulation of environmental processes through the control of climate and disease, nutrient recycling and biological control of flora and fauna populations as well as spiritual and recreational/ leisure benefits (Nasi *et al*. 2008; DeFries *et al*., 2010). The importance of these services to mankind cannot be under-estimated, and this has been reflected by Governments agreeing to put in place conventions to protect life on Earth for the benefit of mankind into the future (Daily, *et al*. 2009). The Convention on Biological Diversity was agreed at the Earth Summit in Rio de Janeiro in 1992, and entered into force at the end of 1993 (CBD 2017). This is an international legally-binding treaty with three main goals: conservation of biodiversity, sustainable use of biodiversity, and fair and equitable sharing of the benefits arising from the use of genetic resources (CBD 2017).

Consequently, conservation effort is targeted towards protecting diversity of threatened species within the world's protected area network, particularly in tropical regions and other species-rich ecoregions, where large numbers of species face extinction (Turner, *et al*. 2007, Butchart, *et al*. 2010). Such effort will succeed in conserving a variety of species as well as maintaining the ecosystems and ecological function that sustains those species and the additional ecosystem services necessary for human well-being (Hoekstra, *et al*. 2005, Turner, *et al*. 2007). However, conservation often tends to focus on conserving remnant or fragmented habitat patches without separating the biodiversity from the processes that threaten its existence. Hence, Protected Areas often fail in achieving the conservation goals as the threats are still present (Margules and Pressey 2000, Hoekstra, *et al*. 2005).

The processes that threaten biodiversity include social, economic and political factors (Margules and Pressey 2000). Many threatened land mammal species are endemic to the developing world where high human population growth rates are placing an unprecedented strain on animal populations (Dunham, *et al*. 2008, Irwin, *et al*. 2010). As the world's human population rises, there is an increased demand for space and resources, resulting in increased transformation of the natural habitat. For instance, agriculture currently utilizes about 38% of the Earth's terrestrial surface area (Monfreda, Ramankutty and Foley 2008, Ramankutty, *et al*. 2008, Foley, *et al*. 2011). Furthermore, 75% of the world's agricultural land is devoted to grazing lands for raising domestic animals (Foley, *et al*. 2011). Continuous deforestation, through forest clearance for farming and livestock grazing, has caused habitat fragmentation (Kearney 2010, Lambin and Meyfroidt 2011). In addition, this protracted loss of tree species has facilitated hunter access into remote parts of forests, further reducing some target species (Ellis, *et al*. 2010). Such landscape modification, and the resultant human-dominated environments, are the primary drivers of species extinction on a global scale (Didham, *et al*. 2007).

Generally, biodiversity loss is threatened by multiple and interrelated factors that includes pressures that are mostly human-induced disturbance to ecosystems, socio-economic effects, failure in governance, poor decision making and policy (Failing and Gregory 2003, Slingenberg, *et al*. 2009, Craigie, *et al*. 2010). The cause of biodiversity loss differs and depends on the biome, geography, climate, type of pressure, biodiversity host country economy, trade patterns, type of governance structure, and other factors. Given the continued increasing pace at which biodiversity is lost and the unlikely elimination in the short term of key underlying drivers, an estimates of 15 % to 37 % in biodiversity loss by 2050 has been projected (Thomas, *et al*. 2004, Slingenberg, *et al*. 2009). Mammals are one of the biodiversity groups showing the most rapid decline worldwide (Hoffmann, *et al*. 2011, Woinarski, Burbidge and Harrison 2015).

1.2 Large Mammals

Large mammals are typically defined as those mammal being larger than 3kg by weight (Fjeldsa, et al. 2004). They are fundamental element in many ecosystems as they regulate the structure and function of the ecosystem in which they occur (McNaughton, Ruess and Seagle 1988, Nasi, *et al*. 2008, DeFries, *et al*. 2010, Ripple, *et al*. 2015). For example, large herbivores function as ecological engineers by changing the structure and species composition of the surrounding vegetation (Dinerstein 2003, Paine and Beck 2007, Wright, *et al*. 2007, Roemer, Gompper and Van Valkenburgh 2009). Their role in seed dispersal is a vital process in maintaining the biodiversity of sites. They play an important role in nutrient cycling, through the consumption of plants at one point and excreting them or dying at another location (Wunderle Jr 1997, Couvreur, *et al*. 2004, Nathan 2006). The activities of large herbivores, such as trampling, are critical in maintaining diverse patches of habitat in many ecosystems (Ripple, *et al*. 2015). This is exemplified by the activities of species such as African elephants (*Loxodonta africana*) in maintaining open patches in a system that naturally supports continuous woody vegetation (Corlett 2013). The wider consequences of losing large herbivores are enormous, as without their activities habitats with heterogeneous vegetation structure would be converted to a homogenous vegetation (uniform characteristic) as has previously become evident in Australia (Rule, *et al*. 2012) and North America (Sandom, *et al*. 2014), lowering biodiversity in these regions.

Regulation of the environment and prevention of wildfire disasters are also influenced by large herbivores (Kareiva, *et al*. 2007, Waldram, Bond and Stock 2008, Holdo, *et al*. 2009). The unique interactions amongst large and small herbivores in the removal of plant biomass prevents fire by altering the quantity and distribution of fire fuel load (Belsky 1984, Ripple, *et al*. 2015). For example, the interactions between white rhinoceroses (*Ceratotherium simum*) and mesoherbivores reduce fuel loads and create biologically-induced barriers to the spread of fire and consequently fewer large, intense fires (Waldram, Bond and Stock 2008, Holdo, *et al*. 2009). The frequency and intensity of fire is strongly associated with the abundance of other ungulates in a landscape (Waldram, Bond and Stock 2008). For instance, a reduction in the extent of fires and delayed recovery of tree populations in the Serengeti is thought to be due to increased grazing pressure from wildebeest (*Connochaetes taurinus*) after their population irrupted following the eradication of rinderpest virus in the 1960s (Holdo, *et al*. 2009).

Large herbivores are also key in terms of maintaining populations of mammalian predators (Ripple, *et al*. 2014b). Large carnivores also directly influence the behaviour, abundance and density of their prey, and indirectly influence habitat structure via trophic-cascades (Berger, Swenson and Persson 2001, Terborgh, *et al*. 2001, Sinclair, Mduma and Brashares 2003, Ripple, *et al*. 2014b). Given the key and positive role of large carnivores in many ecosystems, their persistence depends on the abundance of their prey (De Roos, *et al*. 2008, Moya-Larano 2011) which are currently declining and being depleted in developing countries (Karanth, *et al*. 2004, Berger, Buuveibaatar and Mishra 2013). This threatens the existence of species such as leopards (*Panthera pardus*), lion (*Panthera leo*) and tiger (*Panthera tigris*). For example, the collapse of large herbivores in West Africa due to overhunting has caused regional lion populations to become critically endangered (Henschel, *et al*. 2014).

Large mammals are of utmost importance to the livelihood, security and health of humans in the developing world (Díaz, *et al*. 2006, Ripple, *et al*. 2015), particularly poor, rural people that are constrained by the availability of animal protein and demographic and/or socioeconomic factors (Keane, *et al*. 2011). Wild, or bush meat has played an important role in improving the health and nutrition of children in rural areas (Golden, *et al*. 2011, van Vliet, Nebesse and Nasi 2015). It is estimated that one billion people rely on bushmeat for subsistence (Brashares, *et al*. 2014). Given the high level of human reliance on wild animals for protein, wild mammal populations have been predicted to decline by 80% in African forests during the next 50 years (Fa, Currie and Meeuwig 2003). Hence, humans will be greatly challenged if these species are lost (Díaz, *et al*. 2006).

Besides food, large mammals provide cultural significance that contributes to spiritual wellbeing as well as opportunities for recreation (Potschin and Haines-Young 2006).

Tourists are drawn to protected areas where charismatic herbivores exist in large abundance with significant impact in providing income for communities in such areas (Tao and Wall 2009). However, a decline in these flagship species, and other unpredictable events such as civil unrest and disease epidemics, will intercept the consistency of ecotourism and the benefits derived from the rural communities in the form of trade and employment (Ripple, *et al*. 2015). Therefore, the effect of large mammal decline will be enormous in developing regions such as Africa, where poverty is common (Ripple, *et al*. 2015).

1.3 Threats to African Large Mammals

The global decline in large mammal diversity is well documented (Ceballos and Ehrlich 2002, Cardillo, *et al*. 2005, Sodhi, *et al*. 2008, Brook, Sodhi and Bradshaw 2008, Butchart, *et al*. 2010, Craigie, *et al*. 2010, Hoffmann, *et al*. 2011, Woinarski, *et al*. 2011, Woinarski, Burbidge and Harrison 2015) and threatens the well-being of ecological and human communities (Díaz, *et al*. 2006, Brook, Sodhi and Bradshaw 2008, Butchart, *et al*. 2010). During the late Pleistocene, large mammals declined by a third across the Americas, Europe and Australia due in part to climate change (Renne, *et al*. 2013). However, in Africa the effect of the mass extinction was not as severe, with only 14% of its mammalian community going extinct (Owen-Smith 1987). Today however, mammal species diversity is declining due to factors such as climate change, land conversion, pollution, invasive species and overexploitation (Cardillo, *et al*. 2005, Foley, *et al*. 2005, Butchart, *et al*. 2010, Dorcas, *et al*. 2012). Consequently, the viability of large mammals in Africa is presently uncertain (Brashares, Arcese and Sam 2001, Cardillo, *et al*. 2005, Butchart, *et al*. 2010, Craul, *et al*. 2009, Craigie, *et al*. 2010). Recently, catastrophic large mammal declines have been documented across African regions such as Congo and Gabon (Walsh, *et al*.

2003, Plumptre, *et al*. 2016), Cote d'Ivore (Campbell, *et al*. 2008), Kenya (Ogutu, *et al*. 2016) and Nigeria (Jayeola, *et al*. 2012, Henschel, *et al*. 2014). For instance, within 20 years, an average of 68% decline in abundance of 14 of the 18 species of large mammals was reported in Kenya (Ogutu, *et al*. 2016). In addition, the abundance of Grauer's gorilla (*Gorilla beringei graueri*) in Congo declined by 77% between 1994 and 2015 (Plumptre, *et al*. 2016). Furthermore, forest elephant declined by 62% within a 10 year period across the forests of Central Africa (Maisels, *et al*. 2013). Consequently, it is predicted that Africa, a continent once rich and diverse in large mammal species, will soon be reduced to pockets of large mammal diversity living at low population sizes in protected areas (Caro and Scholte 2007). Hence the need for effective conservation measures to save species from extinction (Ripple, *et al*. 2015).

Species loss and vulnerability to habitat destruction and hunting are mostly associated with animals with a large body size (Gonzalez-Suarez, Gómez and Revilla 2013, Dirzo, *et al*. 2014) consequent slow reproduction, and a narrow ecological niche (Cardillo, *et al*. 2005, Colles, Liow and Prinzing 2009, Davidson, *et al*. 2009). In the developing world, the main threats to large mammals are overexploitation (generally through hunting) and land conversion (particularly for grazing livestock) (Cardillo, *et al*. 2005, Craigie, *et al*. 2010, Ripple, *et al*. 2014a, Ripple, *et al*. 2016).The extensive overhunting for meat and other body parts has resulted in a widespread decline in large mammals in tropical forests (Craigie, *et al*. 2010, Ripple, *et al*. 2014a, Ripple, *et al*. 2016).

Large mammals with 100kg of body mass are threatened by hunting, although, species above 100kg are more at risk of extinction from human consumption (Scholte 2011, Tomiya 2013, Ripple, *et al*. 2015, Ripple, *et al*. 2016). A total of 301 terrestrial mammals, all of which occur in developing countries, are threatened with extinction due to hunting by humans (Ripple, *et al*. 2016). Of the 301 species, 285 are threatened primarily due to hunting and trapping to acquire meat for human consumption, 67 are hunted for traditional medicine, 36 for ornamental uses, and 46 for the pet trade (n=46) (Ripple, *et al*. 2016). These species have important ecological roles yet their populations continue to decline, with only 2% of populations of large mammal species considered stable or increasing (Ripple, *et al*. 2016). Although 40 of the species have been classed as critically endangered, the conservation status of most primates and large ungulates deteriorated between 1996 and 2008, indicating little or no effect of current conservation measures in ameliorating threat (Ripple, *et al*. 2016).

Of major concern is the dramatic drop in large mammal populations owed in part to human encroachment and livestock grazing (Lejju 2004, Fa, Ryan and Bell 2005, Western, Russell and Cuthill 2009, Ripple, *et al*. 2015). The encroachment of livestock into the land needed by native wild grazers and browsers is increasing, mostly in developing countries (Meadowcroft 2009). For example, livestock populations increase at approximately 2 million individuals per month, giving an estimate of 3.6 billion exotic livestock on the planet today (Ripple, *et al*. 2014a). The increase in livestock has resulted in more competition for grazing, a reduction in forage and water available to wild counterparts and a greater risk of disease transmission from exotic to wild species (Mallon and Zhigang 2009).

1.3.1 Illegal grazing

Livestock grazing is one factor driving large mammal population declines and threatening conservation efforts in African savannas (Ogutu, *et al*. 2016, Schieltz and Rubenstein 2016). Since some wild ungulate species are similar to livestock in terms of body mass and diet, the presence of livestock in ecosystems might impact on the structure of native herbivore communities due to competitive exclusion. For example, foraging behaviour, habitat and diet of wild ungulates changes in the presence of competing cattle (Stephens, *et al*. 2001, Mishra, *et al*. 2004, Young, Palmer and Gadd 2005). This occurs mostly during lean resource availability when grazing ranges are constricted to available water and when overall fodder quality is lower (Butt and Turner 2012). Due to diet overlap, there is a reduction in plant biomass available for wild herbivores (Mallon and Zhigang 2009). Hence wild species will consume less suitable forage as they are outcompeted by livestock (Mishra, *et al*. 2004). Therefore, ecosystems with high levels of grazing host significantly fewer mammals than expected (Ashraf, *et al*. 2015, Dacko 2015, Ihwagi, *et al*. 2015). For example, the Bale Mountains National Park in Ethiopia hosts fewer species than previously reported as lion have disappeared, leopard and caracal (*Felis caracal*) are rarely sighted and the encounter rate of large native ungulates was low. The most common species reported was domestic cattle (Stephens, *et al*. 2001). Similarly, a severe threat to the population viability and persistence of large ungulates was reported in Kenya where livestock grazing caused a 72-88% decline among species in most of the rangelands in the country (Ogutu, *et al*. 2016). However, the impact of livestock can be bi-directional, as a number of studies have documented the positive effect of livestock grazing on wildlife (Schieltz and Rubenstein 2016). For instance, livestock grazing has enhanced native forb richness and grass cover in California (Stahlheber and D'Antonio 2013). Indeed, the impact of livestock on wildlife depends on the intensity of grazing on rangeland vegetation (Holechek, *et al*. 2006, Briske, *et al*. 2008, Kutt and Gordon 2012).

Wild ungulates, pastoral herdsmen and their livestock have co-existed for thousands of years (Caron, *et al*. 2013), but the dynamics of this relationship is changing due to increased human population, habitat fragmentation and degradation, isolation of populations of species, and lack of veterinary skills (Deem, Karesh and Weisman 2001, Michel, *et al*. 2006). Thus, wild species may be infected by livestock pathogens and at the same time, be a risk for the re-infection of livestock (Michel, *et al*. 2006, Conner, *et al*. 2008). For example, the outbreak of bovine tuberculosis (a disease of livestock) was first diagnosed in buffalo (*Syncerous caffer*) in South Africa's Kruger National Park in 1990 and has now been transmitted to other large mammals including apex predators (Michel, *et al*. 2006). Therefore, competition and other factors such as disease transmission can have severe impacts on native species.

1.3.2 Bushmeat exploitation

Bushmeat is one of the greatest threats to local wildlife (Ripple, *et al*. 2016). Bushmeat can be defined as non-domesticated terrestrial mammals, birds, reptiles and amphibians, harvested for food (Nasi, *et al*. 2008). Bushmeat hunting provides humans with dietary and livelihood needs for sustenance, mostly in the developing world, and in many countries, people depend on wildlife for their nutritional needs (Fa, Peres and Meeuwig 2002, Robinson and Bennett 2004, Bennett, *et al*. 2007). This subsistence bushmeat hunting is particularly common in western and central Africa (Schulte-Herbrüggen, *et al*. 2013, Fa, *et al*. 2014). However, the increasing demand from the quickly growing urban human population has transformed bushmeat hunting from a subsistence practice to an unsustainable commercialized business (Warchol 2004, Bennett 2011, Abernethy, *et al*. 2013), the outcome of which is the local extinction of wildlife (Robinson and Bennett 2004, Corlett 2007, Singh and Sharma 2009, Bennett 2011, Wilkie, *et al*. 2011). Bushmeat hunting often includes species threatened with extinction (Ripple, *et al*. 2016, Wilkie, *et al*. 2016) and has led to local extinctions of many wildlife populations (Ceballos and Ehrlich 2002, Milner-Gulland and Bennett 2003, Corlett 2007, Bennett 2011, Wilkie, *et al*. 2011). For instance, overexploitation through bushmeat hunting has led to the local extinction of large mammals in Gabon, Ghana and Nigeria, (Van Vliet, *et al*. 2007, Jimoh, *et al*. 2013, Schulte-Herbrüggen, *et al*. 2013) with, 91 species of mammal currently threatened by hunting in Africa (Ripple, *et al*. 2016).

The increasing bushmeat hunting has been enhanced by the increasing use of various hunting methods such as traps, snares, pitfalls, bow and arrows (Kümpel, *et al*. 2009, Alves, *et al*. 2009, Tumusiime, Vedeld and Gombya-Ssembajjwe 2011). In addition, easy access to modern equipment such as fire-arms, explosives, poison and immobilisation drugs make the extraction rate extremely efficient and ultimately unsustainable (Ejiofor and Ali 2014, Enuoh and Bisong 2014). Camping is another hunting strategy that provides sufficient time to hunt during both day and night anywhere including the core area of the forest far from the hunter's community (Atuo, *et al*. 2014), consequently increasing the hunter's off-take and carcass volume (Cronin, *et al*. 2015).

Unsustainable harvest occurs when the extraction level exceeds the population growth rate (Wentworth, Fujiwara and Walton 2011, Mills 2012), particularly if extraction exceeds 20% of production (Robinson, Redford and Bennett 1999). In some African countries like Congo, Cameroon and the Central African Republic, 50% of people obtain their daily protein intake from wild meat and fish (Chivian and Bernstein 2008), most of which is extracted unsustainably. Previous studies on the rate of bushmeat exploitation in the moist-forest regions of the Congo and Amazon basins indicate that the extraction rate in the Congo is 2.4 times higher than the production, and 30 times higher than the extraction to production rate in the Amazon (0.081). Thus, 60% of large mammals in the Congo and Amazon basins are exploited unsustainably (Fa, Peres and Meeuwig 2002).

Bushmeat is considered the cheapest source of animal protein by local people (Loibook *et al*. 2002, Wilkie *et al*. 2016). For example, larger mammals were sold locally by hunters in Tanzania at an average price of $0.46 per kg, calculated from species average weights, lower than the standard price of $1 per kg of beef (Nielsen, 2006). Consequently, many households neighbouring protected areas are engaged in illegal hunting activities (Gandiwa 2011, Nuno, *et al*. 2013). A typical case was reported in the Western Area Peninsula Forest Reserve, Sierria Leone, where 50% of households engaged in hunting activities within a 9 month study period (Conteh, Gavin and Solomon 2015). It was documented that the households with greatest hunting success killed 105 individual animals in 14 hunting trips, while those with low hunting success killed 5 individual animals in 5 trips (Conteh, Gavin and Solomon 2015). In addition, over a two year market survey for evidence of faunal loss, just over 24,000 carcasses from 16 mammal species were estimated in Equatorial Guinea (Albrechtsen, *et al*. 2007). There is a lack of information on wild species population sizes, so sustainable harvest rates are unknown (Rutberg and Naugle 2008, Garel, *et al*. 2010). However, unsustainable hunting for meat across much of the developing world is probably the most important factor in the decline of large bodied mammals (Milner-Gulland and Bennett 2003, Craigie, *et al*. 2010, Lindsey, *et al*. 2013).

Bushmeat consumption has led to species extirpation on a large scale in tropical forests, a process termed the "empty forest" syndrome (Redford 1992, Wilkie, *et al*. 2011b). Thousands of tons of bushmeat are being consumed annually in different parts of the world, with an estimated 12,000 tonnes consumed by rural and urban populations each year in Cross–sanaga, Cameroun (Fa, *et al*. 2006), 23,500 tonnes in Sarawak, Malaysia (Bennett 2002), 1.2 million tonnes in the Amazon basin (Nasi, Taber and Vliet 2011) and 4.9 tonnes in the Congo basin (Fa, Currie and Meeuwig

2003). Since wildlife populations outside protected areas are declining, hunters are moving inside protected landscapes for bushmeat (Lindsey, *et al*. 2013).

1.4 Protected Areas

Protected area (PA) conservation is one approach being used to safeguard remnant populations of endangered mammals from various anthropogenic activities (Bruner, *et al*. 2001, Naughton-Treves, Holland and Brandon 2005). Generally, protected areas are created to ensure environmental sustainability by maintaining biological diversity and slowing the rate of species loss (Chape, *et al*. 2005). There are over 100,000 protected areas worldwide, covering 12% of the Earth's land surface (Brooks, *et al*. 2004). Central and Western Africa have approximately 2.6% of the world's protected areas, with 2,583 sites (Chape, *et al*. 2005). However, the status and actual level of protection differs widely, with many parks being mere "paper parks" i.e. PAs that lack good management, where law enforcement is weak and habitat degradation and poaching is rampant and often unsustainable (Fischer 2008).

In the past, the creation of protected areas involved ejection of the local inhabitants without adequate provision of work and income (Agrawal and Redford 2009) and conservation was based on strict protection combined with stringent penalties imposed on violators of conservation laws (Pretty and Pimbert 1995). In 1982, suggestions were made at the World Park Congress that led to a new paradigm in biodiversity conservation, Management of protected areas should involve both conservation of nature while sustaining local livelihood through development projects, sustainable local use of natural resources, tourism revenue sharing, and education (Western 1992, Naughton-Treves, Holland and Brandon 2005). The final agreement reached in 1992 at the World Park Congress emphasized that protected areas must be managed with an objective to benefit local communities, nations involved, and the world community (Chape, *et al*. 2005). A range of recommendations that address a new plan in the management of protected areas that is becoming a standard operation in some countries such as Austrialia, Mexico, Ecuador, Colombia and Scotland, was developed (Phillips 2003). However, implementing some of these recommendations may be challenging in developing countries due in part to corruption, poor financial support for conservation from the government and poverty, such that not all communities will support conservation and sustainable use (Phillips 2003, Usman and Adefalu 2010).

Nevertheless, PAs have proven to address the extinction crisis as they retain more species at higher assemblage abundance and richness compared to that of the surrounding areas (Jenkins and Joppa 2009, Coetzee, Gaston and Chown 2014). However, there is variation in the efficacy of PAs in terms of achieving the conservation objectives at a relatively low cost (Coetzee, Gaston and Chown 2014). This depends on their designation and management (Balmford, *et al*. 2002). Irrespective of the designation, any exploitation and/or management practices that are harmful to the objectives of the protected areas must be eliminated (Dudley 2008).

Based on the primary objectives, there are six categories of protected areas worldwide which are presented in the Table 1.1. National Parks are one type of protected area with the first designated in the United State of America in 1872 (Yellowstone National Park) and in United Kingdom in 1951 (Peak District). More National Parks were established over 30 years ago in the developing countries in response to the World Parks Congress in 1982, which recommended that all nations strive to place 10% of their total land mass under formal protection (Naughton-Treves, Holland and Brandon 2005). In respect of this, there are over 1000 protected areas grouped under three categories, namely: Strict Nature Reserves, National Parks and Game Reserves;

covering a total land area of 117,441km^2, of which there are seven designated National Parks in Nigeria (David 2008, Usman and Adefalu 2010). Of these three categories, human activities at subsistence level such as "hunting for pot" is allowed in game reserves. Conversely, human activities are considered unfavourable and prohibited through the exclusion of all forms of local participation, policies and practices of biodiversity conservation in creation and management of National Parks (Pimbert and Pretty 1995). This approach has led to the persistent loss of species in developing countries (Naughton-Treves, Holland and Brandon 2005, Muhumuza and Balkwill 2013). Varying degrees of threat, including deforestation and hunting are imposed on flora and faunal species living in their natural habitat (Groom 2006, Lindsey, *et al*. 2013). Differing management programmes are used in different countries to provide effective biodiversity conservation in National Parks. This includes intensive protection of the area by a high density of legally empowered staff (Bruner, *et al*. 2001), monitoring programmes (Kremen, Merenlender and Murphy 1994, Yoccoz, Nichols and Boulinier 2001, O'Connell, Nichols and Karanth 2010), and community–based and co–management strategies that involve local communities and other stakeholders (DeFries, *et al*. 2010).

Table 1.1 IUCN Protected Area Categories, designation and objectives (Boitani, et al. 2008, Dudley 2008)

Category	Designation	Objectives
Ia	Strict Nature Reserve	Managed mainly for science
Ib	Wilderness Area	Managed mainly for wilderness protection
II	National Park	Managed mainly for ecosystem protection and recreation
III	Natural Monument	Managed mainly for conservation of specific natural features
IV	Habitat/species Management Area	Managed manly for conservation through management intervention
V	Protected Landscape/Seascape	
VI	Managed Resources Protected Area	Sustainable use of natural resources

1.4.1 Biodiversity in Protected Areas

Despite the large areas designated as protected areas in Africa, and the fact that PAs retain more species at higher assemblage abundance and richness compared to that of the surrounding areas (Jenkins and Joppa 2009, Coetzee, Gaston and Chown 2014), species extinction rates are high for large mammals and many species are still declining in PAs (Bouché, *et al*. 2010, Craigie, *et al*. 2010, Ripple, *et al*. 2015). For example, of the 156 species reported to be present in the historic and modern lists of Kenya's PAs, 36 species were locally extirpated between 1951 and 2014 (Tóth, Lyons and Behrensmeyer 2014). Furthermore, PAs in Ghana lost 21 to 75% of their large mammal species over a 30 year period (Brashares *et al* 2001). Likewise, duiker species have disappeared from PAs in different African countries such as Gabon (Van Vliet, *et al*. 2007), Nigeria (Jimoh, *et al*. 2013) and Tanzania (Rovero and Marshall 2004, Nielsen 2006). Many of these species have had their range contracted and presently occupy only a tiny fraction of their historical range (Ripple, *et al*. 2015). This is exemplified by the disappearance of kob (*Kobus kob*) and lion (*Panthera leo*) from their historical conservation units in West Africa (Jayeola, *et al*. 2012, Henschel, *et al*. 2014). Based on population size, most species that are ≥100 kg have declined (Ripple, *et al*. 2015). For example, large mammals declined by 59% in abundance within a 35-year period from 1970 to 2005 across African PAs (Bouché, *et al*. 2010, Craigie, *et al*. 2010, Scholte 2011). In addition, many PAs are established in remote areas prone to high human population growth where the landscape provides both economic and biodiversity value (Margules and Pressey 2000, Muhumuza and Balkwill 2013). This has led to the continuous decline in mammals, birds and amphibian species that are economically valuable for food, cash income and medicines (Butchart, *et al*. 2010).

Many species of large mammal only exists in PAs and it is encouraging that species abundances are maintained therein (Tóth, Lyons and Behrensmeyer 2014, Ripple, *et al*. 2015, Barnes, *et al*. 2016). However, this is not the case for all species and in all PAs worldwide, as population gains can be rapidly reversed by poaching activities which is currently observed in Africa (Barnes, *et al*. 2016). Consequently, estimates of future decline have been predicted, indicating Africa as one of the countries to face a large mammalian population decline by the year 2050, with the Democratic Republic of Congo predicted to lose 132 mammalian species, followed by Angola, Cameroon and Nigeria, each predicted to lose 100 species (Visconti, *et al*. 2011). Such predictions poses questions the effectiveness of African PAs in achieving their conservation goals. In spite of these well-documented trends in African large mammal declines, few PAs in Africa have baseline monitoring information on wildlife populations (Steinmetz 2000, Butchart, *et al*. 2010, Hoppe-Dominik, *et al*. 2011) and, as such, the status of many large mammals inside and outside PAs is unknown (Hoppe-Dominik, *et al*. 2011). For example, it is currently unknown whether Government owned PAs in Nigeria are an effective solution to maintaining biodiversity (Usman and Adefalu 2010, Jayeola, *et al*. 2012, Muhumuza and Balkwill 2013). Indeed, there is no baseline information on biodiversity in Nigeria and, as a result, no knowledge on the status of the species in PAs. Consequently, conservation management decisions are often based on crude assessments, expert views, or scholastic guesses, which usually results in erroneous decisions that can be counterproductive (Karanth, *et al*. 2003, Sutherland, *et al*. 2004). In the absence of reliable information on large mammal populations and the associated threats, conservation efforts will fail in halting decline and rebuilding populations (Gibbs, Snell and Causton 1999, Marsh and Trenham 2008, Pimm, *et al*. 2014). Increasing our knowledge about large mammal status and identifying potential threats has been acknowledged as a basis for effective conservation of large mammals in African protected areas (Adams, *et al*. 2004, Blake and Hedges 2004, Pimm, *et al*. 2014).

In order to address the problem of biodiversity loss, a community-based conservation approach was recommended by the International Union for Conservation of Nature (IUCN) and World Parks Congress (WPC) in which local people neighbouring National Parks were allowed to benefit socially and economically through active participation in the management of the park resources (Colchester 2004, Stolton, Mansourian and Dudley 2010). Subsequently, some wildlife-rich countries in Africa, namely Botswana, Kenya, Mozambique, Namibia and Zimbabwe, have participated in this approach (Frost, *et al*. 2007, Jones and Weaver 2009, Rozemeijer 2009, Roe, Nelson and Sandbrook 2009). However, no such schemes exist in Nigeria (Ezebilo and Mattsson 2010, Ngoka and Lameed 2012) where National Parks attempt to restrict all public access through the use of law enforcement (Struhsaker, *et al*. 2004). This restricted access has caused livelihood hardship and poverty among local people and resulted in illegal activities in the National Parks (Archabald and Naughton-Treves 2001).

1.4.2 Illegal Activities in Protected Areas

Past studies on 229 protected areas in the tropics confirmed that 50% of PAs were affected by different types and levels of illegal activities, including poaching/hunting, encroachment, logging, and grazing of livestock (Van Schaik and Kramer 1997). Most of the Nigeria protected areas are affected by high levels of illegal activities (Afolayan, Milligan and Salami 1983, David 2008, Usman and Adefalu 2010). For example, the Kainji Lake National Park, which was the first National Park and the second largest in Nigeria, is almost devoid of large mammals owing in part to illegal hunting and grazing of domestic cattle by the surrounding communities (Meduna, Ogunjinmi and Onadeko 2009). Similarly, the future of wildlife in the largest national park in Nigeria (Gashaka Gumti National Park) is uncertain due to high levels of illegal grazing and other associated activities (Sommer and Ross 2010). Therefore, the problem of illegal activities is common across Nigerian PAs (David 2008, Meduna, Ogunjinmi and Onadeko 2009, Sommer and Ross 2010, Usman and Adefalu 2010).

Despite the high rate of illegal activities in the protected landscapes, rigorous law enforcement is needed to assure protection of wildlife resources, even though this might imply short-term disadvantages for local people (Fischer 2008). Enforcements have included bans on practices such as agricultural activities at park boundaries, hunting of any species and grazing of livestock in National Parks (Archabald and Naughton-Treves 2001, Kideghesho, Røskaft and Kaltenborn 2007, Vodouhê, *et al*. 2010). In addition, fences are often erected to exclude intruders (Kioko, *et al*. 2008, Hayward and Kerley 2009). Such enforcements will not improve people's attitudes towards conservation. However, effective law enforcement has been found to enable the achievement of conservation (Jachmann 2008, Plumptre, *et al*. 2014). Indeed, law enforcement has been identified as the most important component of effective conservation in National Parks, to curbing unsustainable and illegal exploitation of plants and wildlife populations (Holmern, Muya and Røskaft 2007, Gandiwa, *et al*. 2013, Gandiwa, *et al*. 2014).

The most promising form of law enforcement is prevention, and patrols are the primary method of detecting and preventing illegal activities within PAs (Gray and Kalpers 2005, Hilborn, *et al*. 2006, Stokes, *et al*. 2010). For example, as a result of improved law enforcement, poaching activities reduced by 72% in Ghana Savanna protected areas and the encounter rate of wild species increased (Jachmann 2008a, Jachmann 2008b). Similarly, anti-poaching patrol efforts effectively reduced poaching activities and positively affected the abundance of three severely affected species in Tanzania: African buffalo, elephant, and black rhino (Hilborn, *et al*. 2006). In addition, the use of law enforcement in the Serengeti National park with efficient patrols resulted in an arrest of 96 illegal hunters that were residents of local villages within 41km of the park boundary (Holmern, Muya and Røskaft 2007). Furthermore, bushmeat hunting can be sustained through enforcement and protection of wildlife species (Cowlishaw, Mendelson and Rowcliffe 2005, Hilborn, *et al*. 2006, Gardner and Davies 2014). Nevertheless, law enforcement has been shown to be ineffective in 16 PAs in African countries, due to an insufficient number of workforces (park guards) and inadequate salaries, bonuses and equipment to effectively carry out their roles (Struhsaker, *et al*. 2004). In addition, the viability of endangered species is influenced by weak governance and corruption (Wilkie, *et al*. 2005, Fa, *et al*. 2006). Governance is an important component of park effectiveness that enhances the capacity for enforcement in terms of training, communication, law enforcement, control of corruption and effective PA management (Eklund and Cabeza 2016). The combined effect of these factors on the type and/or level of pressure produces either positive or negative conservation outcomes. Many conservation programmes are turned into an avenue for fraudulent practices by the political and implementing officers, resulting in negligible conservation successes (Usman, 2010, Muhumuza, 2013 and Eklund 2016). For example in Malawi, funds meant to be given to local people as an incentive for alternative livelihoods were suspended due to political interference in the project activities limiting the effectiveness of forest management (Kasparek 2008). Other authors have noted that funds meant for conservation programmes are often diverted to other uses which are often personal (Muhumuza and Balkwill 2013). Therefore, immediate action must be taken to reduce corruption in managed protected areas.

1.4.3 The Future of Protected Areas

Despite efforts to achieve the objectives of creating National Parks, both exclusion and community-based conservation approaches have not been adequate to address the rapid loss of biodiversity or reduce the pressures on species (Muhumuza and Balkwill 2013). The next mega extinction is underway and the window of opportunity to safeguard mammals through conservation efforts is rapidly closing, owing to human and/or anthropogenic activities (Ceballos, *et al*. 2015). Therefore, conservation efforts have been labelled as controversial (Brockington and Wilkie 2015). Should conservation strategies in protected areas be free of humans or allow some sustainable resource use? Based on this question, conservation strategies should be evidence-based and be informed by established scientific proof (Kideghesho, Røskaft and Kaltenborn 2007). However, such evidence is scarce, despite the importance in conservation planning and implementation (Hoole and Berkes 2010).

Practical and applied forms of research are needed, particularly those that incorporate a multi-disciplinary approach (Moon, *et al*. 2014, Bennett, *et al*. 2016) . Moreover, responses to address issues related to wildlife crimes, ranging from poverty to human-wildlife conflict, must also be acknowledged in order to provide interventions that will benefit and/or sustain both human and mammal communities (Kideghesho, Røskaft and Kaltenborn 2007, Muhumuza and Balkwill 2013, Duffy, *et al*. 2016).

Up to this point, the majority of research on large mammals has centred on species of conservation interest, particularly mega-fauna such as large carnivores (Packer, *et al*. 2011, Balme, *et al*. 2014, Fernández-Gil, *et al*. 2016), mega-herbivores (Karanth and Sunquist 1992, IUCN 2007) and some primates (Gates 1996, Lootvoet, Philippon and Bessa-Gomes 2015, Estrada, *et al*. 2017). Unfortunately, researchers have largely neglected the human dimension of wildlife-related population dynamics, particularly those communities that depend, exploit and/or can be affected by these wildlife species (Muhumuza and Balkwill 2013, St John, *et al*. 2014). The use of a multi-disciplinary approach will aid in identifying and understanding factors associated with the conservation staus of large mammal and hence improve conservation policy, practice and outcomes (Moon, *et al*. 2014, Bennett, *et al*. 2016).

1.5 Thesis rationale and structure

It has been documented that the ecosystem services that large mammals provide cannot be over-emphasized (McNaughton, Ruess and Seagle 1988, Nasi, *et al*. 2008, DeFries, *et al*. 2010). Large mammals are threatened and at risk of extinction, with global declines driven by anthropogenic activities (Cardillo, *et al*. 2005, Brook, Sodhi and Bradshaw 2008, Sodhi, *et al*. 2008, Butchart, *et al*. 2010, Ceballos, *et al*. 2015). Protected areas may be the last hope to safeguard the remaining large mammals

(Kinnaird, *et al*. 2003, Mackey, *et al*. 2008, Dawson, *et al*. 2011). However, it is uncertain if PAs in Nigeria are currently effective in conserving them (David 2008, Hoppe-Dominik, *et al*. 2011). Many Nigerian PAs lack baseline information on the current status of large mammals and the prevalent anthropogenic activities, yet such information is vital in designing effective management strategies for threatened species and sustainable management strategies (Capon, Leslie and Clegg 2013).

Due to the limited knowledge on the status of large mammals and the quest to identify the factors associated with their declines, a case study of one large West African savanna protected area has been conducted at Old Oyo National Park in south-west Nigeria. Old Oyo National Park (hereafter OONP) was selected on the basis that it is poorly studied in relation to its mammalian fauna, and because of the perception of high levels of anthropogenic activities that may be threatening the park's biodiversity, within a tropical, West African geographic and economic context.

The aim of this study is to describe the status of OONP's large mammal community and identify the possible drivers of large mammal population dynamics. The study attempts to estimate large mammal occupancy/density and illegal activity in the Park and identify socioeconomic factors influencing the occurrence of large mammal in the Park.

Specific objectives of this study are:

- To assess the large mammal population in OONP
- To identify and quantify the illegal activities in the Park
- To identify drivers of illegal hunting activity in OONP
- To identify factors affecting bushmeat consumption by villagers around the OONP.

The remainder of the thesis is structured as a series of interlinked methodological and data chapters, and general discussion and synthesis as given later.

Chapter 2 presents the study context with a full description of OONP. It also provides a summary of and justification for the use of the survey methods for large mammals and the general methods employed in this study.

Chapter 3 assesses the conservation status of the mammal community using multiple techniques, in order to enhance the chances of recording animals in different habitats or performing different behaviours. This is combined with opinions of stakeholders in OONP to inform population status and trends in large mammals inside OONP.

Chapter 4 investigates data on illegal activities derived from camera-trapping, line transects. Villager and ranger surveys are pooled to quantify the level of illegal activity inside OONP. Considering the sensitivity of the conservation issues under exploration, a Randomized Response Technique (RRT) is applied to obtain information on sensitive questions (regarding illegal activities) from the respondents (villagers). The evidence from the surveys provides an understanding of factors associated with the status of the entire community of large mammals in this landscape.

Chapter 5 critically examines the socio-economic drivers of illegal hunting and tests hypotheses about the illegal hunting activities of the local communities neighbouring OONP. This chapter aimed to identify and/or understand the characteristics of individuals that would influenced the self-reported rate of illegal hunting activities with findings having potential implications for the management of the study area.

Chapter 6 tests hypotheses about bushmeat consumption by the local communities neighbouring OONP. Therefore, the socio-economic characteristics of individuals that could influence their consumption of bushmeat were investigated and findings are documented to aid in designing effective conservation measures.

Chapter 7 gives a general discussion and synthesis of all the findings based on the objectives of this study and provides detailed conclusions, proposed government policies, and management recommendations that will improve the trade-offs between active involvement in hunting and other livelihood attributes as a step towards the recovery of large mammal populations in a protected landscape. This is not only important for the regional conservation effort but also to inform conservation planning in less impacted areas at risk of future increases in anthropogenic threat.

Chapter 2: Study site and survey methods

2.1. History of wildlife conservation in Nigeria

In Nigeria, wildlife conservation came into existence as soon as the first Forest Reserve (Olokemeji) was established in 1900 for preserving tree and plant species and other associated wildlife (Hopkins and Jenkin 1962, Usman and Adefalu 2010). Over time, many more Forest Reserves were established, making up the majority of protected areas in the country (covering a total area of 99,991Km^2) (Usman and Adefalu 2010). During the 20th century, animal populations in the Forest Reserves benefited from the lack of human settlement and hunting (Happold 1971). However, outside the Forest Reserves, researchers reported a rapid decline in wild animals in many parts of Nigeria during the 1930's, and suggested the creation of game reserves to ensure appropriate management of wild animals (Collier, 1934; Shorthose, 1935 as cited in (Happold 1971).

Both Collier (1934) and Shorthose (1935) had conflicting views on whether conservation of animals should consider short term interests (provision of protein supply) of the local population as a priority over the long-term interest of conservation (revenue generation). Shorthose (1935) advocated stricter conservation measures where the animals were not exposed to any form of disturbance or threat in the proposed National Parks and Game Reserves. At about the same time, Haywood (1932) suggested a system of Game Reserves (these are large areas of land managed mainly for the protection of wild animals) that included the existing Forest Reserves, as well as the creation of new reserves which would later be designated as National Parks. These suggestions led to the creation of more reserves in Nigeria (Usman and

Adefalu 2010). However, the indiscriminate hunting of animals by the local communities rendered the established reserves ineffective (Boyle 1948).

At the time of independence in 1960, many of the Forest Reserves were upgraded to Game Reserves to protect wildlife from illegal hunting, with hunting only conducted under permit. Petrides (1965) found that some species such as pygmy hippo (*Choeropsis liberiensis)* had become extinct in the reserves and some large cats were threatened with extinction, concluding that intensive land use was the major factor affecting wildlife abundance in Nigeria. Petrides (1965) also emphasized the need for stricter legislation and enforcement of game laws, suggesting that some Game Reserves, including Upper Ogun Game Reserve (now Old Oyo National Park), be upgraded to National Parks to maintain biodiversity and protect endangered species - since no unauthorised entry and/or extraction of natural resources is allowed in National Parks. This led to the Wild Animal Ordinance, promulgated by the Federal Government, which gave full protection to all animals within areas designated as Game Reserves (Happold 1971). Nigeria signed the new "African Convention for the Conservation of Nature and Natural Resources" at Algiers (Happold 1971), which required actions to be taken over important clauses relevant to the progress of wildlife conservation. A summary of the clauses is: (i) total protection for certain species, (ii) full and proper maintenance of National Parks and conservation areas, (iii) promotion and encouragement of research related to conservation management and the sustainable use of natural resources with particular attention to ecological and sociological factors and (iv) the establishment of a single agency to deal with biodiversity conservation matters. Subsequently, Nigeria also became a signatory to international conservation-related conventions, including: the RAMSAR Convention on the Conservation of Wetlands of International Importance (1971); Convention on

International Trade in Endangered Species of Fauna and Flora (CITES, 1973); Conservation of Migratory Species of Wild Animals (1973); and the Framework Convention to Combat Desertification (1994) (Usman and Adefalu 2010). These have been implemented in local wildlife conservation laws such as the Land Use Act of 1976, the Endangered Species Decree of 1985, and the National Park Decree of 1979, later reviewed in 1991 and 1999 (Blaser, *et al*. 2011).

Despite Nigeria's involvement in these conventions, many of the actions and suggestions expressed over the past 40 years have not been progressively considered to counteract the gradual destruction of wildlife resources (Happold 1971, Usman and Adefalu 2010). For example, at present, none of the Nigerian reserves or parks are fenced, hence many are degraded and have low wildlife abundance (Usman and Adefalu 2010). Consequently, of the seven National Parks in Nigeria, both Kanji Lake National Park and Old Oyo National Park are heavily exploited and continuously threatened by farm encroachment and poaching (Meduna, Ogunjinmi and Onadeko 2009, Usman and Adefalu 2010). Although long-term biodiversity surveys have been conducted by the Wildlife Conservation Society at Cross River National Park and Gashaka-Gumti National Park (supported by the World Wildlife Fund in partnership with the Nigerian Conservation Foundation), the other five national parks lack adequate research

Therefore, very little is known about the status of wildlife across Nigeria, irrespective of whether these are in protected areas or not (Afolayan, Milligan and Salami 1983, David 2008). Hence, more research needs to be conducted to establish baseline presence and abundance data for future management across the majority of Nigeria's Reserves and National Parks (David 2008).

2.2. Study area

This study took place at Old Oyo National Park (OONP), which is located in South-West Nigeria (Figure 2.1) at latitude 8^o 15’ to 9^o 00’N and longitude 3^o 35’ to 4^o 42’ E. It covers 2512km^2, making it the fourth largest National Park in Nigeria. OONP was created by merging the former Upper Ogun River Game Reserve and the Old Oyo Forest Reserve. These reserves were established in 1936. OONP was officially gazetted under the Nigeria National Park Decree No. 36 of 1991 which was later cancelled and substituted with Act No. 46 of 1999. The park is managed by the Federal Government of Nigeria and, for management purposes, OONP is divided into five administrative units (hereafter termed Ranges (Figure 1): Oyo Ile (476 km^2), Marguba (617 km^2), Tede (422km^2), Sepeteri (607 km^2) and Yemoso (390 km^2).

The topography of the park is typically low lying land between 330 and 508 metres above sea level comprising gently undulating savannah plains and forest. The park is drained in a southwards flow by the River Ogun (largest river) and its numerous tributaries, namely: Owu, Owe, Oopo, Iwawa, and Tessi (Figure 2.1).

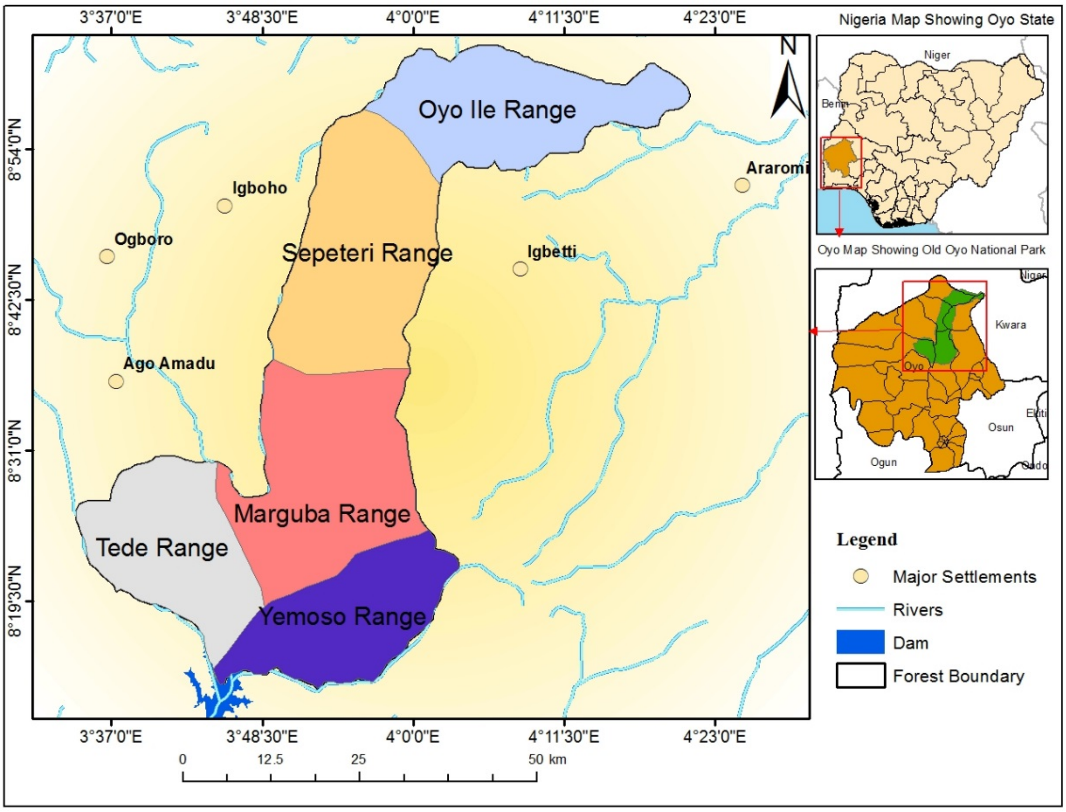


Figure 2.1 Map of OONP showing the five ranges, surrounding settlements and its location in Oyo State and Nigeria.

2.2.1. Climate

OONP experiences two seasons: one hot/dry season with virtually no rain between November and March, and a wet season between April and October. Average annual rainfall is between 1100mm and 1250mm, with 80% falling between April and October (Afolayan, Milligan and Salami 1983, Adetoro 2008). The mean annual temperature ranges from 20°C (minimum) to 34°C (maximum), with the hottest months being December/January and coolest being June/July each year (Afolayan, Milligan and Salami 1983).

2.2.2. Vegetation, flora and fauna

The study area falls within the Southern Guinea Savanna zone of West Africa and is characterised as woodland savanna (Afolayan, Milligan and Salami 1983, Ajiboye 2012, Oladipo and Abayomi 2014). The park's vegetation is further classified into five broad groups, including forest, open savannah, closed savanna, grassland and rock outcrop vegetation (Geerling 1974, Afolayan, Milligan and Salami 1983). Common trees include *Afzelia africana* (African mahogany), *Butyrospermum paradoxum* (Shea butter tree), *Danielia oliveri* (African copaiba balsam), *Parkia biglobosa* (locust bean tree) and *Terminalia species* (Combretaceae) *(Oladipo and Abayomi 2014)*, and grass types include *Andropogon gayanus* (gamba grass), *Hyparrhenia rufa* (thatching grass) and *Pennisetum purpureum* (elephant grass) (Oladipo and Abayomi 2014). OONP was once home to a diverse mega-fauna such as elephant and large carnivores such as lion, leopard, spotted hyaena and wild dogs (Afolayan, Milligan and Salami 1983, Anadu and Green 1990, Usman and Adefalu 2010). A full description and status of naturally occurring species in the historic record of OONP is presented in Table 2.1.

Table 2.1 The status of large mammal species found in historical reports of OONP. DD/ not known – (data deficient), Endangered (species is unlikely to survive if the factor posing threat persists), Vulnerable (likely to become endangered if the factors posing threat persist), LR/cd- low-risk-conservation dependant (species in no immediate danger but survival will depend on implementation of effective conservation measures in its range). Information from (Blench and Dendo 2007, Mbaya and Malgwi 2010, Idowu and Morenikeji 2015).

Species	Description	Status in Nigeria
Aardvark (*Orycteropus afer*)	Solitary and rarely seen nocturnal animal. They are exterminated in many agricultural areas, thereby making them vulnerable in settle areas or extinct in many localities (Happold 1973)	DD/Not known
African civet (*Civettictis civetta*)	Abundant in forested areas. They are omnivores and can eat poisonous fruits and insects (Happold 1973).	LR/cd
Buffalo (*Syncerus caffer*)	Mainly found in habitats that do not suit large carnivores and offer easy retreat into cover such as mosaics and savannahs with patches of thicket. They feed on grasses. Feeding behaviour is influenced by human predation and species switches from continuous grazing to night-time grazing (Happold 1973, Eniang, *et al*. 2016).	DD/Not known and appeared to be threatened
Bushbuck (*Tragelaphus scriptus*)	Found in thickets and are mostly browsers. Water is essential to their daily needs but they can subsist on dew. They are negatively impacted by illegal hunting and grazing (Afolayan, Milligan and Salami 1983, Averbeck, *et al*. 2012, Lameed, *et al*. 2015)	Vulnerable
Bush pig (*Potamochoerus larvatus*)	Found in forested and woodland habitats. Diet includes roots, tubers, bulbs and corms. They are mainly nocturnal (Ghiglieri, *et al*. 1982)	Not known
Cane rat/grasscutter (*Thryonomys gregorianus*)	They are Grassy hill and savannah rodents. Feed mostly on stems of grasses, fruits, bark and roots of plants (Happold 1973). Highly exploited as a food source by carnivores, eagles and humans (Happold 1973).	LR/cd

Table 2.1 continued

Species	Description	Status in Nigeria
Elephant (*Loxodonta africana*)	The largest land animals found in all major vegetation types from tropical swamp forest to desert. Depending on the season they feed on grass and browse plants. They move extensively in search of food, water and minerals or in response to disturbance. Continuous encroachment and poaching threatens the remaining population (IUCN 2007)	Endangered
Giant pouched rat *(Cricetomys)*	Exclusively low-land rain-forest rodent, feed mostly on fruits seeds nuts, roots and leaves (Happold 1973)	LR/cd
Wild dog *(Lycaon pictus*)	Large, blotchy dog with prominent, round ears and tufted tail always white at the tip. Species are commonly found in woodlands, savannahs, grasslands and steppes. They exist wherever there is sufficient prey. Hunting dogs are threatened by direct persecution and competition with livestock (Breuer 2003).	Endangered
Kob *(Kobus kob*)	Medium-sized antelope found in grasslands. They are grazers with a preference for short swards and strong fidelity to watering points. Poor quality food sources are utilized and converted to meat by these species thereby make them grow faster than any other bovid (Happold 1973). Their population has been negatively impacted by illegal hunting and livestock grazing (Jayeola, *et al*. 2012).	Endangered
Leopard (*Panthera pardus*)	The most beautiful among large cats found in variety of habitat, mostly where vegetation provides cover and from high mountains to the coast. Threats includes forest exploitation through urbanization and habitat conversion as a result of farming and hunting (Hes 1997, Angelici, Akani and Luiselli 1998)	Endangered

Table 2.1 continued

Species	Description	Status in Nigeria
Lion (*Panthera leo*)	The chief predator in nearly all terrestrial ecosystems. It has a wide habitat range but is absent from rainforests and extreme arid areas. Naturally dependent on an adequate supply of large and medium size prey but not averse to scavenging whenever the opportunity arises (Hes 1997).	Critically endangered
Long-snouted mongoose *(Herpestes naso)*	They are nocturnal and habitat generalists, but are particularly common in forested areas and woodlands near water courses (Bahaa-el-din, *et al*. 2013, Angelici 2014). They are predators of invertebrates and small vertebrates, but also eat fruit, and they are water dependent (Angelici 2014). Mongoose are hunted for bushmeat and so the population is decreasing (Ray *et al*., 2015).	Not known
Maxwell's duiker (*Cephalophus maxwelli*)	Found in rainforest and moist or derived savannah. Food resources include fallen fruits, herbs and shrubs. Habitat loss and illegal hunting are the major threats to the species (Happold 1973).	Vulnerable and or suspected to be in endangered, vulnerable or rare categories
Olive baboon (*Papio anubis)*	Extensively distributed in woodlands and forest mosaic habitats (Kunz and Linsenmair 2008, Johnson, Swedell and Rothman 2012). As omnivores, they are opportunistic feeders with a diet ranging from grass to fruits, resins, gums and locusts depending on the region, season and time of day (Johnson, Swedell *et al*. 2012).	L/cd
Oribi (*Ourebia ourebi*)	Tall slender medium-size antelope. They are found in grasslands maintained by fire or heavy grazing and feed on fresh green grass. Threats include habitat destruction, agricultural settlement, livestock and poaching (Anadu and Green 1990).	L/cd

Table 2.1 continued

Species	Description	Status in Nigeria
Patas monkey (*Cercopithecus (Erythrocebus) patas*)	Found in all habitat types (Adanu, Sommer and Fowler 2011, Chism and Rowell 1988, Kingdon 2015) and are infrequent visitors to water sources (Chism, Rowell 1988). They eat grass rhizomes, insects and small vertebrates and recently adapted to feeding on exotic foods and food crops. Status of patas have undoubtedly been affected by agricultural expansion, deforestation and illegal hunting (Kingdon 2015). They depend on human-made water sources and have been found close to cattle ranches (Isbell & Chism, 2007; De Jong *et al*., 2008).	LR/cd
Red-flanked duiker (*Cephalophus rufilatus*)	Found in forest relics and riverine thickets within savannah. They feed on fruits, flowers and foliage from trees, shrubs and herbs (Mc Grew *et al*., 2014). Their population has been reported as in decline due to illegal hunting and habitat destruction, but they can withstand considerable hunting pressure as long as suitable habitat remains available (Pailer *et al*., 2009; Mc Grew *et al*., 2014).	LR/cd
Roan antelope (*Hippotragus equinus*)	Mostly found in savannah woodlands and localities with few competitors and carnivores. Pure grazers but occasionally browse shrubs or herbs. Expanding livestock economy and poaching is a major threat to this species (Chardonnet, 2013).	Endangered
Scrub hare *(Lepus saxatilis*)	Prefers grasslands and feed on grass species that are close to the ground	LR/cd
Spotted hyena (*Crocuta crocuta*)	A large carnivore, powerful predator and highly mobile animal found in open plain savannas and semi-arid desert. Spotted hyenas have a flexible diet. They are efficient scavengers and effective hunters (Hes 1997).	Not known

Table 2.1 continued

Species	Description	Status in Nigeria
Tantalus monkey (*Cercopithecus (aethiops*) tantalus	Inhabit many habitat types and consume a wide range of food resources including cultivated plants, insects and small vertebrates (Happold 1973).	Not known
Warthog (*Phacochoerus africanus*)	Inhabit a mosaic of vegetation types, mostly in savannah and open-woodland areas (Muwanika, *et al*. 2007). They are predominantly grazers and occasionally eat fallen fruits, faeces and animal foods. Warthog stay within walking distance of water but can subsist for a while on succulents and other water-conserving plants (Muwanika, *et al*. 2007). Their population has been decimated by competition for resources, predation and hunting (Muwanika, *et al*. 2007, White 2010).	Endangered
Water buck (*Kobus ellipsiprymnus*)	Inhabit any habitat type with permanent water. Predominantly grazers but can be found browsing leaves or even fruits where green grass is scarce. Illegal hunting and livestock grazing have eliminated the species in most localities where they naturally exist (Averbeck, *et al*. 2012).	Not known
Western hartebeest (*Alcelaphus buselaphus*)	Predominantly grazers, found in grassy plains and woodlands. They are water dependent and as such go to water regularly. Population has declined drastically due to habitat alteration and disturbance(Akinyemi and Kayode 2010)	Vulnerable

2.2.3. Human population and ecosystem services

The five ranges of the study site are surrounded by over 100 villages (Figure 2.2) within a 10km radius of the park border, in 11 Local Government Areas within Oyo and Kwara States. The areas surrounding OONP have experienced an influx of people migrating from other parts of the country to escape insurgency and unemployment (Cook 2014, Idowu and Morenikeji 2015). Based on the last National population census conducted in 2006, Oyo and Kwara states had populations of 5,580,894 and 2,365,353 people, respectively, with a projected increase to 7,840,864 and 3,192,893 persons, respectively, by 2016 (Macro and National Population Commission 2009). Consequently, the human population is rising around OONP.

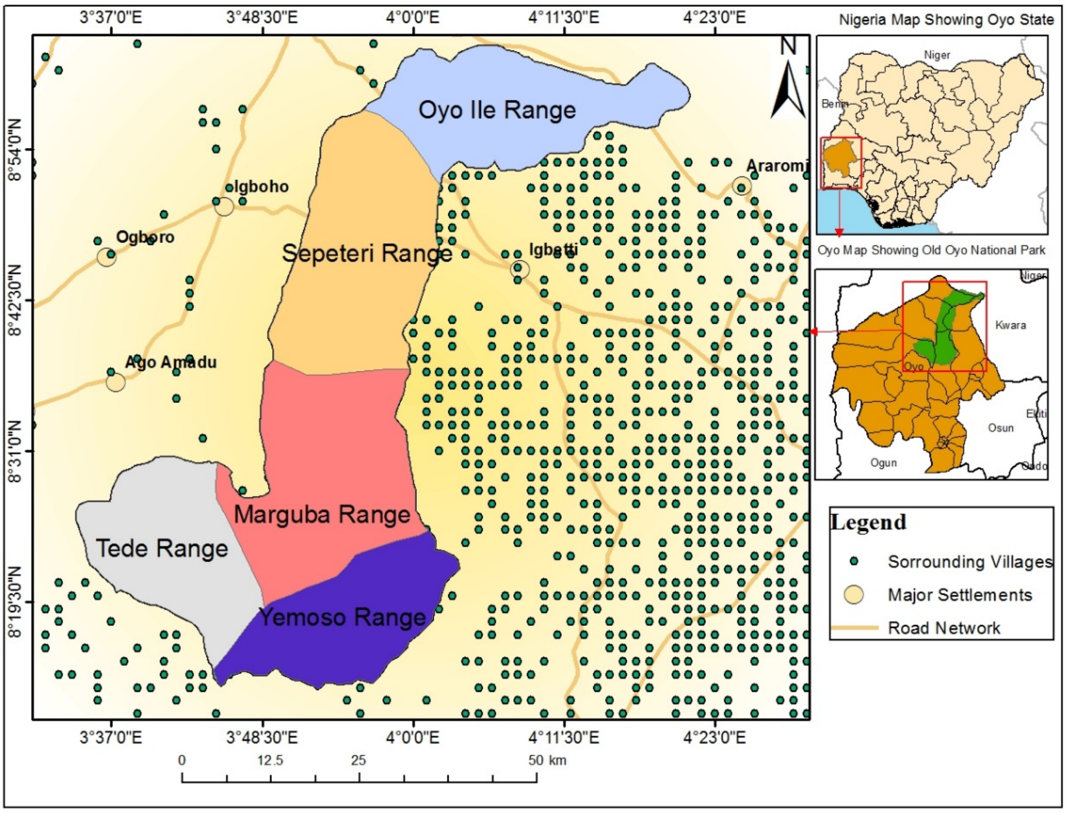


Figure 2.2 Map of OONP showing the villages surrounding the Park.

Villagers living close to the boundary of OONP comprise people from different ethnic groups (Yoruba, Hausa, Fulani, Tiv, Ibariba and Idoma) (Oladipo and Abayomi 2014). The livelihoods are acquired through small-scale agricultural production (crop farming and livestock farming) and charcoal making (Akinyemi and Kayode 2010, Oladipo and Abayomi 2014). The majority of these people belong to lower income classes with their livelihoods depending on natural resources (Okojie and Amujo 2011, Ibrahim and Adetoro 2015).

Local ecosystem goods and services, and the economic values provided are immensely important for human well-being, and to local and national economies. These goods and services include climate regulation, timber, bushmeat, medicinal herbs/plants, agricultural pollination, irrigation, and forest sites of high historical, archaeological and cultural value (Oladipo, Olatubosun and Babatunde 2013).

OONP is especially valuable in terms of its unique and spectacular features of historical and archaeological value (such as Kosomonu Hill, referred to as a compass since it assists the inhabitants in locating their destination (Oladipo, Olatubosun and Babatunde 2013). The natural water resources, scenic rock formations and diverse wildlife species combine to make the Park a unique ecological and cultural/historical park. Since the creation of the Park, a strict non-utilisation policy has been implemented which states that it is illegal to extract any form of wildlife and/or natural resource from the park. The entry of any kind into the Park without permission for any purpose is also prohibited. Although, the Park boundaries are unfenced so animals and people can move freely in and out. Hence, the boundaries are patrolled by rangers to deter illegal activities.

2.3. Study design: General consideration

To date, many techniques have been developed, introduced and used in monitoring programmes to collect data on terrestrial large mammals. Methods tend to vary depending on the focal species and objective of the study (Espartosa, Pinotti and Pardini 2011). These techniques range from line transect methods (both diurnal and nocturnal censuses) to camera trapping (Munari, Keller and Venticinque 2011). Under certain circumstances such as when target species are in abundance, their biological traits support effective observation and identification, or there is an adequate number of surveyors and adequate budget/finance, these techniques are fine. However, for elusive or rare species, there may be need for alternative approaches as most of these techniques fail to provide adequate data from which high quality information on occurrence, abundance and density can be obtained (Munari, Keller and Venticinque 2011). This failure could result in few sightings even in areas of high population density, and in turn results in poor estimates of abundance and density (Carrillo, Wong and Cuarón 2000). Hence, there is a need for a multi-disciplinary approach with concurrent use of diverse techniques to enhance chances of recording animals of different habit or behaviour necessary for reliable density, abundance or occurrence estimates (Schwarz and Seber 1999, MacKenzie 2006, O'Brien, *et al*. 2010).

Increasingly, many studies are applying multiple detection methods at study sites to obtain a sufficient number of sightings for estimates of occupancy probability, abundance and density (Nichols, *et al*. 2008). The concurrent use of different techniques improves the chance of recording animals of different habit or behaviour (Silveira, Jacomo and Diniz-Filho 2003) and help to achieve adequate data for population estimates (Schwarz and Seber 1999, MacKenzie 2006). Furthermore, a multidisciplinary approach that combines ecological and social surveys has been highlighted as the best technique to obtain a robust data set for ecological indicator species and develop intervention programmes that will benefit both humans and wildlife (Bonebrake, *et al*. 2010, St John, *et al*. 2014).

This study adopted a multidisciplinary approach that combined ecological survey (camera trapping and distance sampling) (Espartosa, Pinotti and Pardini 2011) and social survey (St John, *et al*. 2014) methods. Camera trapping was used to determine the presence of large mammals, so that occupancy estimates could be derived. Also, distance sampling was used to derive density estimates of species. The perceptions of local people and law enforcement staff were derived from social surveys to further determine the status of wildlife species, and socioeconomic factors that influence their occurrence. Information gathered from these sources was used to determine the baseline status of large mammals and investigate possible causes of decline. Such information is vital for future studies to compare and monitor large mammal population status. A brief description of the methods used for monitoring large mammals is presented in the next section.

2.3.1 Survey methods (large mammals)

Over the years different methods have been used to monitor population trends, including new methods that reduce parameter uncertainty to obtain accurate estimates of populations (Marsh and Trenham 2008, McAlpine, *et al*. 2008). Principally, monitoring entails taking an inventory of species of interest in an area either at local, regional or international level to inform management (Kauhala and Auttila 2010).

Monitoring can be carried out using either direct or indirect survey methods. Direct methods involve counts of animals sighted. For example, line transects, capture-mark-recapture, spotlighting, radio-tracking and camera trapping (Sadlier, *et al*. 2004).

Indirect methods depend on counts of field signs of species of interest, such as foot prints, droppings and/or scats, nests and dens (Harrington, *et al*. 2010). Generally, both methods have advantages and disadvantages. Direct methods are quantitative techniques that provide detailed data such as accurate estimates of abundance, but they are expensive and time-consuming. Licenses may also be required and difficult terrains cannot be surveyed (Rowcliffe, *et al*. 2008). Although indirect methods are cost-effective, good for elusive species and can be used as an index of abundance, they are not robust enough for estimating density as species may not be detected where present (Sadlier, *et al*. 2004).

Suitable survey methods depend mostly on the biology and traits of the studied species, as well as the terrain and weather conditions in the study area. For instance, detecting cryptic and nocturnal species is difficult, hence such characteristics should be factored into the methodology adopted (Schwarz and Seber 1999).

Fortunately, recent advances in surveys with the use of camera traps have established an effective method of animal detection (Pettorelli, *et al*. 2010). Camera traps have the potential to provide a non-invasive direct means of gathering data on multiple species concurrently and constantly in any given area over a long period of time (Rowcliffe, et al. 2014).

Since an investigator does not have control over animal detection, it is uncertain that any method used will provide an unbiased estimate. Alternatively, the use of an index of population size provides some idea of the size of the population, but such results cannot be used to inform management decisions. Nevertheless, they can prevent the cost of basing conclusions on false estimates of population size and/or rejecting the estimate entirely (Sutherland 2006).

In order to determine the status of large mammals and to identify the factors driving their population dynamics in this study, three approaches were adopted:

1) Camera trapping, in combination with occupancy analysis (MacKenzie 2006)

2) Distance sampling (Buckland, *et al*. 2005)

3) Stakeholder (local villagers and rangers) interviews (Folke 2004, White, *et al*. 2005)

Camera trapping and occupancy analysis

Camera trapping is widely used in wildlife ecology to collect data on a wide range of species, to generate measureable variables appropriate to multispecies surveys (Rowcliffe, *et al*. 2008, Tobler, *et al*. 2008). Overall, camera trapping reduces difficulties associated with observing cryptic and rare species during ecological studies, and provides access to undisturbed observations of multiple species under any environmental conditions at any time of the day (O'Connell, Nichols and Karanth 2010).

Metrics such as indices of relative abundance (RIA), derived from camera trapping data are vital to inform conservation measures and efforts (Balme, Hunter and Slotow 2009), particularly to support large-scale biodiversity conservation efforts, given the scarcity of information available on many species at global, regional and local levels (O'Brien, *et al*. 2010, Ahumada, Hurtado and Lizcano 2013). The RIA from camera trapping surveys is based on the assumption that photo detection rates are related to animal abundance and are constant across areas, time or species (Moruzzi, *et al*. 2002, Harmsen, *et al*. 2010, Sollmann, *et al*. 2013). However, these assumptions are unlikely to be true (MacKenzie 2006, Hayward, *et al*. 2015) because relationships between indices and abundance are influenced by variation in animal detectability (mostly influenced by the environment), observers, animal movements and animal status (O'Brien, *et al*. 2010, Hayward, *et al*. 2015).

Fundamentally, it is necessary to consider the ecological and observational process of camera trapping to obtain quality data in order to make a robust inference about species abundance (Burton, *et al*. 2015). This has led to the use of occupancy modelling, a surrogate for abundance (O'Brien, *et al*. 2010, Chandler and Royle 2013). Occupancy is a state variable used in monitoring populations, and is the proportion of an area or sample unit occupied by the species of interest (MacKenzie 2006). The occupancy framework has been applied to both single species and multispecies camera trapping assessments in discrete or continuous habitats, with sites in which occupancy has not not changed over a sampling period (Burton, *et al*. 2012). Accurate modelling of mammal occupancy level requires robust observations and implicit assumptions that species are absent from locations where not detected (Guisan & Zimmermann, 2000, Mackenzie, 2006). In addition, the sampling situation should be carefully designed with cameras deployed in a probability-based design, i.e. sites are selected randomly and are a true representation of the entire population for the appropriateness and accuracy of inferences (Burton, *et al*. 2015).

Considering the presence and absence data from the camera trapping survey, a non-detection of species at a site does not confirm species absence (Burton, *et al*. 2015). The species might be present at the site, but undetected during the survey (MacKenzie 2006). However, repeated surveys have been found to minimize the possibility of declaring a species falsely absent from a location (MacKenzie 2006, Burton, *et al*. 2015).

During the course of this study, 28 passive infra–red camera traps (Bushnell trophy cam model number 119436) were available for the survey. The camera trap survey was conducted in 78 randomly selected squares across the Park. In each square, 3 points were randomly selected for the placement of camera traps. Hence, one passive infra-red camera trap was deployed in each randomly selected point (199 sites) across the Park. Camera stations were selected using a stratified random sampling technique. A stratified technique entails the division of an entire area or population into several sub-areas or populations (strata). Each stratum is individually more homogeneous and items are randomly selected from each stratum to constitute a sample (Kothari 2004, Sutherland 2006). Since each stratum is more homogeneous than the total population, estimating each component's parts accurately produces a better estimate of the whole. This design was used to obtain a sample that is representative of the entire study area, and to provide more reliable and detailed information (Kothari 2004, Sutherland 2006). The study area has already been stratified into five administrative ranges (strata) as mentioned in section 2.3. The survey squares (78 squares) and points (camera stations and/or sites) were randomly selected within each range to improve the detectability of a greater number of species without prior knowledge of species of interest using ArcGIS Environment (ESRI V.10). The randomly selected points were located in the field for placement of camera traps using a Global Positioning System unit (GPS – Garmin 62). Due to the low numbers of camera traps, the survey were carried out in each range sequentially. Cameras were programmed to take photographs of animals and other objects 24 hours per day throughout the survey period. Camera trap data was retrieved at the end of the 14-day survey period at each site. Data collection and analysis for the camera trap survey is detailed in the relevant subsequent chapters.

Distance sampling

The distance sampling method is widely used to determine mammal densities (Buckland, *et al*. 2005, Hounsome, *et al*. 2005). Population density is a measure of species abundance per unit area (Mills 2012). Abundance refers to the relative representation of a species in a particular ecosystem (Mills 2012). Estimates derived using the distance sampling method were found to be accurate when compared with other survey methods (Buckland, *et al*. 2005, Hounsome, *et al*. 2005). The main methods in distance sampling include line and point transects (Thomas, *et al*. 2002). Line transect sampling is simple, economical and relatively precise and, when combined with the programme DISTANCE (Thomas, *et al*. 2010), it produces unbiased estimates of density despite potential sources of error from the estimation transect and population density (Cassey and McArdle 1999). The method is ideal for surveying large mammals in open habitat, allowing population estimates from data collected through direct observations of animals seen from the line transect (Fernanda *et al*., 2001). However, given the need for a high number of detections (>40) (Peres 1999, Buckland, *et al*. 2005), this technique may not reliably estimate scarce, elusive or nocturnal animals (Obbard, Howe and Kyle 2010) . This due in part to low density or to the animals feeling insecure during the day due to human harassment or disturbance from other non-native species (Waltert, *et al*. 2006, Obbard, Howe and Kyle 2010). Therefore, a lot of effort is required adequately to capture rare and elusive species.

Generally, reliable results from any sampling exercise depend critically on a good survey design (Thomas, *et al*. 2010). The distance sampling technique relies on the basic principle of randomization and replication (Buckland, *et al*. 2005). Randomization involves randomly laying out transects within a study area. Standard analysis methods assume a uniform coverage probability, i.e. each point within the study area has the same probability of being sampled (Thomas, *et al*. 2002). This assumption is used at two points in estimation. Firstly, because the lines are randomly placed in respect to animals, the true density of animals close to the transect is the same as it is far from it. Therefore, any variation in the rate of animal detections with increasing distance from the line can be interpreted as variation in the rate of detection and not in the true density. This allows estimates of variation in detection rate with distance from the line, the average rate of detection, and density of animals in the sampled area (part of the study area surveyed by the sampler). Secondly, because all areas are equally likely to be sampled, the estimated density can be applied to the whole study area and not just the surveyed region (Thomas, Williams and Sandilands 2007).

Replication involves placement of multiple lines in the study area. This is required for assessment of uncertainty in design-based estimates. Increasing the number of replicate lines increases the reliability of variance estimates by having an equal total line length throughout the survey period (Marques, *et al*. 2001). In general, for a good design a minimum of 10-20 replicates should be considered. Also, a fixed total length with short lines is preferable to few long lines and is recommended (Plumptre 2000). The appropriate use of systematic and stratified random placement of sampling locations (lines or points) reduces variance (Buckland, Goudie and Borchers 2000, Buckland 2004) and promotes reliable inferences. A standard 60 to 80 observations of individual species is required for accurate and precise density estimates in distance sampling analysis (Sutherland 2006).

For the monitoring of large mammals in this study, a stratified random sampling design was employed. Two of the five ranges were systematically surveyed, a 1km x

9 transects with random starting points (the first transect was laid randomly) each in Oyo-Ile and Marguba range of the Park for security purpose. The remaining transects were laid at fixed intervals (every third trail/tracks were selected and surveyed). A random sampling technique was used in laying an equal length and a number of transects (1km x 9 transects) in each of the remaining three ranges of the study area. Within the five ranges that were surveyed, 45 transects were walked for a total distance of 45 km. therefore a total of 45 transects and 306 km of survey effort (Table 3.2) were included in the analysis. The establishment of transects and enumeration and census of animals in each range followed the protocols recommended by past researchers (Peres 1999, Buckland, *et al*. 2001, Buckland, *et al*. 2010). All signs of large mammals (animals > 3 kg of weight) were observed and recorded along transects by teams of two experienced observers (the researcher and a ranger) during the daylight. Signs included direct sightings, footprints, feeding activity/remains and hunting (feral dogs and human trails/foot prints). The vegetation of the study area has been classified as Southern Guinea savannah, characterised by forest savanna mosaic and wooded savanna. Therefore, visibility is best during the dry season and censuring conditions are excellent. Observations were made from ground level on foot with naked eyes. Occasionally, binoculars (Eagle Optics 10 x 50 Ranger SRT Binoculars) were used for accurate species identification at a distance beyond 50 metres. The distance between the animal(s) and the transect was determined with a laser rangefinder. Animal enumerations were conducted twice per day during the survey period. Further details on data collection and analysis are reported in the relevant chapters.

Stakeholder interviews

Over the past decades, social surveys have been found suitable, and are increasingly being used to obtain information for ecological studies (White, *et al*. 2005). Such information is vital since stakeholders and local communities are increasingly involved in biodiversity conservation. Indeed, local people have been identified to be reliable sources of information about the presence and absence of wildlife, and other biological information relevant to conservation effort (Folke 2004, White, *et al*. 2005). For instance, stakeholder questionnaires have been used in ecology to quantify human illegal behaviour (St John, *et al*. 2012), perception of animal status (Gandiwa 2012, Ngorima 2016) and attitude (Gadd 2005, Kideghesho, Røskaft and Kaltenborn 2007). However, such information could be too noisy to be informative and hence must be treated with caution (Gilchrist, Mallory and Merkel 2005). For example, data provided by rangers is open to error of omission and falsification through either negligence or on purpose, due to lack of motivation and dedication (Jachmann 2008). Despite this, such studies can provide reliable and cost-effective alternatives to large-scale field surveys for direct observation or signs of species that are rare and difficult to detect in a short survey period (van der Hoeven, Christiaan A, de Boer and Prins 2004, Anadón, *et al*. 2009, Gandiwa 2012).

Stakeholder surveys have proved effective in determining species abundance, particularly in human-dominated landscapes where factors such as theft or tampering of cameras, the need for large numbers of research team members, and funding are obstacles to the collection of data (Zeller, *et al*. 2011). In the absence of historical data, local people can also provide information on past situations which can be used to diagnose species decline within a short time frame and to evaluate baseline estimates of abundance (Lozano-Montes, Pitcher and Haggan 2008).

Pilot study

For this survey, two stakeholder groups (villagers and rangers) were identified and included in a face-to-face interview survey. Before the main data collection, the questionnaires (research instrument) comprising open and close-ended questions was designed and pre-tested between June and August, 2014 on 80 villagers and 40 Rangers (randomly selected) across the five ranges of the park. This was done to test the effectiveness, strength and consistency of the research instrument. After the pilot study, the villager questionnaire was sectioned into two parts and information from each section obtained using different methods Randomized Response Technique (RRT) and Direct Questioning (DQ). Entry of any kind into the Park is prohibited and the rangers patrolling each Range enforce the law by arresting any violators. Therefore, questions related to illegal use of park resources through DQ would have been difficult to employ in the surrounding local communities and considered sensitive. Considering the sensitivity (illegal activities) of the conservation issues under exploration, findings presented will not represent the true behaviour being studied, or produces biases due to the respondents providing untruthful answers or non-responses during data collection (Groves *et al*., 2006). In order to overcome these problems the RRT method was used. RRT is a novel, quantitative social research method designed specifically for investigating sensitive issues, such as quantifying illegal killing of carnivores (St John, *et al*. 2012, John, Mai and Pei 2015), illegal resource use (Arias and Sutton 2013), bushmeat hunting and consumption (Razafimanahaka, *et al*. 2012). Therefore, RRT was deemed suitable for investigating illegal extraction of park resources and/or rule breaking behaviour alongside the DQ method. It was also observed that some of the rangers were unable to provide reliable answers to the questions. This was due to them being either newly employed and/or transferred from another National Park to the study area, which led to the change in sampling method from random to purposive sampling (a non-probability sample selected based on the characteristics of a population and the objective of the study). Therefore, all the rangers in the protection unit of the Park were included in the actual survey.

Actual survey

A stratified multi-staged sampling design (Kothari 2004, Jain and Hausman 2006) was used for selecting the potential villagers to be surveyed. A list of 121 villages was provided by the range heads and the research officer (Olanrewaju Kazeem) of the park. The 121 villages were stratified into five ranges (strata). The first stage of sampling involved a random selection of 8 villages each from the five ranges I.E. the primary sampling unit (PSU) from the group of villages in each stratum (range). Selections were achieved using mechanical process (Kothari 2004, Sutherland 2006). Within the PSU, 20 household heads (secondary units) were randomly selected in each villages across the five ranges in the study area. This second stage of selection employed the use of an unconventional method (paper token) that gave each unit (household head) the same probability of being sampled (Sutherland 2006). Since the sampling unit was the household heads (the head of a group of people who were living together and have joint economic activities), and each village surveyed had more than 30 households which make the use of randomization relatively easy to implement. At the village level, there was no register or list of households, therefore to randomize in a classical way was challenging. A means of randomisation was thus invented in the form of a paper token of 40 pieces comprising 20 ‘Yes’ to be interviewed and 20 ‘Not’ to be interviewed. The representatives from each household in the village were asked to pick a token and the heads of the household whose representative picked ‘Yes’ were surveyed. Where the household heads were not available, a male child or representative above 18 years of age was surveyed. Therefore, 20 heads of households whose representatives picked ‘Yes’ to be interviewed were surveyed within each of the 40 villages (8 per Range across 5 Ranges), giving a total of 800 household heads. Besides flexibility, cost and time effectiveness, the multi-stage sampling method is effective for conducting social survey where face-face contact is required during primary data collection from a geographically dispersed population (Kothari 2004).

A reconnaissance investigation of the selected villages was done prior to data collection for the purpose of gaining acquaintance and to seek permission from the village heads. Consent was given (by all the household heads) after being duly informed of the research purpose and information was sent to each household in advance, in order for householders to become acquainted with the visit.

The survey survey team was constituted by the researcher, a research assistant and a translator/interpreter. Efforts were made to collect reliable data by recruiting an assistant, a Yoruba-speaking graduate in environmental sciences from the Osun State University, Nigeria who had previous experience in questionnaire based research. However, the research assistance was trained particularly on how to conduct the RRT survey. The local communities around the OONP comprised multiple ethnic groups, and therefore, communicating fluently with some of the non-speaking Yoruba’s was a challenge. Hence, there was a need for an interpreter with expertise in Fulani/Hausa languages. The assistance of a bi-lingual ranger, who could interpret in the Hausa/Fulani language and knew the routes to the villages was used to address this challenge. Together with the survey team, I was present at 283 of the face-to-face interviews.

A purposive sampling design was used to survey all the rangers (100) in the protection units across the five ranges of the park. This approach was used in order to obtain reliable data that provided an in depth understanding of the status and the associated drivers of large mammal populations in the study area. Permission was sort for and granted to conduct the survey by the conservator of the park at the head office of OONP. Consent was given by the range head and also the rangers involved after being duly informed of the research purpose.

The questions from the research instrument used in the relevant subsequent chapters are highlighted in Table 2.2 See Appendix 1 and 2 for the villager and ranger questionnaires.

Table 2.2.2 Lists of variables and scales for measuring the variables in stakeholders questionnaires administered in OONP during the 2015 survey. QN, question number in the questionnaire; NA, not applicable

Chapters	Villagers				Rangers			
Chapters	QN	Variables	Scales	Transformed scales	QN	Variables	Scales	Transformed scales
	1	Gender	Male Female	NA	1	Gender	Male Female	
	2	Age	Under 30 years 31 – 50 years 51years and above	NA	2	Age	Closed ended	Under 30 years 31 -40 years 41 – 50 years Above 50 years
	3	Annual income	N100,000 and below N110,000 – N200,000 N210,000 – N300,000 N310,000 – N400,000 Above N410,000	Low High	3	Education	Primary - level Secondary -level OND HND University degree None	Primary Secondary Tertiary
	4	Ethnicity	Yoruba Idoma Tiv Fulani Hausa Juku/bororo Ibariba Togolese Other	Yoruba Fulani Others - (PRC - people from other region and/or neighbouring country)	4	Annual income	Up to N250,000 per year N251,000 – N450,000 per year Above N451,000 per year	

Table 2.2 continued

	5	Education	Primary level Secondary level Tertiary level No formal education	Educated Not –educated	5	Length of service/years of experience	Closed ended	0 – 5years 6 – 10 years Above 10 years
	6	Primary occupation	Crop farmer Livestock farmer Mixed farmer Trader Charcoal maker Fisherman Other artisans Unemployed	Crop farmer Livestock- farmer Mixed -farmer Other- artisans	NA			

Table 2.2 continued

	7	Secondary occupation	Crop farmer Livestock farmer Mixed farmer Trader Charcoal maker Bushmeat Hunter and trader Fisherman Unemployed Other artisans	Have secondary occupation Do not have secondary occupation	NA			
Chapter three	8.3	Awareness of animal occurrence	Seen Not seen	NA	14	Awareness of animal occurrence	Seen Not seen	NA
	12.2	Perception of animal status	Increase Remain-unchanged Decreased Don't know	NA	15.2	Perception of animal status	Increase Remain-unchanged Decreased Don't know	NA

Table 2.2 continued

Chapter four	Section A (1-9) RRT	Nature and extent of illegal activities	Yes No	6	Motivation	Items/statements 1-5	Strongly disagree Disagree Indifferent Agree Strongly agree	Accepted Unsure Rejected
	1	Do you grow your own crop (control question)	Yes No	7	Job satisfaction	Items/statements 1-5	Strongly disagree Disagree Indifferent Agree Strongly agree	Accepted Unsure Rejected
	2	Since the National Park has been established in 1991, have you ever entered the park	Yes No	8	Recognitio n	Items/statements 1-5	Strongly disagree Disagree Indifferent Agree Strongly agree	Accepted Unsure Rejected

Table 2.2 continued

	3	Did you enter the National Park last week	Yes No	9	Role clarity	Items/statements 1-5	Strongly disagree Disagree Indifferent Agree Strongly agree	Accepted Unsure Rejected
	4	In the last 12 months did you ever enter the park to get fire wood	Yes No	10	Extent of illegal hunting	Every day Every week Every month Every 6 months Every year		NA
	5	In the last 12 months did you ever enter the park to hunt	Yes No	NA	NA	NA	NA	NA
	6	In the last 12 months did you ever enter the park to get plants and vegetables	Yes No	NA	NA	NA	NA	NA
	7	In the last 12 months did you ever enter the park to fish	Yes No	NA	NA	NA	NA	NA

Table 2.2 continued

	8	In the last 12 months did you ever take livestock into the park to graze	Yes No	NA	NA	NA	NA	NA
	9	In the last 12 months did you enter the park to view animals/sight-seeing without seeking permission	Yes No	NA	NA	NA	NA	NA
Section B (direct questioning)	8.1	Awareness of the park (question 1 - 14)	Agree Disagree Do not know					
	8.2	Awareness of illegal extraction of wildlife resources in OONP (question 1 – 6)	Agree strongly Agree Indifferent Disagree Disagree strongly No opinion	Accepted Rejected Unsure No opinion				

Table 2.2 continued

	12.1	Trend in illegal hunting	Increased sharply Increased slightly Remained constant Decreased slightly Decreased sharply	Increased Remained-constant Decreased	15.1	Trends in illegal hunting	Increased sharply Increased slightly Remained constant Decreased slightly Decreased sharply	Increased Remained-constant Decreased
Chapter five (section B – RRT Direct question)	5	In the last 12 months did you ever enter the park to hunt	Yes No	NA	NA	NA	NA	NA
	11	Source of protein consumed (lists contain fish, egg, beef (regarded as meat from domestic mammals), bushmeat and poultry	Every day Once a week Once a month Not at all	Consumed Not -consumed	NA	NA	NA	NA

Table 2.2 continued

Chapter six	11	Source of protein consumed (bushmeat)	Every day Once a week Once a month Not at all	Consumed Not -consumed	NA	NA	NA	NA

2.3.2 Ethics statement

This research had been approved by the ethics committee of Nottingham Trent University. All methods and protocols in this study were considered in terms of their impacts on animals, humans and the environment. Full permission was gained from the National Park Services and the management of OONP to conduct the camera trapping, line transect and stakeholders (rangers) surveys. For the stakeholders (villagers), advocacy visits were made to the village heads to obtain approval for the administration of the questionnaire. Informed consent was gained from the research participants (villagers) for both the pilot and the main survey. At the start of the face-to-face interview, a clear and detailed explanation was given to each participant on the aims of the study and how data will be stored and used and that their participation is voluntary. Due to low level of literacy in the area oral consent was obtained. Information obtained during the study was anonymous as no identifying information was collected and location of the study villages was anonymised when data was presented outside the research team. Ethical approval was given for the project by the NTU Ethical Committee on 12th May, 2014 with code ARE 89.

2.4 Description of participant characteristics

The sample population comprised of 100% males (N=800). This homogenous representation of males could probably be attributed to the study design, where household heads are the main target of the survey, and the general cultural norm in Nigeria is that men are the heads of the households and thus should speak on behalf of the family. More than two-thirds of the villagers are not educated (88.6%), belonging to the low income class (89%), engaged in agricultural related jobs – farming activities (61.2%) and lacked a secondary occupation (77.5%). Less than half of the villagers (≤ 44 %) indicated they frequently consumed fish and bushmeat while other sources of animal protein were indicated by all the respondents (100 %) to be frequently consumed. There is possibility of overestimation of animal protein source claimed to be consumed by respondents who indicated to frequently and/or occasionally consume animal protein. Overestimation distort true value and such effect may bias results. Therefore, other sources of animal protein (beef, egg and poultry) were dropped from further analysis in the relevant chapter (Chapter 5).

For the rangers, the sample population (N=100) comprised 94% males and 6% female respondents. Less than half (45%) of the sample had completed tertiary education while others had primary (11%) and secondary (44%) level of education. One-third (34%) earn up to N250, 000; N251, 000 – N450, 000 and 32% earn above N450, 000. Forty one percent of the rangers have worked in National Parks for over 10 years. The details of the socioeconomic characteristics of the villagers and rangers are presented in Table 2.3

Table 2.3 Socioeconomic and demographic characteristics of the respondents (villagers and rangers) in OONP during the 2015 stakeholders' questionnaire survey. Key: PRC, people from other region or country; SV; measuring scale for villagers, SR; measuring scale for the rangers, N; sample size, frequency and percentage in parenthesis (%), NA; not applicable.

Variable	SV	Frequency (%)	SR	Frequency (%)
Gender				
	- Male	800 (100)	- Male	94 (94)
	- Female	NA	- Female	6 (6)
Age				
	- Under 30 years	371 (46.4)	- Under 30 years	13 (13)
	- 31 – 50 years	321 (40.1)	- 31 – 40 years	49 (49)
	- Above 50 years	108 (13.5)	- 41 – 50 years	32 (32)
			- Above 50 years	8 (8)
Ethnicity				
	- Yoruba	475 (59.4)		NA
	- Fulani	246 (30.8)		NA
	- Others (PRC)	79 (9.9)		NA
Level of education				
	- Educated	91 (11.4)	- Primary	11 (11)
	- Not educated	709 (88.6)	- Secondary	44 (44)
			- Tertiary	45 (45)
Annual income				
	- Low income class	712 (89)	- Up to ₦250,000	10 (10)
	- High income class	88 (11)	- N251, 000 – N450, 000	57(57)
			- Above N450, 000	33 (33)

Table 2.3 continued

Primary occupation			NA	
	- Crop farmer	397 (49.6)		
	- Livestock farmer	243 (30.4)		
	- Mixed farmer	133 (16.6)		
	- Other artisans	27 (3.4)		
Secondary occupation			NA	
	- Have secondary occupation	180 (22.5)		
	- Do not have secondary occupation	620 (77.5)		
Length of service		NA	Length of service	
			- 0 -5 years	17 (17)
			- 6 – 10 years	43 (43)
			- 11 – 15 years	19 (19)
			- Above 15 years	21(21)
Source of animal protein consumption			NA	
Fish	- Not consumed	239 (29.9)		
	- Consumed	561 (70.1)		
Egg	- Not consumed			
	- Consumed	800 (100)		
Beef	- Not consumed			
	- Consumed	800 (100)		
Bushmeat	- Not consumed	449 (56.1)		
	- Consumed	351 (43.9)		
Poultry	- Not consumed			
	- Consumed	800 (100)		

Chapter 3: Large mammal population assessment in Old Oyo National Park using a multi-disciplinary approach

3.1. Introduction

Populations of large mammals are declining globally (Ripple *et al*. 2016), and it is commonly recognised that substantial declines are occurring in protected conservation areas including those on the continent of Africa (Ciani, *et al*. 2005, Ogutu, *et al*. 2011). The rate of decline is also alarming (Kormos and Boesch 2003, Foguekem, Tchamba and Omondi 2010, Jimoh, *et al*. 2013, Henschel, *et al*. 2014). Over 35 year period between 1970 to 2005, there has been a 59% decline in populations of large mammals in Africa, and a decline of 85% was also reported more specifically in Western Africa (Bouché, *et al*. 2010, Craigie, *et al*. 2010, Scholte 2011, Ripple, *et al*. 2014). In addition, 7 of the 16 commonly occurring African carnivore species may now be fully extinct at Mole National Park, Ghana (Cole Burton, *et al*. 2011), and low abundances have been reported for lion in 4 out of the 21 large Protected Areas (PAs) within their historical range (Henschel, *et al*. 2014). The observed decline is not exclusive to large carnivores. Elephant are now only found in small numbers and are scattered across the region (IUCN 2007) and there has been a 60% decline in the majority of the 11 most abundant ungulates between 1978 and 1998 in Comoe National Park, Ivory Coast (Fischer and Linsenmair 2001). The observed decline in large mammal populations has been linked to various anthropogenic activities in and around PAs at local, national and regional levels (Fischer and Linsenmair 2001, Craigie, *et al*. 2010, Scholte 2011).

The causes of large mammal declines in West Africa mirror the general causes of global population declines, namely habitat loss and fragmentation, overexploitation, competition, and conflict with ranchers and farmers (Wilkie, *et al*. 2005, Burton, *et al*. 2012). However, the rate of decline may be underestimated in developing countries because large mammal population assessments and monitoring processes are constrained due to limited resources, thereby making sustainable management increasingly difficult (Bouché, *et al*. 2010, Craigie, *et al*. 2010, Scholte 2011, Ripple, *et al*. 2014).

Nigeria is one such country, with an historically rich biodiversity which is facing unprecedented pressures on its natural resources from a rapidly growing human population. The population of Nigeria currently stands at 174.5 million, with a predicted annual growth of 2.4% (CIA 2010). Many of Nigeria's large mammals are thought to be declining and at risk of extinction (Afolayan, Milligan and Salami 1983, Anadu and Green 1990, David 2008, Jayeola, *et al*. 2012, Oladipo and Abayomi 2014, Idowu and Morenikeji 2015) and recent evidence highlights the disappearance of some species at the local and national level (Henschel, *et al*. 2014, Idowu and Morenikeji 2015). The principal drivers of this decline are regarded as habitat encroachment and fragmentation, plus over-exploitation for bushmeat, (Afolayan, Milligan and Salami 1983, Anadu, Elamah and Oates 1988, Henschel, *et al*. 2014, Idowu and Morenikeji 2015).

Despite the acknowledgement that large mammals are under severe pressure in Nigeria, the scale of the problem is relatively unknown due to a lack of robust and long term monitoring programmes (Afolayan, Milligan and Salami 1983, Anadu and Green 1990, David 2008, Henschel, *et al*. 2014). In most tropical environments, the main limitations to monitoring large mammal populations are the low detectability associated with a species' elusive nature and low population densities, combined with dense vegetation cover (Tobler, *et al*. 2008, O'Connell and Bailey 2011). However, various researchers have conducted surveys to obtain presence-absence data and also to estimate species density and abundance in such habitats (Afolayan, Milligan and Salami 1983, Akinyemi and Kayode 2010, Oladipo and Abayomi 2014). For example, although Nigeria has a total of 247 mammalian species (including apex carnivores, herbivores and rodents) found across 7 National Parks (NFNBR, 2016), only a handful of studies have reported the status of large mammals across the country and these are often restricted to a few species of primates within the National Parks. Nevertheless, the majority of reports observed a decline in numbers of Nigeria Cameroon chimpanzee (*Pan troglodytes ellioti*), and baboon-sized drill (*Mandrillus leucocephaeus*) in Cross River National Park and Gashaka Gumti National Park (Beck and Chapman 2008, David 2008, Hughes, *et al*. 2011, Buba, *et al*. 2016). This lack of baseline information on wildlife population across Nigeria's PAs further exacerbates conservation problems (Afolayan, Milligan and Salami 1983, David 2008) as, in the absence of quality population data, it is difficult to monitor population changes and determine whether current conservation management practices are appropriate (Gibbs, Snell and Causton 1999, Boddicker, Rodriguez and Amanzo 2002, Hoppe-Dominik, *et al*. 2011).

At Old Oyo National Park (OONP), 26 large mammal species were observed between 1960 and 1970 including large herbivores such as elephant and buffalo, and carnivores such as lion, leopard, spotted hyena, and wild dog (Afolayan, Milligan and Salami 1983, Oladipo and Abayomi 2014). However, recent evidence shows a decline in mammal numbers between 1983 and 2014 (Akinyemi and Kayode 2010, Oladipo and Abayomi 2014, Oyeleke, Odewumi and Mustapha 2015). However, the last complete mammal abundance data collected in OONP was in 1979 (Afolayan, Milligan and Salami 1983), before the Upper Ogun Game Reserve and Oyo-Ile Forest reserve was merged and upgraded to a National Park. Therefore, these findings cannot serve as a baseline for OONP. In addition, the sampling design employed at the time was not robust enough to estimate any population parameters (Long, *et al*. 2012). An indirect sampling technique that involved counting of animal tracks, faecal droppings and footprints was employed due to poor visibility in the dense woodlands (Afolayan, Milligan and Salami 1983). Therefore, animal population estimates could not be computed for the Reserve (Afolayan, Milligan and Salami 1983) making the findings (population indices) less informative for conservation management purposes (Hayward, *et al*. 2015). Furthermore, the survey methods failed to accurately determine the presence of species that currently exist in the park, producing conflicting information on the presence and absence of species such as western hartebeest and buffalo (Akinyemi and Kayode 2010, Oladipo and Abayomi 2014, Oyeleke, Odewumi and Mustapha 2015), Oyeleke, Odewumi and Mustapha 2015). More recent studies conducted in OONP document population estimates for five species (Akinyemi and Kayode 2010), and presence-absence data for all species (Oladipo and Abayomi 2014). However, none of these are comprehensive surveys of the large mammal community in OONP. Given the increasing pressure from illegal anthropogenic activities in many of Nigerian's PAs, most studies lack robust techniques that consider the social aspect of ecological problems (Brittain 2013, Muhumuza and Balkwill 2013, Martinez-Marti, *et al*. 2016) and or provide baseline ecological data necessary for conservation management.

In this study, a multi-disciplinary approach that combined camera trapping, line transects and questionnaire surveys to account for differential detectability and incorporate a robust technique that provides reliable data (MacKenzie 2006). The camera trapping method was used to detect and quantify the presence of multiple species. For more detailed information on the density of large herbivores, a line transect distance sampling method was used, to which future monitoring can be compared. Since there is lack of information on species abundance in the park, and people's perceptions of species abundance can provide understanding on what the status of mammals is currently and historically (Steinmetz 2000, Gandiwa 2012), a stakeholder (villagers and rangers) questionnaire was conducted. This was aimed at villagers as they were more likely to exploit the park's resources, and rangers as they are tasked with protecting the natural resources of the park.

This chapter aims to assess the status of large mammal species in Old Oyo National Park in Nigeria, using information derived from two field surveys and a stakeholder questionnaire.

Specifically, this chapter aims to:

- Report the species composition and richness of large mammals within OONP using camera traps
- Determine estimates of occupancy and detection probability of each species observed in OONP
- Determine the density of the common species in OONP using distance sampling
- Report the perception of villagers and rangers regarding the status of large mammals in OONP

- Collate the above measures for large mammals in OONP in order to gain an overall understanding of the current status of mammal species, relative to available historic data

3.2. Methods

Between January and July 2015, a combination of camera trapping and walked line transects was used to determine the large mammal species composition, richness, occupancy and density in OONP. In addition, questionnaire surveys of local villagers and park rangers were conducted to assess their current perception of the status of large mammals in the park, compared to five years ago.

3.3. Camera trap survey

Camera trapping was used to collect data on species composition, richness and occupancy in the study area. The use of a camera trap was prompted by its efficiency and suitability for surveying low density and elusive species that would otherwise be difficult to observe using conventional observational techniques (Karanth, *et al*. 2006, Rowcliffe, *et al*. 2008, Roberts 2011).

3.3.1. Selection of sites and setting of camera traps

The study area was divided into 1x1 km grid squares in ArcGIS Environment (ESRI V. 10). A 10km buffer was created around each administrative range to reduce potential edge effects caused by high anthropogenic activity, which could negatively bias estimates of species abundance. A stratified random sample of 20 squares was selected for camera trapping within a 10km square around each of the 5 ranger stations (to aid accessibility), giving a total of 100 selected $1km^2$ survey squares in OONP (Figure 3.1). Three random points were generated on ArcGIS in each 1km square and considered to be the sampling sites for camera traps without *a priori* knowledge of species abundance or composition (Figure 3.1). The waypoints for each sampling site were uploaded into a Global Positioning System unit (GPS – Garmin 62) and navigated to in order to place camera traps in the field. If the initial GPS location fell in open canopy, areas that lacked trees, or rocky or excessively steep areas, cameras were repositioned no more than 100 m from the original location. Surveys were only possible in 78 of the 100 selected sites, with 22 survey squares proving impossible to access, due to threats of attack by poachers as determined by the rangers.

Each camera location consisted of one passive infrared camera trap (Bushnell Trophy Cam model number 119436). Each camera was attached to a tree via a strap, set at a height of 30 cm from the ground (Figure 3.2) and positioned at an optimum angle for sensor detection for a range of different mammal species (Kays, *et al*. 2008). Camera sensor sensitivity was set to medium, to reduce triggering by moving vegetation, and the number of photographs taken per detection was set to 3, with a 59 second delay between photo series. Once placed, reinforced cable locks were used to prevent damage or theft of cameras (Kays, *et al*. 2008). The sampling method was passive, so no attractants were used to lure animals to the camera location to enhance detection rates.

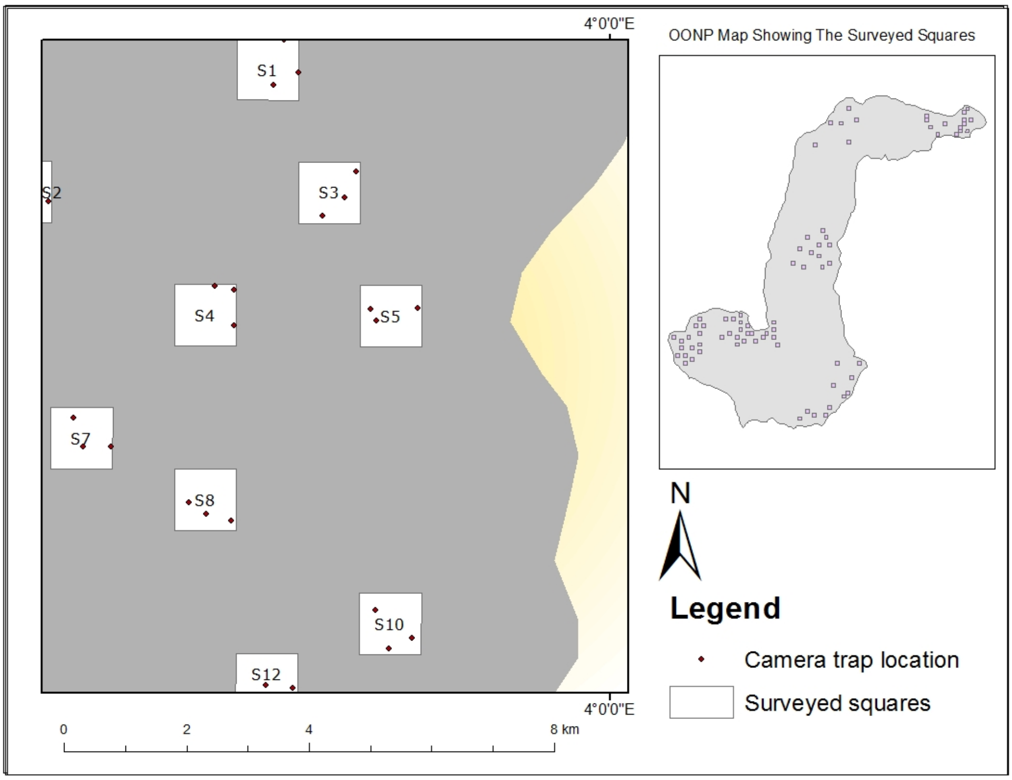


Figure 3.1 Map of OONP showing the randomly selected squares for the camera trapping survey, and a close-up view showing camera trap locations within each square.

Figure 3.2 Setting of camera trap

3.3.2. Data collection

Prior to the actual survey, a pilot study was carried out between June and August 2014 to assess the effectiveness of the camera trap survey method in determining the species composition and presence of large mammals in a landscape with a considerable risk of anthropogenic pressure. Standard camera trapping methodology was undertaken in 35 accessible squares across the park (MacKenzie 2006). However, few cameras detected large mammals within 5 days of camera trapping in each station, suggesting the need to increase the survey effort for the final sampling design. According to Shannon *et al* (2014), rare species with low detection rates require a minimum of 10 days to capture at least one image, depending on the abundance of the species. Hence, the sampling period was increased in this study from 5 to 14 days to improve detection during the actual survey.

The actual survey took place from January to July 2015. Camera traps were left in location for a period of 14 days to establish a species inventory across the park and presence at each camera trap location. During the survey, 2 cameras malfunctioned, 5 were stolen and 3 were vandalized. The affected camera locations are not included in any analyses. The survey effort for camera trap survey was presented in Table 3.1. At the end of the sampling period, memory cards were recovered and images of mammal species were identified using Kingdon (2015) and verified by RWY.

Table 3.1 Survey effort calculated for camera trap study in 2015. The number of squares surveyed, number of repeats and total number of sites removed in each range is shown with the total survey effort in each range and across the park.

Survey efforts						
Range	No. of squares surveyed	No. of repeats	No. of sites removed	Total no. of sites surveyed	No. of trap days	Survey effort (trap days)
Oyo Ile	20	3	3	57	14	798
Marguba	20	3	4	56	14	784
Tede	15	2	1	29	14	406
Sepeteri	12	3	0	36	14	504
Yemoso	11	3	2	21	14	294
total	78	16	10	199	14	2786

3.3.3 Data analysis

A species list was compiled for animals captured by the cameras (see Table 3.3). All images of mammals, hunters and domestic livestock were used in analyses. Species richness, defined as the total number of different species present/detected by the camera trap throughout the survey period, was calculated for each of the five administrative ranges across the park as the number of species per unit area.

The Relative Index of Abundance (RIA) for all mammal species was calculated by the number of days each species was captured on a camera, divided by the total number of days a camera was set, multiplied by the number of cameras.

$$\text{Relative Index of Abundance} = \frac{\text{Number of days each species was captured}}{\text{Number of survey days X Number of cameras}}$$

Note: Number of survey days is the total number of days each camera was set at each survey site

One way Analysis of Variance (ANOVA) test was conducted to compare RIA of each species across ranges.

3.3.4 Occupancy estimates of large mammals

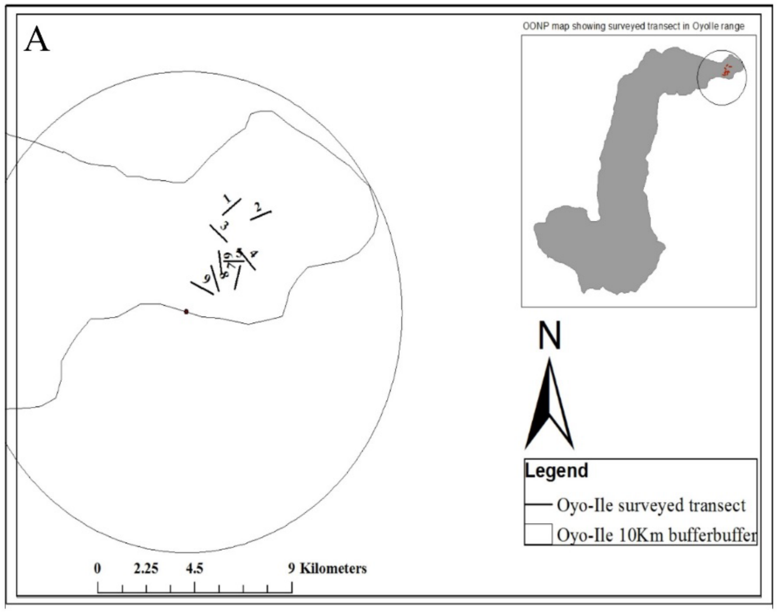
Single species/single season occupancy models were produced using the program PRESENCE 6.4 (Hines 2006), to estimate the probability that a site was occupied by a given species (ψ) and the detection probability of the given species (p) (MacKenzie 2006). Species-specific detection histories were generated for each of the squares surveyed across the study area. Within the 14-day sampling period, species were either recorded as 'present', denoted by '1', or 'absent', denoted by '0'. The three repeat camera trap locations were treated as three separate sampling occasions (Long, *et al*. 2012). Occupancy models were produced with covariates that were perceived to predict mammal occupancy. Environmental covariates (vegetation cover/habitat type) at each camera station was extracted from the land cover map of OONP (produced by the Institute of Ecology and Environmental Studies, Obafemi Awolowo University, Ile-Ife, Nigeria) using ArcGIS 9.3.1. Two different habitat classifications were used as covariates: 1) Forest; 2) Savanna. Anthropogenic covariates included the RIA of human hunters and domestic cattle (see section 3.3.3). A proximity covariate, the straight line distance in metre from the centre of each site (square) to the nearest road, river or village was calculated using the NEAR tool on ArcGIS 9.3.1., as other studies have shown that roads and human settlements can impact upon the occupancy of large mammals (Dumbrell, *et al*. 2008, Vanthomme, *et al*. 2013). All continuous site covariates were standardized to z-scores to normalise the data for occupancy analysis (Field 2013).

The potential covariates were allowed to vary individually or in combination for occupancy. Occupancy was either maintained in global models (combination of potential covariates) or the candidate model (individual covariates) or remained constant (without covariates). Simpler models were also considered where both occupancy and detection probability were kept constant. Model fit was assessed by estimating the mean dispersion parameter c-hat ($\hat{c}$), for the top best fitting models using 1000 parametric bootstraps, as recommended by (MacKenzie, Bailey and Nichols 2004). Models with $\hat{c}\sim1$ were regarded as being adequate descriptors of the data while models with $\hat{c}>1\leq2$ were also considered (Lebreton, *et al*. 1992). $\hat{c}>2$ suggested that there was more variation in observed data than expected by the model (Burnham and Anderson 2003) so these models were rejected. Model selection was ranked in order of parsimony for each species using Akaike's Information Criterion (AIC) by minimum ΔAIC $\leq$ 2. Models with AICwgt $\leq$ 0.05 were also removed (Burnham and Anderson 2003). Model averaging was used to estimate occupancy, detection probability and covariate coefficients when multiple models provided adequate descriptions of the data to compare their relative importance for each species. Results were compared for covariate types across all analyses on site occupancy and detection probability of mammals. All models that failed to converge (I.E. the standard error is very large relative to the occupance value) were excluded from the analysis.

3.4 Line transects and distance sampling

3.4.1. Line transect selection

A stratified random design was used to lay transects (Thomas *et al.,* 2010) across the park. Nine transects of 1km length were systematically laid in two of the park ranges: Oyo-Ile (in Agbaku, Kosomonu and Leere area) and Marguba (Odokoko, Yemoso hill and Afawole area) (Figure 3.3 A and B), to avoid possible attack from poachers and herdsmen, as suggested by the rangers. Nine transects of 1km length were randomly laid in each of the three remaining ranges (Figure 3.4 and 3.5). All 45 transects were also laid independently of animal locations (along camera trap sites, existing tracks and trails), to aid accessibility. The line transect survey was conducted at the same time as the camera trap survey, from January - July 2015.



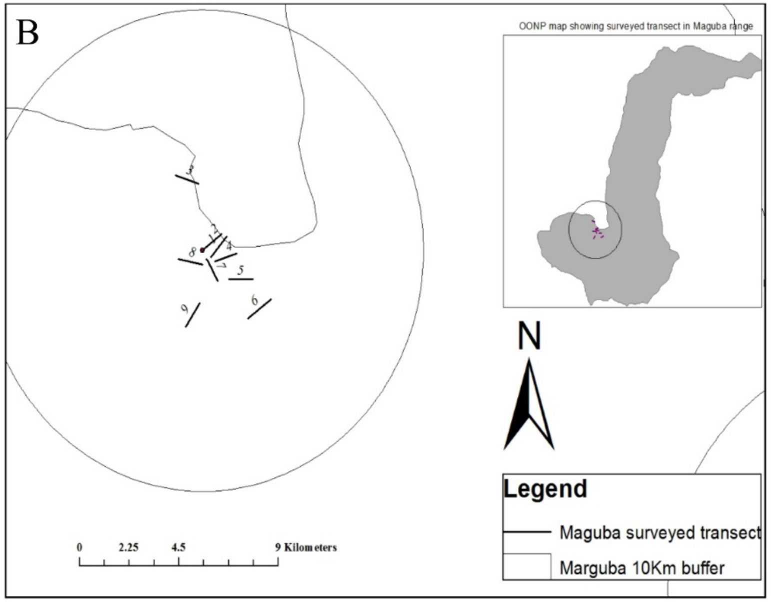


Figure 3.3 A and B maps showing the transects walked during the 2015 line transect animal census in (A) Oyo-Ile range and (B) Marguba range of Old Oya National Park, Nigeria.

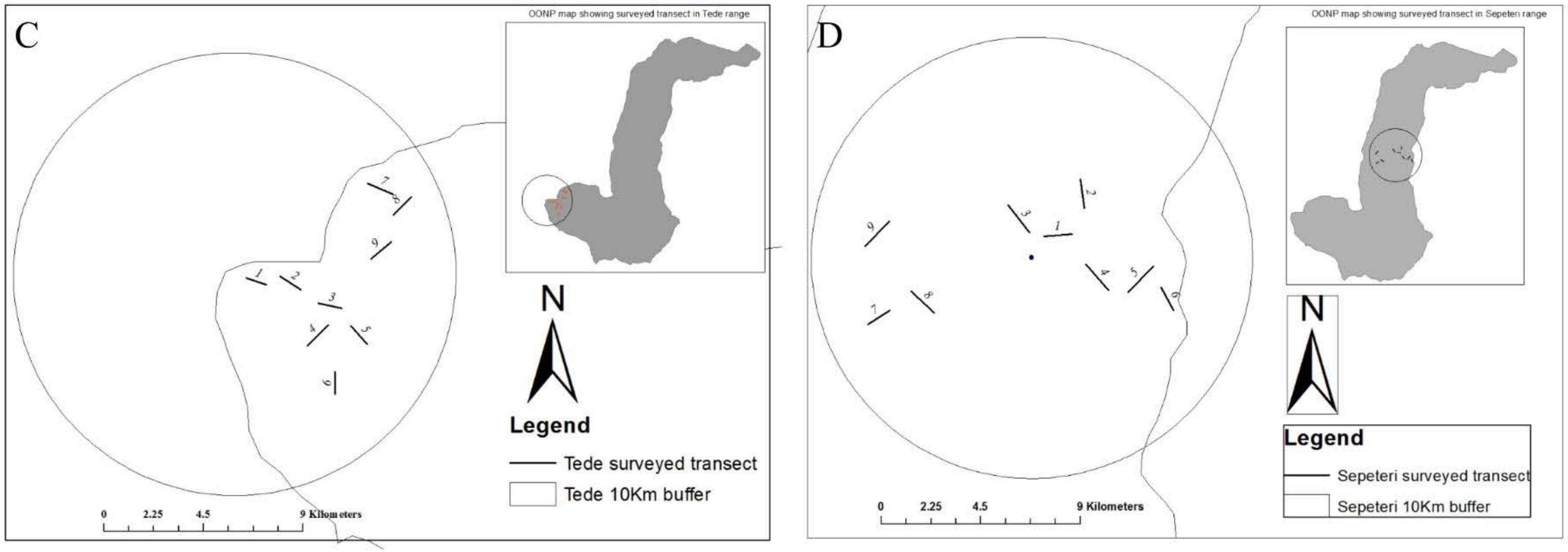


Figure 3.4 C and D Maps showing the transect walked during the 2015 line transect animal census in (C) Tede range and (D) Sepeteri range of Old Oyo National Park, Nigeria

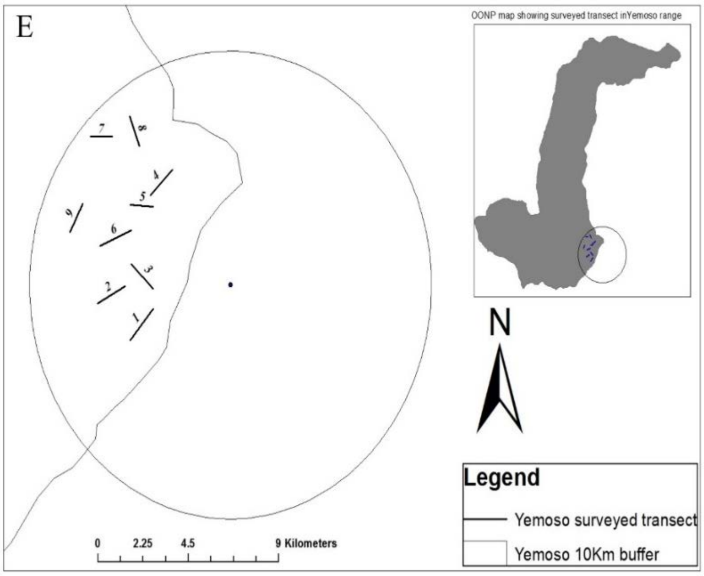


Figure 3.5 Map showing the transect walked during the 2015 line trasnect animal census in Yemoso range of Old Oyo National Park, Nigeria.

3.4.2. Data collection

Each transect was surveyed twice, one day per week for a period of three weeks (ie six repeats) in Oyo Ile, Tede, Sepeteri and Yemoso ranges. However, at Marguba range ten repeats (five weeks of survey) were conducted due to easy access to the study sites (Table 3.2). All transects were located on established tracks, such as old cattle and animal trails, therefore, resulting estimates may be subject to bias associated with track presence (Buckland, *et al*. 2001). Large mammals were recorded during the morning (06:30-11:30) and evening (15:00- 18:00) (Peres 1999) between January and July 2015. Rapid and total counts of individuals of the targeted species (large mammals) were carried out on 9 X 1km transects in each of the five ranges of the park during the survey. Surveys were conducted on dry days only as mammals are less active when it rains (Peres 1999). Animal censuses were conducted by a single observer (the author) who is proficient in animal detection and species identification. Transects were walked slowly by two observers, 10-25cm apart at 1.0-1.2 km/hr, in search of large mammals. The survey was conducted between the pick of dry season and the onset of rainy season, hence the vegetation in the park was thin which make animal census easy. Observations were made by naked eye up to 80 metres for medium sized. Confirmation were made for certain species sighted at a distance greater than 50 metres with the use of binoculars (Eagle Optics 10 x 50 Ranger SRT Binoculars). During the transect, a standardized data sheet was used for collecting transect length (measured with a GPS Garmin 62), sighting angle between animal and line transect (measured with a standard Silva compass), sighting distance between observer and animal (measured with a Nikon Laser 1200 Rangefinder), time, and the number and species of any animals sighted.

Table 3.2 Survey effort for large mammal line transects in Old Oyo National Park in 2015. The number of independent line transects walked (NIL), the number of repeats (NR) and Total survey effort (km walked) in each range is shown

Range	NIL	NR	Total survey effort (km)
Oyo Ile	9	6	54
Marguba	9	10	90
Tede	9	6	54
Sepeteri	9	6	54
Yemoso	9	6	54
Total	45	40	306

3.4.3. Large mammal density estimates

Density (number of animals per km^2) was calculated for each species from the perpendicular distance of the animals to the transect line, using the program DISTANCE 5.0 (Thomas, *et al*. 2010), with outlier observations being truncated to improve subsequent model fitting (Buckland, *et al*. 2001). Species were mostly detected in clusters, therefore detection refers to the detection of a cluster of animals. If clusters occur singly, then all clusters are of size one and cluster density is animal density. Cluster density and animal density were estimated using the Program DISTANCE. The quality of the statistical models (model fit) for dataset for each species were judge using Akaike Information Criterion (AIC) values. The model with the lowest AIC was the best possible model chosen: often the half-normal model with cosine adjustments. . Estimates of the following parameters were generated: encounter rate (n/L), average probability of detection (*p*), cluster density (>*D* s), cluster size (>Y) and animal density (>*D*). The recommended number of independent detection events (> 40 sightings) per species per census for the program DISTANCE (Peres, 1999; Buckland *et al.*, 1993; 2010) was only achieved for kob (75 sightings), with a maximum of 40 sightings for bushbuck and baboon. However, all three species densities were calculated in DISTANCE.

The encounter rate for each species was calculated using the formula:

$$\text{Encounter Rate} = \frac{\text{Number of sightings}}{\text{Total distance walked}}$$

Note: Number of sightings is the total number of sightings achieved for each species throughout the survey period

For species with less than 40 detections, a Relative Index of Abundance was calculated using the formula:

$$\text{RIA} = \frac{\text{Total number of individual species sighted}}{\text{Total distance walked}}$$

Note: total number of individual species sighted throught the survey period

Data were pooled and treated as a single sample for each species detected.

3.5. Villager and ranger perceptions of the status of large mammals

The perception of villagers and rangers regarding the presence and population trends of large mammals in OONP was elucidated through a questionnaire survey.

3.5.1. Sampling and data collection

Two stakeholder groups were identified as potentially having knowledge of the status of large mammals in OONP: the villagers within 10km of the park boundary, and the rangers who regularly patrol the park. For the villagers' survey, a stratified multi-staged sampling method was used. The sampling design and data collection are detailed in section 2.3.1 of Chapter 2.

For the rangers' survey, a purposive sampling method was used (see Chapter 2 for detailed description of the sampling method). The specific questions for the rangers and the associated scales of measurement for each variable in this present chapter and other chapters are detailed in Table 2.2.

The status of large mammals in the study area was measured by asking the following questions of both villagers and rangers:

(i). in the last 12 months, which of these animals have you seen inside OONP? Indicate by ticking seen/not seen (lists of species in the historical record of the park in the last 35 years were given).

(ii). Please tick one box which best describes what you think has happened to the numbers of species listed within the last five years inside OONP. Boxes to tick were increased, remain unchanged, decreased and don't know. The list of species in the historical records of the park was given.

Perceptions of the villagers and rangers on the status of large mammal species in the study area was thus investigated and compared to the field data and historical species records.

3.5.2. Data analysis of the questionnaire survey

Data were analysed using descriptive statistics (counts and percentages). All analyses were conducted using Microsoft Excel (2013) (Walkenbach 2013) and Statistical Package for Social Sciences (SPSS) version 22 software (SPSS 2013).

3.6. Results

3.6.1 Species composition and richness

A total of 25 species of wild mammals belonging to 8 mammalian orders were detected using the camera trap and line transect surveys: Artiodactyla, Carnivora, Largomorpha Pholidota, Primates, Proboscidea, Rodentia and Tubulidentata (Table 3.4). Data from 10 sites where cameras malfunctioned and/or are stolen was discarded giving a total of 199 sites surveyed across 78 squares (Table 3.1). Domestic cattle and humans (hunters) were also recorded but excluded from this chapter as they are reported in depth in Chapter 4.

Of the 25 species detected in this study, 23 were detected from the camera traps whereas only 13 were sighted directly on line transects. A total of 13 and 14 species were indicated as seen by the villagers and rangers, respectively (Table 3.2). The following species were detected in all surveys: aardvark, bushbuck, duiker, grasscutter, hare, kob and roan antelope.

Of the 28 species previously recorded in the park, fewer large mammals (22 species) were recorded in this study, suggesting a decline in species richness. Oribi, lion, leopard, spotted hyena, elephant and wild dog were not detected by any method in this study despite historical records of presence, indicating they may have become locally extirpated. However, four additional species: **caracal**, **crested porcupine**, **ground pangolin** and side-stripped jackal, which were not present in the historic records, were observed in this study via the camera traps. Three of the four species not seen previously are nocturnal so harder to observe, certainly by the villagers.

Mammal species richness during the camera trapping and line transect surveys was similar in each of the five ranges (range = 11-19 species, mean = 14, SD = 3) (Figure 3.6; Appendix 3). Marguba range had the highest species richness (19 mammals), whereas Tede had the lowest (11). Although aardvark, bush pig, caracal, jackal, pangolin, porcupine, red colobus monkey and white-throated monkey were found in only one range each, 17 species were found in more than 2 ranges and during camera trapping surveys, 6 species were detected in all five ranges. The RIA for the nine species (aardvarks, bush pigs, caracals, pangolins, porcupines, ground squirrels, side-stripped jackals, tantalus monkey and western hartebeest) that were not frequently detected by the camera trap was low (≤ 0.005). The species with the lowest RIA were aadvark, caracal and pangolin (RIA < 0.005) while the bushbuck has the highest RIA (0.039). The RIA of mammals was highest in Sepeteri followed by Marguba, Oyo-Ile range, Yemoso and lowest in Tede range (Figure 3.7). Of the 17 species found in more than 2 ranges, there were significant difference in RIA of nine species within the five ranges. The species are: baboon, roan antelope, water buck, western hartebeest, red flanked duiker, scrub hare and tantalus monkey (Table 3.3). There was no significant difference in RIA of the remaining eight species namely: bushbuck, civet, giant rat, grasscutter, long snouted mongoose, red patas monkey, warthog and ground squirrel) within the five ranges. The RIA for 23 species of large mammals in the five ranges of the park was highest for bushbuck, followed in descending order by civet, and kob

(Figure 3.8). The species with the lowest RIAs were aardvark, caracal, and pangolin, with only one image captured of each species during the study.

Table 3.3 The result of one way ANOVA comparing the RIA of species across the 5 ranges in OONP. Species; F statistis, P = level of significant (*)

Species	F (statistic)	P
Baboon	6.93	.000***
Bush buck	0.68	.606 ns
Civet	0.88	.483 ns
Duiker	2.68	.038*
Giant rat	1.65	.172 ns
Grass cutter	0.59	.675 ns
Ground squirrel	2.15	.083 ns
Kob	6.73	.000***
Long snouted mongoose	1.956	.110 ns
Red flanked duiker	8.52	.000***
Red patas monkey	0.930	.451 ns
Roan antelope	2.78	.033*
Scrub hare	4.17	.004**
Tantalus monkey	3.43	.013*
Warthog	2.20	.077 ns
Water buck	4.21	.004**
Western hartebeest	4.16	.004**

Degree of freedom for all anova numerators is 4 and for denominator is 73. *Sig at 5% level or $P \leq .05$; **sig at 1% level or $P \leq .01$; ***sig at $P \leq .000$; "not significant (ns) at $P \geq .05$.

Table 3.4 A list of mammalian species recorded by camera trap, line transect and questionnaire surveys at Old Oyo National Park. NA (not applicable) indicates the species were not included in the questionnaire. Historical lists were obtained from past studies conducted in OONP (Afolayan, Milligan and Salami 1983, Akinyemi and Kayode 2010, Oladipo and Abayomi 2014, Oyeleke, Odewumi and Mustapha 2015).

						Stakeholder	
Species	**Scientific name**	**Order**	**Historical list**	**Camera trap**	**Line transect**	**Villager**	**Ranger**
aardvark	*Orycteropus afer*	Tubulidentata	yes	yes	no	yes	yes
african civet	*Civettictis civetta*	Carnivora	yes	yes	no	yes	yes
buffalo	*Syncerus cafer*	Artiodactyla	yes	no	no	no	yes
bushbuck	*Tragelaphus scriptus*	Artiodactyla	yes	yes	yes	yes	yes
bush pig	*Potamochoerus porcus*	Artiodactyla	yes	yes	no	NA	NA
cane rat	*Thryonomys gregorianus*	Rodentia	yes	yes	yes	yes	yes
caracal	*Felis caracal*	Carnivora	no	yes	no	NA	NA
crested porcupine	*Histrix cristata*	Rodentia	no	yes	no	NA	NA
elephant	*Loxodonta africana*	Proboscidea	yes	no	no	no	no
giant pouched rat	*Cricetomys*	Rodentia	yes	yes	no	NA	NA
ground pangolin	*Smutsia temminckii*	Pholidota	no	yes	no	NA	NA

kob	*Kobus kob*	Artiodactyla	yes	yes	yes	yes	yes
leopard	*Panthera pardus*	Carnivora	yes	no	no	no	no
lion	*Panthera leo*	Carnivora	yes	no	no	no	no
long-snouted mongoose	*Herpestes naso*	Carnivora	yes	yes	no	yes	yes
Maxwell's duiker	*Cephalophus maxwelli*	Artiodactyla	yes	yes	yes	yes	yes
olive baboon	*Papio anubis*	Primates	yes	yes	yes	NA	NA
Oribi	*Ourebia ourebi*	Artiodactyla	yes	no	no	NA	NA
patas monkey	*Cercopithecus (Erythrocebus) patas*	Primates	yes	yes	yes	NA	NA
red-flanked duiker	*Cephalophus rufilatus*	Artiodactyla	yes	yes	no	NA	NA
red colobus monkey	*Piliocolobus sp.*	Primates	yes	no	yes	NA	NA
roan antelope	*Hippotragus equinus*	Artiodactyla	yes	yes	yes	yes	yes
scrub hare	*Lepus saxatilis*	Largomorpha	yes	yes	yes	yes	yes
side-stripped jackal	*Canis adustus*	Carnivora	no	yes	no	NA	NA

spotted hyena	*Crocuta crocuta*	Carnivora	yes	no	no	no	no
striped ground squirrel	*Euxerus erythropus*	Rodentia	yes	yes	yes	NA	NA
tantalus monkey	*Cercopithecus (aethiops) tantalus*	Primates	yes	yes	no	NA	NA
warthog	*Phacochoerus africanus*	Artiodactyla	yes	yes	yes	yes	yes
waterbuck	*Kobus ellipsiprymnus*	Artiodactyla	yes	yes	no	yes	yes
western hartebeest	*Alcelaphus buselaphus*	Artiodactyla	yes	yes	yes	yes	yes
white-throated monkey	*Cercopithecus erythrogaster*	Primates	yes	no	yes	NA	NA
wild dog	*Lycaon pictus*	Carnivora	yes	no	no	no	no
Primates		Primates	yes	NA	NA	yes	yes
Total			***28***	***23***	***13***	***13***	***14***

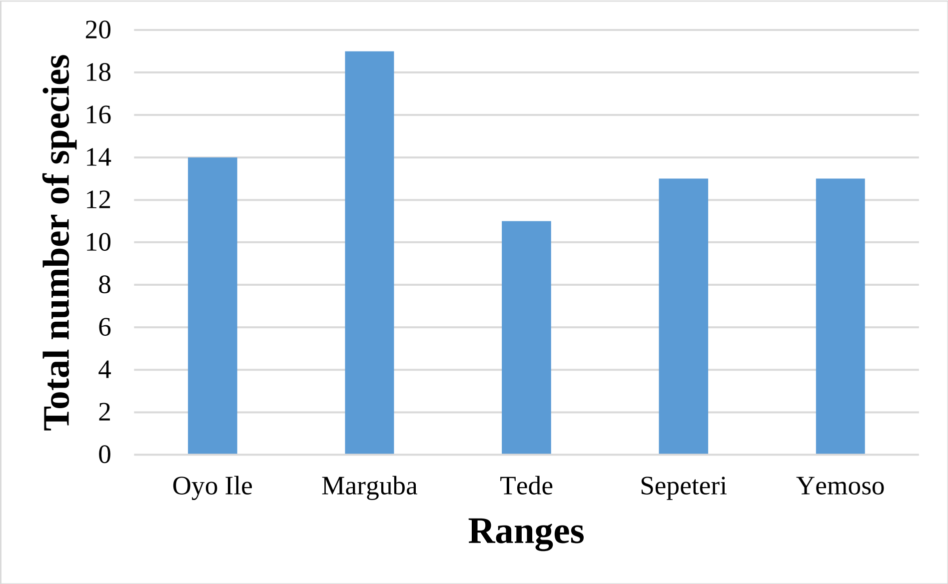


Figure 3.6 Large mammal species richness (Maximum possible 23 species) per range as calculated using camera trapping and line transect survey in Old Oyo National Park in 2015

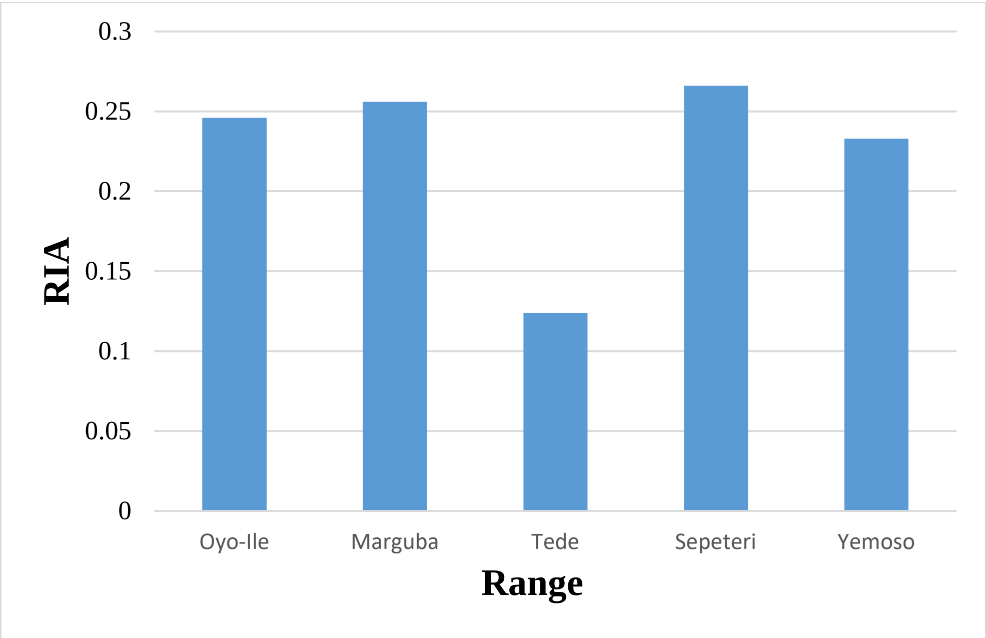


Figure 3.7 The Relative Index of Abundance (RIA) for camera trapping in each of the five ranges and across the study area

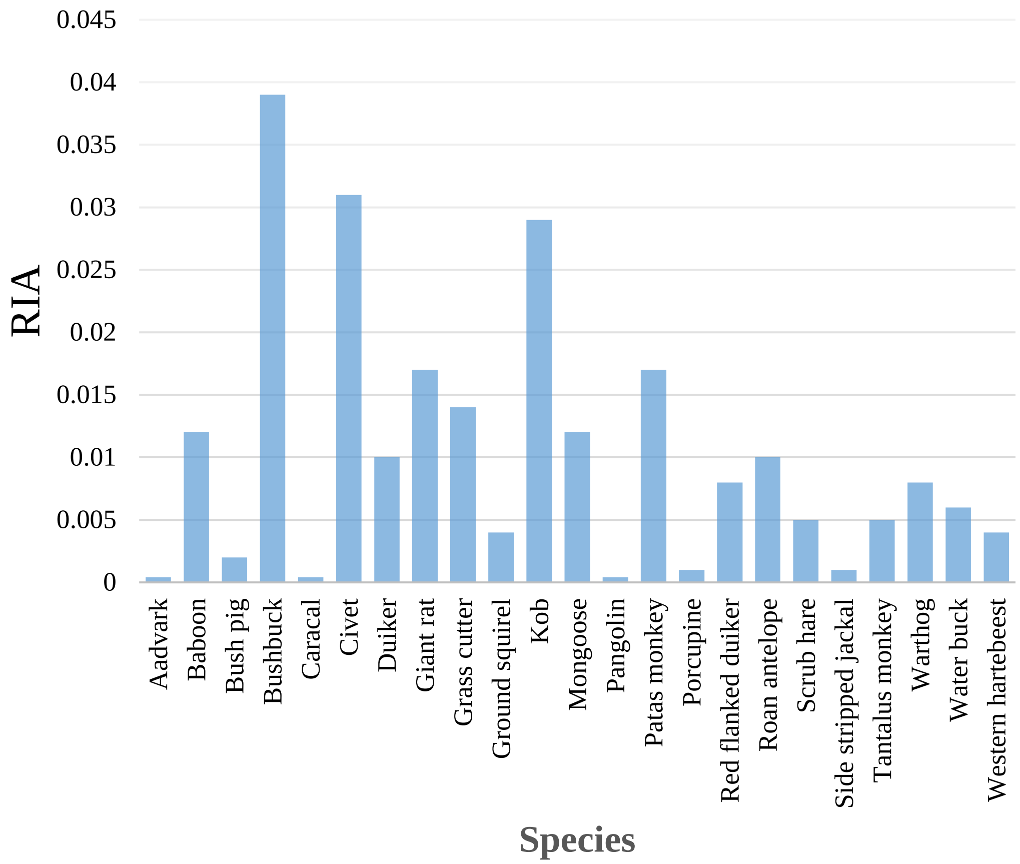


Figure 3.8 The Relative Index of Abundance (RIA) for the 23 large mammal species captured during camera trapping across the study area.

3.6.2. Large mammal occupancy and relative index of abundance

A total of 2,786 trap-nights yielded 419 independent photo captures of large mammals, excluding domestic cattle and human hunters.

Site occupancy focused on the 13 most frequently detected large mammal species. Models for tantalus monkey, western hartebeest, jackal, porcupine, bush pig, pangolin, aardvark and caracal were affected by low detection, so were not included in further analyses. Across all species and models, estimates of site occupancy and standard errors ranged from 0.18±0.10 for grasscutter to 0.96±0.15 for kob, with the detection probability ranging from 0.08±0.08 for scrub hare to 0.38±0.06 for bushbuck. Due to low levels of detection, estimates of occupancy were typically higher than naive occupancy, I.E. the proportion of sites at which the target species was detected (Table 3.5).

The species with the highest estimate of occupancy was kob, followed by civet, giant rat and scrub hare (occupancy ≥0.80), and with the highest detection probability was bushbuck, followed by kob and civet (detection probability ≥0.284).

The occupancy models for the 13 species were improved (best fit occupancy models) when covariates were added to the models, but none of them were significant in terms of the beta coefficients. The most common covariates that influenced the models were forest habitat, presence of hunters and proximity to roads and rangers' stations, with a constant detection probability (Table 3.6).

Table 3.5 Occupancy estimates from constant detection models [Psi (.), P (.)] for 13 species. NO, naïve occupancy; Ψ, occupancy estimate; SE, standard error; CI, 95% confidence interval; P, detection probability.

Species	NO	Ψ ± SE	CI	P ± SE	CI of P
Baboon	0.244	0.631±0.259	0.162-0.938	0.180±0.077	0.073-0.380
Bushbuck	0.551	0.794±0.112	0.502-0.937	0.384±0.062	0.272-0.510
Civet	0.500	0.896±0.174	0.181-0.997	0.284±0.063	0.178-0.421
Maxwell's duiker	0.256	0.614±0.267	0.149-0.935	0.190±0.091	0.069-0.427
giant rat	0.282	0.842±0.397	0.015-0.999	0.149±0.075	0.052-0.358
grasscutter	0.090	0.179±0.102	0.053-0.459	0.245±0.140	0.069-0.588
Kob	0.560	0.956±0.150	0.020-1.000	0.323±0.057	0.223-0.444
mongoose	0.230	0.680±0.328	0.1000-0.976	0.153±0.077	0.053-0.369
patas monkey	0.350	0.686±0.190	0.279±0.925	0.247±0.074	0.130-0.418
red-flanked duiker	0.130	0.255±0.119	0.091-0.538	0.247±0.115	0.089-0.525
roan antelope	0.210	0.419±0.161	0.164-0.725	0.237±0.096	0.099-0.467
scrub hare	0.154	0.800±0.730	0.001-1.000	0.081±0.076	0.012-0.394
waterbuck	0.170	0.396±0.215	0.088-0.812	0.193±0.113	0.056-0.495

Table 3.6 Best fitting occupancy models for 13 species. Key: **X**; covariate that improved the occupancy model for each species and its direction of effect in parentheses (- or +)

	Covariates							
Species	Forest habitat	Hunter presence	Domestic cattle presence	Proximity to road	Proximity to river	Proximity to ranger station	Proximity to village	Constant detection probability
baboon	x (-)	x(+)						x
bushbuck	x(+)			x(+)		x(+)		
Civet		x(+)						x
Maxwell's duiker	x(+)			x(+)	x(+)			x
giant rat					x(-)			
grasscutter	x(-)	x(+)	x(-)	x(-)	x(+)	x(-)	x(-)	x
Kob			x(-)					x
mongoose	x(+)			x(-)		x(-)		
patas monkey	x(+)	x(-)	x(+)	x(+)	x(-)	x(+)	x(+)	x
red-flanked duiker						x(-)	x(+)	x
roan antelope			x(+)					x
waterbuck	x(+)	x(+)	x(-)	x(-)	x(-)	x(-)	x(-)	x(-)

Note: For example for baboon, x(-) means that including the covariate "forest habitat" improves the occupancy model (x) but the presence of the forest habitat has a negative effect on the occupancy (-). In contrast, presence of hunters has a positive effect on occupancy (+).

3.6.3. Large mammal density estimates

The transect survey estimates for large mammals showed 13 species in the study area (Appendix 3). Detections were very low for most species encountered, and only three species had sufficient numbers of detections to enable DISTANCE analyses: 45 baboon, 43 bushbuck and 75 kob sightings. Density estimates generated in DISTANCE all had good fitting models with half normal cosine adjustment terms and data truncation (Table 3.6). Among the three species, kob has the highest density of 5.65/km^2 and an estimate of 15.47 individuals'/km^2 (I.E an average of 3 individuals per cluster).

Table 3.7 The best fit DISTANCE models used to estimate species density from distance sampling at OONP using Akaike's Information Criterion (AIC) and % coefficient of variation (% CV). Details of truncated data to improve model fit and estimated densities are also given. Dcl, density of clusters; D, density of individuals; CI, confidence interval; ER, encounter rate. Total effort, 306 km.

Species	**Model**	**Truncation**	**AIC**	**%CV**	**Dcl (km^{-2})**	**D (km^{-2})**	**95%CI (km^{-2})**	**ER (km^{-1})**
baboon	Half normal cosine	Right 70m	313.60	21.12	2.76	14.98	9.34 - 24.02	0.15
bushbuck	Half normal cosine	None	300.85	17.61	4.27	4.84	3.39 - 6.90	0.14
Kob	Half normal cosine	Right 70m	538.56	18.06	5.65	15.47	10.03 - 23.85	0.25

3.6.4. Perception of the status of large mammals

The most common species seen by villagers was hare, followed by grasscutter, primates, bushbuck, kob and warthog, whereas the most common species seen by rangers was kob, followed by duiker, grasscutter, warthog, primates and bushbuck, (Table 3.7). Notably, hares were the most common species seen by 83 % of villagers, but the 9th most common one seen by rangers, a greater proportion of whom had seen large mammals. The least common species seen by villagers was lion, followed by leopard, buffalo and wild dog, the same four as detailed by the rangers. However, buffalo are seen by notably more rangers (29%) than villagers (1.2%). Nevertheless, sightings are very similar between the stakeholders, indicating consistency in perceptions.

Perceptions in the change of status of large mammals in the five years preceding the survey (Table 3.8), indicated that no villagers, and very few rangers, believed that any species had increased in abundance. Similarly, very few stakeholders perceived the abundance of any large mammal to remain unchanged. Over 90% of villagers believed that 10 of the species had decreased, although the majority said they didn’t know whether the abundance of buffalo and wild dog had changed. Interestingly, the rangers don’t know the status of buffalo and wild dog either, but they perceived that more aardvarks had decreased whereas primates had increased.

Table 3.8 The status of species inside OONP as indicated by stakeholders in the five years preceding the survey. Total numbers of villagers and rangers were 800 and 100, respectively. Results are presented in counts with percentages in parenthesis (%).

	Villagers		Rangers	
Species	**Seen**	**Not seen**	**Seen**	**Not seen**
aardvark	164 (20.5)	636 (79.5)	37 (37)	63 (63)
buffalo	10 (1.2)	790 (98.8)	29 (29)	71 (71)
bushbuck	599 (74.9)	201 (25.1)	92 (92)	8 (8)
Civet	578 (72.3)	222 (27.7)	61 (61)	39(39)
duiker	584 (73.0)	216 (27.0)	98 (98)	2 (2)
grasscutter	642 (80.3)	158 (19.7)	95 (95)	5 (5)
Hare	658 (82.3)	142 (17.7)	83 (83)	17(17)
Kob	593 (74.1)	207 (25.9)	99 (99)	1 (1)
leopard	8 (1.0)	792 (99.0)	3 (3)	97(97)
Lion	4 (0.5)	796 (99.5)	10 (10)	90(90)
mongoose	579 (72.4)	221 (27.6)	81 (81)	19(19)
primates	637 (79.6)	163 (20.4)	92 (92)	8 (8)
roan antelope	522 (65.3)	278 (34.7)	87 (87)	13(13)
warthog	586 (73.3)	214 (26.7)	94 (94)	6(6)
western hartebeest	512 (64.0)	288 (36.0)	85 (85)	15 (16)
wild dog	44 (5.5)	756 (94.5)	7(7)	93(93)

Table 3.9 The status of species inside OONP within the five years preceding the survey, as determined by stakeholders. Increase (I), remain unchanged (RU), decrease (D), don't know (DK). Total number of villagers and rangers are 800 and 100, respectively. Results were presented in counts and percentages are in parenthesis (%).

	Villagers				**Rangers**			
Species	**I**	**RU**	**D**	**DK**	**I**	**RU**	**D**	**DK**
Aadvark	0	18 (2.3)	590 (73.8)	192 (24.0)	4 (4)	1 (1)	88 (88)	7 (7)
Buffalo	0	3 (0.4)	157 (19.6)	639 (80.0)	0 (0)	0 (0)	19 (19)	81 (81)
Bushbuck	0	12(1.5)	759 (94.9)	29 (3.6)	9 (9)	10 (10)	72 (72)	9 (9)
Civet	0	18 (2.3)	720 (90.0)	62 (7.8)	2 (2)	9 (9)	72 (72)	17 (17)
Duiker	0	15 (1.9)	756 (94.5)	29 (3.6)	3 (3)	6 (6)	91 (91)	0 (0)
grasscutter	0	8 (1.0)	770 (96.3)	22 (2.8)	1 (1)	1 (1)	98 (98)	0 (0)
Hare	0	20 (2.5)	754 (94.3)	26 (3.3)	1 (1)	3 (3)	90 (90)	6 (6)
Kob	0	8 (1.0)	757 (94.6)	35 (4.4)	6 (6)	4 (4)	89 (89)	1 (1)
mongoose	0	8 (1.0)	740 (92.5)	52 (6.5)	1 (1)	5 (5)	86 (86)	8 (8)
primates	0	10 (1.3)	763 (95.4)	27(3.4)	3 (3)	4 (4)	67 (67)	26 (26)
roan antelope	0	8 (1.0)	763 (95.4)	29 (3.6)	4 (4)	9 (9)	80 (80)	7 (7)
warthog	0	13 (1.6)	729 (91.1)	58 (7.3)	4 (4)	1 (1)	88 (88)	7 (7)
western hartebeest	0	9 (1.1)	754 (94.3)	37 (4.6)	0 (0)	7 (7)	72 (72)	21 (27)
wild dog	0	10 (1.3)	24 (3.0)	766 (95.7)	0 (0)	0 (0)	13 (13)	87 (87)

3.7. Discussion

The findings of this study revealed a similar richness of species as in the past. However, some of the large mammals were no longer found in the Park, whilst some new ones were detected. The results revealed that the probability of occurrence for most species in the study area was low and the impression from stakeholders is that the numbers of most species within the park have declined. There is some indication of an increase in numbers of species by the rangers, but this is low to ascertain the perceived increase in species status. This result shows that some of the rangers appears not be familiar with the species status in the Park. As national parks are expected to hold viable populations of various species of large mammals (Butchart, *et al*. 2010, González-Maya, *et al*. 2015), this is cause for concern.

Based on the present survey results, the species richness differed depending on the survey method adopted. Camera traps detected more species than line transects and stakeholder surveys. However, besides buffalo, wild dog, leopard and lion, camera trap and transect methods consistently recorded common species in the park that were listed in the questionnaire. The findings from the stakeholder survey indicated the presence of buffalo and wild dog which were not observed using the camera trap or transect survey methods. However, the proportion of stakeholders that indicated seeing these species was very low. Such results could be linked to response bias by the stakeholder (White, *et al*. 2005) and/or misidentification of species. Hence, species not indicated as ‘seen’ by more than 10% of each stakeholder surveyed should be treated with caution.

In 1979, lion, leopard, wild dog, spotted hyena, buffalo, elephant and oribi were all recorded in OONP (Afolayan, Milligan and Salami 1983). Since then, two different studies (Akinyemi and Kayode 2010, Oladipo and Abayomi 2014) and this one, have failed to detect these species using conventional line transect methods. These species, except for buffalo, were also not recorded in this study by any of the methods adopted (although elephant and oribi were not included in the stakeholder survey), suggesting that the species are likely to be extinct from the park. Buffalo presence, as indicated by the stakeholder survey, is consistent with Oyeleke *et al*. (2015) who reported the presence of buffalo at OONP, although those findings were only based on observations made by rangers. Since buffalo were similarly only indicated present through the current stakeholder's survey, the accuracy of this result should be assessed by ground-truthing i.e. empirical evidence as opposed to information provided by inference (White, *et al*. 2005).

The absence of apex predators from OONP is also mirrored across PAs in West Africa. For example, large carnivores such as lion, cheetah (*Acinonyx jubatus*) have become extinct in 63% of the PAs where they were historically present (Henschel, *et al*. 2014, Brugière, Chardonnet and Scholte 2015), and although spotted hyena are widespread in Africa, the species is reported to be declining and near extinction across West African PAs (Mills and Gorman 1997). Interestingly, the extirpation of leopard from 37% of its historical range in Africa is thought to be a result of bushmeat harvests (Ray, Hunter and Zigouris 2005).

The disappearance of African elephant in the current study is not surprising because only a small fragmented population remains in West Africa (Bouche, *et al*. 2011, Lindsell, Klop and Siaka 2011). Among other African countries, less than 2% of the continent's known African elephant population are spread over only 13 remaining elephant range states in West Africa (Blanc, *et al*. 2013). This low-level population, coupled with various threats, could drive the species to local extinction (Purvis, *et al*.

2000, Fagan and Holmes 2006, Brook, Sodhi and Bradshaw 2008). Since OONP has lost its apex carnivores and mega herbivores, it could be regarded as having a degraded large mammal community which is likely to have cascading effects on the vegetation structure in the Park.

Interestingly, four new species - caracal, crested porcupine, ground pangolin and black-backed jackal were recorded, probably due to the use of camera trapping for the first time (Brown, Reilly and Peet 2007). It is somewhat unusual that these species had not been recorded before, since they are common across the African continent (Kingdon 2015). However, it is possible that they moved into the park since the last survey, or were always present but not recorded. The results of this study demonstrate some similarities with other studies involving the use of camera traps that observed species not previously recorded in parks in Botswana (Lisek 2013), Brazil (Melo, Sponchiado and Cáceres 2012), Peru (Bowler, *et al*. 2016) and Thailand (Jenks, *et al*. 2011). The detection of the previously unrecorded species supplement the park records and further demonstrate the advantage of camera trap studies to detect rare, cryptic, elusive and shy species (O'Brien, *et al*. 2010, Ahumada, *et al*. 2011). Of the four new species detected, pangolin are a species of conservation concern (Heinrich, *et al*. 2016) as they are under threat of illegal hunting for the large local and global trade for protein consumption (Mohapatra, *et al*. 2015, Shairp, *et al*. 2016) and in traditional medicines (Katuwal, *et al*. 2013, Mohapatra, *et al*. 2015). At present, pangolins are classed as ‘near extinction’ in Asia and the African species are listed as ‘vulnerable’ (Heinrich, *et al*. 2016, Mwale, *et al*. 2016). Therefore, basic inventories of wildlife in PAs is essential better to understand and manage populations such as pangolins.

3.7.1. Occupancy estimates

This study provides the first baseline occupancy data for OONP from which future monitoring can be informed. Overall, camera detection and direct sightings of mammals was low, with many species exhibiting low occupancy and density across study sites. For the species occupancy models, none of the covariates significantly predicted species occurrence, but some improved the model fit. Although dwarf antelopes (antelopes of 2-25kg such as duiker) were frequently recorded on camera traps and regarded as being present by stakeholders, their occupancy seemed lower than expected in an African tropical landscape (Rovero and Marshall 2009, Amin, *et al*. 2015). Similarly, stakeholders were of the opinion that duiker have declined in the five-year period preceding the study. Factors such as predation, overexploitation and habitat degradation can drive the decline of species population (Butchart, *et al*. 2010, Craigie, *et al*. 2010, Scholte 2011). However, given that the natural predators were absent in the study area, the observed low number of duiker are more likely due to bushmeat hunting or habitat degradation.

Although the findings in this study are based on low detections of mammals at sites, and the lack of data for sites where cameras were stolen, occupancy estimates derived could serve as a baseline measure of large mammal species in the study area. The mammal with the highest occupancy was kob (occupancy = 0.965), which was also recorded previously as the most common ungulate in the study area (Afolayan, Milligan and Salami 1983, Anadu and Green 1990, Jayeola, *et al*. 2012). However, the level of occupancy for the larger herbivores was generally low, with both roan antelope and waterbuck having under half the occupancy of kob. Nevertheless, the stakeholders acknowledged the presence of the herbivore guild but perceived a decrease in all species. The occupancy models of best fit for roan antelope and waterbuck included the presence of domestic cattle which had a positive impact on roan antelope but a negative impact on waterbuck. This contrasts with studies that have reported the decimation of wild grazer populations due to competition for resources and habitat alteration, as well as the presence of domestic cattle (Fischer and Linsenmair 2007, Jayeola, et al. 2012, Chardonnet and Crosmary 2013, Averbeck, et al. 2012, Kingdon and Hoffmann 2013). It was surprising to find occupancy models with presence of domestic cattle as the best fit for species that are predominantly grazers. However, these findings provide further evidence that roan antelope and waterbuck are potentially mixed feeders, as these species can shift from grazer to browser diets depending on vegetation structure and/or resource availability (Codron, *et al*. 2007, Kassa, Libois and Sinsin 2008, Guenda, *et al*. 2016). Similar findings have been reported for kob that can utilize poor quality food, leading to faster growth rates compared to other bovid species (Afolayan and Amubode 1985, Kingdon 2015). Considering the way pastoralism is being practiced in the developing world, whereby large herds of cattle are moved in an irregular pattern in search of fresh pasture, there is an increased probability that livestock herders select the same habitat as the wild grazers for their livestock (Scoones 1995, Schieltz and Rubenstein 2016). Hence, large ungulates are likely to be present where domestic cattle are found. This interaction between wild and domestic species will increase competition for resources, and could cause wild populations to decrease. Conversely, bushbuck occupancy models were unsurprisingly improved by forest habitat and proximity to rangers' stations. As bushbucks are predominantly browsers (MacLeod, Kerley and Gaylard 1996), their utilization of forest habitat depends on the availability of cover and forage species (Dankwa-Wiredu and Euler 2002, Coates and Downs 2005) and a lack of hunting pressure from humans (Wuver 2006).

Within the carnivore guild, the civet had the highest level of occupancy, followed by the long-snouted mongoose (ψ = 0.90 and 0.68, respectively). The occupancy estimate for civet was high compared to some other areas in Africa (Johnson, Vongkhamheng and Saithongdam 2009, McShea, *et al*. 2009, Farris, *et al*. 2015, Jennings, *et al*. 2015). The presence of human hunters as a covariate improved the occupancy models for both species, positively. There is a possibility that civet and mongoose use a wide range of habitat and/or the local hunters are targeting sites with higher density of wildlife population in their effort to increase the number of successful hunts. The result of this present study further support the past finding that high carnivore occupancy occurred at sites with highest hunting activities in Madagascar (Farris, *et al*. 2015). In addition, habitat disturbance can drive species such as prey items away from their preferred habitat. It is possible that civets and mongoose have benefited from this disturbance, alongside the lack of apex predators. Other best fit models for mongoose were improved by proximity to ranger station and roads, negatively. The presence of both species was again confirmed by the majority of stakeholders but they were perceived to have decreased in number in OONP. The nocturnal habits of these species could explain why they are not easily encountered by humans, but this does not explain why humans perceive them to have declined.

For the primates, occupancy estimates were relatively high in comparison to some other taxonomic groups, with patas monkey and olive baboon occupying large proportions of the Park (ψ = 0.69 and 0.63, respectively). However, the levels of primate occupancy in this study were lower than estimates from previous studies in other PAs (Kalan, *et al*. 2015, Sales, Hayward and Passamani 2016). Indeed, primate populations were confirmed to be present but in reduced numbers according to the stakeholders. Occupancy models for baboon were improved by forest habitat and presence of human hunters in a positive direction. Of the best occupancy models for patas monkey, forest habitat, presence of domestic cattle, proximity to a road, village and ranger station, all improved the models positively, while occupancy models for the remaining primates were negatively improved by the presence of human hunters and proximity to a river. The covariates human hunter and proximity to river has a negative influence on other primate species occurrence in the Park. These observations are in line with previous findings on the environmental requirements of primate species in protected landscapes in Africa, whereby certain species preferred closed habitats and even thrived in man-made landscapes (Ey, *et al*. 2009, Higham, *et al*. 2009, Hoffman and O'Riain 2012, Sales, Hayward and Passamani 2016). For example, baboon and patas monkey are habitat generalists and opportunistic feeders and hence can eat a wide range of food resources (Johnson, Swedell and Rothman 2012, Vanthomme, *et al*. 2013, Butynski and Jong 2014). They can also adapt to human disturbance including hunting (Johnson, Swedell and Rothman 2012, Vanthomme, *et al*. 2013, Butynski and Jong 2014). Nonetheless, hunting is a threat to a number of primates (Rovero, *et al*. 2012) but levels of hunting near roads may differ as well as the ability of species to avoid road associated disturbance (Vanthomme, *et al*. 2013).

Within the rodent guild, the giant pouched rat had the highest occupancy estimate followed by scrub hare (ψ = 0.84 and 0.80, respectively). These estimates are somewhat similar to findings on rodents in Tanzania (Hegerl, *et al*. 2015). Again, stakeholders confirmed the presence of these species but their populations were perceived to have decreased. The low occupancy of grasscutter (ψ 0.18) confirms the observation that this species is the most preferred rodent by hunters due to its high meat and cash value (Afolayan, Milligan and Salami 1983). The variation in the occupancy of the giant pouched rat and other mammals further suggerts a relationship between the effect of hunting and body size, with smaller bodied species being less affected by human disturbance (Canale, et al. 2012)

3.7.2. Density estimates

Density estimates were calculated for the three most common wild mammals (baboon, bushbuck and kob), as these were the only species with sufficient detections. The density estimates of 15.47/km^2 and 4.27/km^2 for kob and bushbuck, respectively, were lower than estimates reported previously (25.08/km^2 and 5.97/km^2) (Afolayan, Milligan and Salami 1983). In addition, the encounter rates of 0.25/km and 0.14/km for kob and bushbuck, respectively, were lower than estimates reported previously (0.56/km and 0.41/km) (Akinyemi and Kayode 2010). These lower density and encounter rates suggest a decrease in populations whereby species that are encountered increasingly infrequently (where once they were common) may be in the danger of extinction (Petrides 1965, Caro 2008, Scholte 2011).

3.7.3. Conclusion and implications for conservation

OONP is still home to a diverse mammal community but this is incomplete as it now lacks apex predators and some mega herbivores. More worryingly, people's perceptions of the large mammals in the park indicate that almost all species included in the questionnaire have declined. Without management intervention, more species are likely to become locally extinct. Data provided from this study, and the methods employed, may be incorporated into future monitoring and the development of targeted conservation management programmes within OONP. However, for management plans to be implemented, the cause of the decline of species must be elucidated, and this is the focus of the next chapter.

Chapter 4: Quantifying illegal activity in Old Oyo National Park

4.1 Introduction

Global biodiversity is decreasing at an alarming rate despite conservation efforts (Sachs, *et al*. 2009) with current extinction rates 1000 times higher than background extinction rates (Pimm, *et al*. 2014). Future threats of extinction have been predicted for 21-35% of tropical species by 2030 (Wright and Muller-Landau 2006), prompting discussion of a biodiversity crisis (Brook, Sodhi and Bradshaw 2008) and a sixth mass extinction (Barnosky, *et al*. 2011). Humans are implicated directly and indirectly in this mass extinction due to increasing population sizes that lead, amongst other things, to the appropriation of extensive areas of land for agriculture, resource extraction and other activities, placing an unprecedented strain on natural resources (Chapman, *et al*. 2000, Ceballos and Ehrlich 2002, Foley, *et al*. 2005). Indeed, the sixth mass extinction is likely to be more catastrophic in the tropical developing region given the high species diversity and the large, escalating human populations (Sodhi, Brook and Bradshaw 2009, Adams and Hadly 2013, Laurance, *et al*. 2012).

The suggested underlying drivers of wildlife decline vary regionally and include climatic change, habitat loss and fragmentation through encroachment (Craigie, *et al*. 2010, Scholte 2011). However, the major drivers of wild population decline, especially in large mammals, are thought to be over-exploitation through unsustainable hunting for bushmeat (Lindsey, *et al*. 2011, Lindsey, *et al*. 2013, Ogutu, *et al*. 2014) and competition over resources through livestock grazing (Madhusudan 2004, Harris, *et al*. 2009, Ogutu, *et al*. 2011, Woinarski, *et al*. 2011, Ogutu, *et al*. 2016).

The heavy dependence of local people on bushmeat (an open access resource) creates unsustainable harvesting which has catastrophic effects on wildlife populations (Wilkie, *et al*. 2011, Nasi, Taber and Vliet 2011) This includes variation in the sex ratio of wild ungulate calves (Marealle, *et al*. 2010) and population decline in faunal species (Fischer and Linsenmair 2001, Stoner, *et al*. 2007, Plumptre, *et al*. 2015). As a consequence, it is predicted that by 2020 large mammals in some tropical regions will be hunted to local extinction (Wilkie, *et al*. 2005, Schenck, *et al*. 2006). The loss of these species will result in changes in species composition, a general reduction in biological diversity and the disruption of ecological processes (Nasi, Taber and Vliet 2011, Effiom, *et al*. 2013).

As well as Bushmeat consumption, livestock grazing impacts negatively on global biodiversity (Schieltz and Rubenstein 2016). For example, 72-88% decline among species was reported in Kenya, indicating that ecosystems with high levels of grazing host significantly fewer mammals than expected (Ashraf, et al. 2015, Dacko 2015, Ihwagi, et al. 2015, Ogutu, et al. 2016). Livestock directly influence the behaviour of native species, particularly large herbivores, through competition for resources such as habitat and food, regularly altering population sizes and causing local extinctions (Marealle, *et al*. 2010, Ogutu, *et al*. 2016). However, livestock can also have an indirect influence on wildlife, changing vegetation structure and cover, and exposing wildlife to higher risks of predation and poaching (Wallgren, *et al*. 2009, Stahlheber and D'Antonio 2013, Carrasco-Garcia, *et al*. 2016).

In order to combat biodiversity loss, protected areas (PAs) have been created across the world to ensure environmental sustainability by maintaining biological diversity and slowing the rate of species loss due to anthropogenic and/or illegal activities (Chape, *et al*. 2005, Naro-Maciel, *et al*. 2010, Usman and Adefalu 2010). Despite the objectives of establishing protected areas, many species have declined or become locally extirpated (Anadu and Green 1990, Usman and Adefalu 2010, Jayeola, *et al*. 2012, Jimoh, *et al*. 2013). Illegal activities such as bushmeat hunting and livestock grazing are thought to be the cause of species population declines and local extinction in Nigerian PAs (Anadu and Green 1990, Usman and Adefalu 2010). Indeed, it is widely acknowledged that the persistence of mammals at local, regional and global levels depends on their survival both inside and outside PAs where they come into conflict with humans and livestock from neighbouring villages (Kent 2011). However, wildlife conservation authorities often have limited data on the levels of illegal activity within PAs (Hockings, Stolton and Dudley 2000, Pitcher, *et al*. 2002, Gavin, Solomon and Blank 2010). Where such information is available, it is often obtained from the rangers (law enforcement staff) (Jachmann 2008a, Jachmann 2008b, Wiafe 2016) who may themselves be unmotivated to carry out their enforcement roles (Wiafe 2016). Furthermore, local people neighbouring PAs in the developing world have different traditional livelihood practices such as nomadic and transhumance agro-pastoralism (seasonal movement of people with their livestock to find fresh pasture for grazing) from those in Western civilisations. Examples include the Maasai in Kenya and Tanzania, and Fulani in Nigeria (Scoones 1995, Bollig, Schnegg and Wotzka 2013, Majekodunmi, et al. 2014). Hunting and gathering of wild animals continues to be an important aspect of life in rural African societies. Examples includes the Koria and Ikoma tribe in Tanzania and Yoruba in Nigeria (Kaltenborn, Nyahongo and Tingstad 2005, Ajibade 2006). Clearly, empirical studies that provide information about the intensity and magnitude of illegal activities are of great importance to biodiversity conservation, helping the implementation of management strategies that engage traditional culture and practices with positive conservation impacts (Critchlow, *et al*.

2015). This could reduce and/or eradicate these threats to biodiversity as managers will have baseline data to monitor success of conservation efforts and to design more efficient interventions. However, such information is lacking for many Nigerian PAs.

Quantifying illegal activity in a protected landscape can be challenging as resource use is covert, difficult and dangerous to detect, hence posing methodological challenges (Gavin, Solomon and Blank 2010). However, the use of camera trapping has proved effective in detecting illegal activities in tropical PAs (UNEP 2014, Hossain, et al. 2016). For example, poachers and domestic dogs constituted 8.2% and 2.6% of camera trap photographs, respectively in Khao Yai National Park, Thailand (Jenks, *et al*. 2011). Similarly, camera traps recorded 290 times more illegal human activities such as fishing, crab and firewood collection than normal patrolling activities (Hossain, *et al*. 2016).

Another way of gathering such information is to ask local peoples' about illegal activities in the area (Bitanyi, *et al*. 2012). Surveying local people can provide important information on the extent and degree of illegal activities such as their use of wildlife and/or natural resource in PAs (Poulsen and Luanglath 2005, Bitanyi, *et al*. 2012). However, many may not give accurate answers to such sensitive questions (St John, *et al*. 2012). Nevertheless, the use of Randomized Response Techniques (RRT) over direct questioning has proven effective for obtaining information on sensitive topics (St John, *et al*. 2014). The RRT ensures anonymity of the respondent, as none of their answers can be traced back to them (Nuno, *et al*. 2013, St John, *et al*. 2012, St John, *et al*. 2014).

Most studies quantifying illegal resource use have focused on bushmeat hunting (Nuno, *et al*. 2013, Watson, *et al*. 2015), whereas little is known about the extent of livestock grazing in protected areas (Kiringe and Okello 2007). However, useful information about the dynamics of all illegal activities that occur within a PA is essential for conservation managers to develop adaptive management programmes to address illegal resource use (Gavin, Solomon and Blank 2010).

To this end, this study used a multi-disciplinary approach that combined camera trapping, line transects and questionnaire surveys of local villagers to assess the levels of illegal activity in Old Oyo National Park.

This chapter aims to:

- Identify the nature of illegal activity in OONP
- Determine the extent to which illegal activities occur in the park

4.2 Methods

The study took place inside and outside OONP. Field data from camera trap and walked line transect surveys were compiled to quantify the level of illegal activity (numbers of hunters and cattle) inside OONP between January and July 2015. In addition, perceptions of illegal activity were assessed through stakeholder (rangers inside and villagers outside) OONP (Figure 4.1). Survey methods followed those described in Chapter 3.

4.2.1 Occupancy estimates of illegal activities

Images of illegal activities from the camera traps were identified and categorised as either bushmeat hunting or domestic cattle grazing. Humans carring Dane guns (locally made firearm), with a sack bag and wearing headlamps were identified from the camera trap photographs as hunters while herders are usually photographed with the cattle, carrying a rod, small animal skin bag and/or water bottle. The number of independent events was defined as the number of non-duplicated images per hour and used to calculate the Relative Index of Abundance for each administrative range (Figure 4.1), using the same methods in Chapter 3. The RIA for each illegal activity detected by the camera trap across the ranges was compared using ANOVA. To obtain occupancy (proportion of sites occupied) estimates of illegal activities, data from each range were pooled due to low encounter rates.

Detection histories of illegal activity (hunting and livestock grazing) were generated for each of the squares surveyed across the study area (see section 3.2). Within the 14 day sampling period, illegal activity was recorded as ‘present’, denoted by ‘1’ or ‘absent’, denoted by ‘0’. The three repeat camera trap locations were treated as three separate sampling occasions (Long, *et al*. 2012). Occupancy models were produced using the program PRESENCE 6.4 (Hines 2006), to estimate the probability that illegal activities (bushmeat hunting and livestock grazing) occurred at a given site (ψ) (Hines 2006), and the detection probability of the activity (p) (MacKenzie 2006), with closure assumed for the entire sampling period (i.e., no changes in occupancy). Occupancy models were produced with covariates that were perceived to predict the likelihood of illegal activity: habitat type, and proximity to road, river, village and ranger’s station (Jenks, Howard and Leimgruber 2012). Covariates were estimated using the same methods in Chapter 3, and again all continuous site covariates were standardized to z-scores prior to analyses (Field 2013).

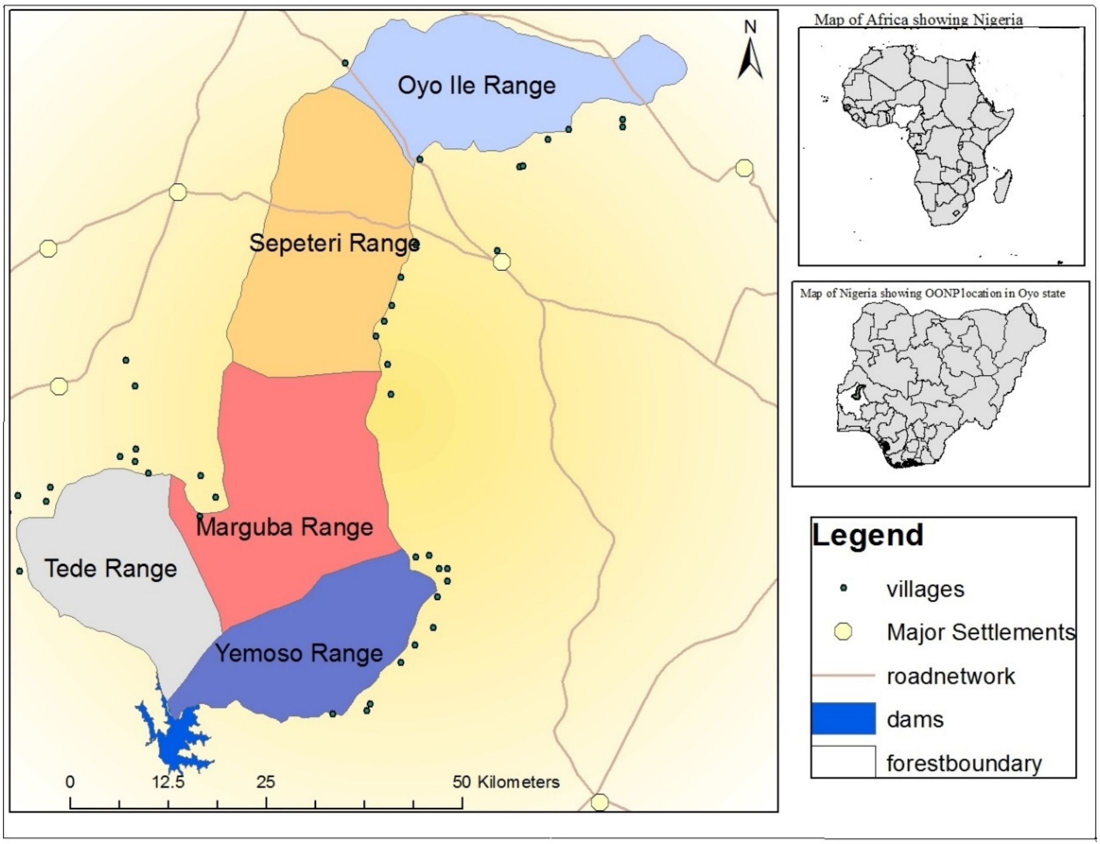


Figure 4.1 A map of the study area showing the five administrative ranges major towns and all the surveyed villages where the study of illegal activities was carried out in Old Oyo National Park (OONP) during the 2015 survey.

4.2.2 Density estimates of illegal activity

Line transect data on illegal activities (bushmeat hunters and domestic cattle) were collected following the methods described in Chapter 3. Density (number of activities per km^2) was calculated for the number of livestock from the perpendicular distance to the transect line, using the program DISTANCE 5.0 (Thomas, *et al*. 2010). The recommended number of independent detection events (> 40) per species per census was only achieved for domestic cattle (n= 42). Again, models followed the same methods used in Chapter 3.

4.2.3 Villagers' perceptions of illegal activities

The perception of villagers, regarding illegal activities in OONP, was elucidated through the same questionnaire survey employed in Chapter 3. The structured questionnaire comprised two sections: section A for Randomised Response Technique (RRT) and section B for direct questions such as socioeconomic background.

The RRT section included closed-ended questions in a binary format (Yes/No). Since the questions in this section were completely dichotomous, they eliminated opportunities for the respondents to express a neutral viewpoint. However, some of the direct questions in section B included closed-ended questions in both binary and Likert scale formats. Likert-type scales were used in order to get the degree of opinion of the respondents on a particular variable and also to collect data on factors that contribute to that sentiment (Dolnicar, Grün and Leisch 2011). The specific questions and the associated scales of measurement for each variable are provided in Tables 2.2 and 4.1.

The RRT section was in the form of a game where respondents were given a bag of 10 coloured balls: 8 white, 1 red and 1 black. The respondents were asked to pick one ball from the bag. A question was then read out and if a white ball was chosen (probability 8/10), the respondent had to answer the question truthfully. If a red ball (P = 1/10) was chosen, a ‘yes’ answer had to be given by the respondent, irrespective of the truthful answer, and if black ball (P= 1/10) was chosen, a ‘no’ answer had to be given, irrespective of the truthful answer. The ball chosen was not shown to the interviewer (Figure 4.2). Since the interviewer did not know whether the respondent said ‘yes’ because they had undertaken an illegal activity, or because they had chosen a red ball (degree of uncertainty), this ensured that respondents remained anonymous (Hox and Lensvelt-Mulders 2004). Therefore, the identity of the respondents was protected at the cost of introducing a degree of uncertainty into the responses. The question “do you grow your own crop” was used as a control question for comparing villagers responses to none and/or less sensitive question, to their responses to other questions that are believed to be sensitive questions in conservation. A minimum of 15 minutes was spent on each respondent during the interview.

Table 4.1 Lists of variables, questions, scales used for collecting data on the perception and extent of illegal activities in and around the park and method used for administering the questionnaire in OONP

Variables	**Questions**	**Scales**	**Methods used in asking the questions**
Awarenes of the park	Please indicate how much you agree or disagree with the following statements: 14 statements were given	Agree/Disagree/Do not know	Direct question
Perception of illegal activities	To what extent do you agree or disagree with the statement that people from this village enter the park to: fetch firewood, hunt animals, get poles and roofing materials, get wild vegetables, get medicinal plants and herbs and make charcoal? All activities are illegal in the national park	Agree/Disagree/Unsure/No opinion	Direct question
Control question	Did you grow your own crop	Yes/No	Randomised Response Technique
Nature and extent of illegal activities	Since the National Park has been established in 1991, have you ever entered the park?	Yes/No	
	Did you enter the National Park last week?	Yes/No	
	In the last 12 months did you ever enter the park to get fire wood?	Yes/No	
	In the last 12 months did you ever enter the park to hunt?	Yes/No	
	In the last 12 months did you ever enter the park to get plants and vegetables?	Yes/No	
	In the last 12 months did you ever enter the park to fish?	Yes/No	
	In the last 12 months did you ever take livestock into the park to graze?	Yes/No	
	In the last 12 months did you ever enter the park to view animals without permission	Yes/No	
	In the last 12 months did you enter the park to view animals/sight-seeing without seeking permission”	Yes/No	
Trends in illegal hunting activities (direct question)	In your own opinion, what has happened to hunting frequency during the last five years	Increased/Remained constant/Decreased	

Figure 4.2 Photograph of a household head during the Randomised Response Technique (RRT) section of the 2015 villagers' face-to-face questionnaire survey.

Villager Survey Analysis

The scales for measuring some of the variables in the villagers' survey were transformed and/or collapsed into fewer categories to remove redundancy during data analysis (Table 2.2). Therefore, data analyses was performed on transformed data. Descriptive data (frequencies and percentages) were used to report all variables including the illegal extraction of natural resources/proportion of rule breaking behaviour for the direct questioning. Variation in the most frequent illegal activities within the five ranges in the study area was examined using a Kruskal-Wallis test. Therefore, it was hypothesised that there is no variation in the number of people engaging in illegal activity across the five ranges in the Park.

The proportion of rule breaking in the RRT was estimated using the forced response model employed by Hox and Lensvelt-Mulders (2004) (see Figure 4.3):

$$\pi = (\lambda - \theta)/P_1.$$

Where π = proportion of respondents who have broken the rule,

λ = proportion of all responses that are Yes,

θ = probability of being required to say Yes (conditional on being forced),

P_1 = probability of having to answer the sensitive question truthfully

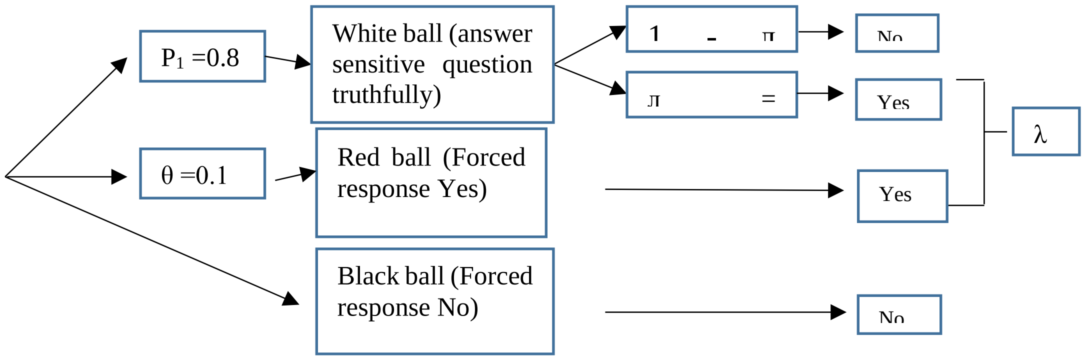


Figure 4.3 Decision tree for a forced response randomised response survey using 10 balls (eight white balls, one red ball and one black ball). π: the proportion of respondents who have broken the rule; λ: proportion of all responses that are Yes; θ: probability of being required to say Yes; P_1: probability of having to answer the sensitive question truthfully.

4.2.4. Rangers' perceptions of illegal activities

The purpose of this survey was not only to gain information on perceptions but to elicit information on factors that could affect the effectiveness of the rangers. The perception of rangers, regarding illegal activities in OONP, was elucidated through the same questionnaire survey employed in Chapter 3. Table 4.2 presents the specific questions for this chapter and the associated scales of measurement. Secondary data on the frequencies of offences and/or arrests was also obtained from the Litigation and Protection unit of the park to cross-validate the type and trends of illegal activities in OONP from 2004 to 2013.

The scales for measuring some of the variables in the rangers' survey were transformed and/or collapsed into fewer categories to remove redundancy during data analysis (Table 2.2 and 4.2). Therefore, data analyses were performed on the transformed data. Descriptive data (frequencies and percentages) were used to report all variables.

Table 4.2 Lists of variables, questions and the scales used for collecting data on the rangers' perception of the extent and trends in illegal hunting activities in OONP.

Variables	**Questions**	**Scales**
Extent of illegal hunting activities	How frequently do hunters acquire bushmeat in and around OONP?	Every day/Every week/Every month/Every 6 months/Every year
Demography of poachers	Illegal hunting in the park is mostly carried out by 1. People living far away from the park 2. People from the neighbouring villages 3. Both	Agreed/Disagreed/Unsure
Demography of poachers	How far in terms of average distance do local poachers mostly come from?	Open ended (re-grouped into 0-10 km, 11-20 km, 21- 40 km, above 40 km
Trends in illegal hunting	In your own opinion, what has happened to hunting frequency during the last five years	Increased/Remained constant/Decreased

4.3. Results

4.3.1. Relative index of abundance and occupancy estimates of illegal activities

Across 2,786 survey days and nights, a total of 256 images of hunters and 670 images of domestic cattle grazing were captured, comprising 66 and 196 independent events, respectively. The camera trap survey captured 51 day images and 205 night images of hunters; 19.92% and 80.08%, respectively. One image captured showed a hunter in the act of shooting a duiker (Figure 4.4). The RIA for hunters was highest in the Tede range and lowest in Yemoso (Table 4.2). However, there was no significant difference in the RIA of hunters within the five ranges [F (4,73)=2.12, P=0.09).

Figure 4.4 Image of a human (hunter) in the act of killing a duiker, captured by a camera trap in Old Oyo National Park.

All capture events for domestic livestock showed herds rather than individual cattle and 45% showed human herders in attendance. The camera trap survey captured 617 day images and 53 night images of domestic cattle; 92.09% and 7.91%, respectively. Domestic cattle grazing was detected by cameras in four out of the five ranges, with only Yemoso in the southeast failing to detect any cattle (Figure 4.5). There was a significant difference in the RIA of domestic cattle within the five ranges [F (4,40)) =7.86, P=0.000), where the highest RIA was in Oyo Ile Range in the North.

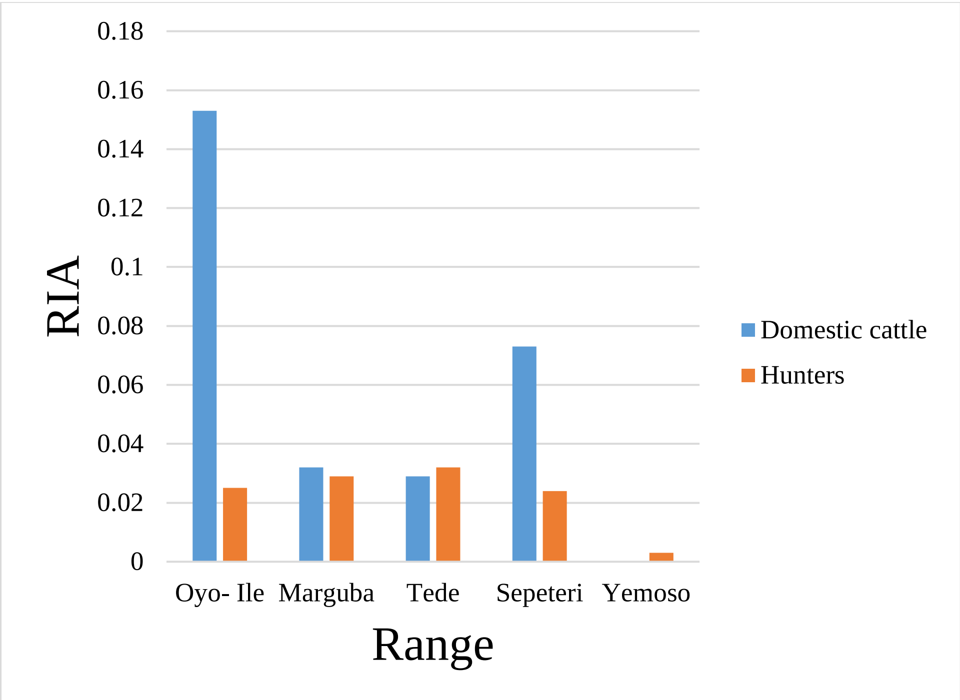


Figure 4.5 Relative Index of Abundance (number of independent events per camera trap days). Total RIA for domestic cattle and hunter activities from all cameras combined in the five ranges. Data from 2,786 camera trap day during the camera trapping survey in Old Oyo National Park

Estimates of site occupancy and detection probability for hunters and domestic cattle were high (Table 4.3), indicating that illegal human activity was prevalent across Old Oyo National Park. When covariates were added to the models, none of them significantly predicted the occurrence of hunters and domestic cattle in the occupancy models, but they improved the model fits. Thus, occupancy models for hunters were improved by the covariates proximity to road and proximity to rangers' station in positive and negative directions, respectively. Also, occupancy models for domestic cattle were all positively improved by the covariates proximity to village, river, and rangers station (Table 4.4).

Table 4.3 Occupancy estimates for constant detection models [Psi (.), P (.)] for the presence of hunters and domestic cattle. NO = naïve occupancy; Ψ = occupancy estimate; SE = standard error; CI = 95% confidence interval (specified by Program PRESENCE output), and P = detection probability.

Species	NO	Ψ ± SE	CI	P ± SE	CI
Domestic cattle	0.44	0.68±0.13	0.40-0.87	0.34±0.07	0.22-0.48
Hunters	0.47	0.97±0.22	0.00-1.00	0.24±0.06	0.14-0.38

Table 4.4 Best fitting occupancy models for the two types of illegal activities. Key: **X**; covariate improved the occupancy model for each illegal activities

	Covariates							
Species	Forest habitat	Hunter presence	Domestic cattle presence	Proximity to road	Proximity to river	Proximity to ranger station	Proximity to village	Constant detection probability
Domestic cattle					x(+)	x(+)	x(+)	x
Hunter				x(+)		x(-)		x

4.3.2 Illegal activity/domestic cattle density estimates

Domestic cattle grazing was the only illegal activity recorded directly during the line transect surveys, with 42 sightings across OONP. Of the 42 encounters with domestic cattle, the ranger attached to the researcher only made an attempt to apprehend the herdmen twice but only one arrest was achieved in Oyo-Ile range (opportunistic arrest) Due to experience and skill he was able to sight the herdman fast enough when climbing a tree to hide and/or escape. No hunter was encountered during the survey but gunshots were heard and one sighting of a feral dog was achieved. Therefore, there are no RIA or density estimates for hunting. There was a significant difference in the RIA for domestic cattle between the five ranges (χ^2=14.24, df=4, P=0.007), where RIA was highest in Oyo Ile (Figure 4.6). The density estimate generated in DISTANCE was high at 85.3 cattle per km^2 (Table 4.5), with half normal cosine adjustment terms in the model.

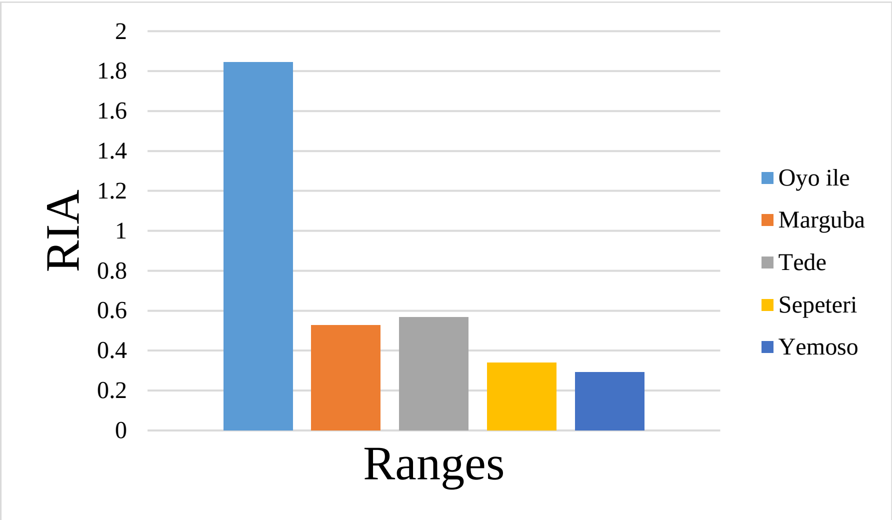


Figure 4.6 RIA of domestic cattle sighted per transect survey in each of the five administrative ranges in Old Oyo National Park.

Table 4.5 Abundance, density and relative index of abundance (RIA) of domestic cattle grazing (illegal activities) in Old Oyo National Park. N number of observations (detection); Dcl =density of clusters; X= average cluster size; D= density of individuals; CV(D)= percent coefficient of variation; 95% CI= 95% confidence interval. Total effort= 306 km

Illegal activity	N	Abundance	Dcl (Km^{-2})	X	D(Km^{-2})	CV (D) (%)	95%CI (Km^{-2})	RIA
Domestic cattle	42	214, 280	1.74	48.94	85.3	37.53	41 - 177.30	5.74

4.3.4 Villagers' perceptions of the park

Out of 800 completed questionnaire surveys, all of the respondents (100%) were aware of the park existence and protection, and that permission is needed to enter, (Table 4.6). Nearly all (> 99%) accepted that the park was created to: protect endangered animals, protect communities against natural hazards, offer spiritual wellbeing and recreation, and to benefit local communities. Also, the majority of respondents (>87%) disagreed that the park should be a source of food, medicinal herbs, firewood, poles and building materials, and a place for grazing livestock.

Table 4.6 Villagers' perceptions of OONP.

Variable	**Agree Frequency (%)**	**Disagree Frequency (%)**	**Do not know Frequency (%)**
The park is a source of food to you	84 (10.5)	699 (87.4)	17 (2.1)
The park is a source of medicinal plants or herbs	37 (4.6)	758 (94.8)	5 (0.6)
The park is a source of firewood	14 (1.8)	779 (97.4)	7 (0.9)
The park is a source of poles/ building materials	6 (0.8)	770 (96.2)	24 (3.0)
The park is a place for grazing livestock	7 (0.9)	784 (98.0)	9 (1.1)
The park was created to protect endangered animal	796 (99.5)	4 (0.5)	
The park protects the communities against natural hazards like drought and floods	800 (100)		
The park offers spiritual wellbeing	800 (100)		
The park offers recreation experience	800 (100)		
The park benefits local communities	800 (100)		
A National park exists here	800 (100)		
The park is protected	800 (100)		
Entering the park without permission is illegal	800 (100)		
Permission is needed to enter the park	800 (100)		

4.3.5 Villagers' perceptions of wildlife resource extraction from the Park

Among the villagers surveyed, 42.5% accepted that people in their villages hunt animals (Table 4.7). The next highest reason for entering the park was to fetch firewood, followed by gathering medicinal plants/herbs. Around a third of the villagers were unsure whether people (neighbours) enter the park to extract each of the wildlife resources listed. Most of the villagers rejected or had no opinion that people enter the park to collect material to make charcoal.

Table 4.7 Respondent's awareness and perception of neighbours' wildlife resource extraction in OONP. Results are presented in counts and percentages in parentheses (%)

Wildlife resources extraction (How much do you agree or disagree with people from this village entering the park to	Accepted (agreed)	Unsure	Rejected (disagreed)	No opinion
Fetch firewood	128 (16)	335 (41.90)	301 (37.70)	36 (4.50)
Hunt animals	340 (42.5)	261 (32.60)	189 (23.60)	10 (1.30)
Get poles and roofing materials	23 (2.90)	467 (58.90)	252 (31.50)	58 (7.30)
Get wild vegetables	10 (1.30)	391 (48.90)	321 (40.20)	78 (9.80)
Get medicinal plants and herbs	60 (7.60)	362 (45.30)	323 (40.40)	55 (6.90)
Make charcoal	21 (2.70)	236 (29.50)	405 (50.70)	138(17.30)

4.3.6 Level of illegal activities of villagers

For both the RRT and DQ surveys, the proportion of villagers responding positively to the control question (Do you grow your own crop) was high, indicating responses to both survey techniques were in agreement. Agreement was also seen for the number of villagers entering the park since 1991. However, the DQ survey revealed low proportions (≤15%) of villagers entering the park to harvest resources when compared to the proportions produced from the RRT survey (≥39%), ie. estimates of non-compliance and/or illegal resource extraction when measured through RRT were considerably higher than when measured by direct questioning for all resources. In response to the direct question on perception of the park (Table 4.6) only 10.5 % of the respondents agreed that the park should be a source of food as opposed 42.5 % who agreed that neighbours entered the Park to hunt wild animals (Table 4.7). This variation in the responses of the participants project their attitudes into the response situation when asked to answer structured questions from the perspective of another person or groups (neighbours rather than themselves). The respondents may project their unconscious biases into ambiguous response situations and reveal their true feelings about socially-sensitive issues as shown in Table 4.7. RRT revealed that most villagers (85%) had entered the park in the previous week, and that a high proportion (>60%) entered to hunt animals, collect plants or collect firewood in the twelve months prior to the study. A lower proportion (39%) admitted to grazing their cattle and other livestock in the park. Interestingly, a high proportion of villagers in both survey techniques entered the park simply to view animals (Table 4.8).

Table 4.8 Comparison of Randomised Response Techniques (RRT) and Direct Questioning (DQ) to quantify estimates of illegal resource extraction among the villagers during the questionnaire survey (n=800).

Reason for entry in the last 12 months	No. of 'Yes' responses from RRT	No. of 'No' responses from RRT	Estimated proportion from RRT	No. of 'Yes' responses from DQ	No. of 'No' responses from DQ	Proportion from DQ
Control (do you grow your own crop?)	775	25	.968	800	0	1.00
Entered the park since 1991	727	73	0.903	796	4	0.995
Entered the park last week	676	124	0.845	131	669	0.16
Collected firewood	486	314	0.607	186	614	0.23
Hunted animals in the last 12 months	612	188	0.765	228	572	0.28
Collected plants and vegetables in the last 12 months	556	244	0.695	132	668	0.16
Went fishing in the last 12 months	436	364	0.545	114	686	0.14
Grazed livestock in the last 12 months	312	488	0.390	116	684	0.15
Entered to view animals without seeking permission in the last 12 months	721	79	0.901	378	422	0.472

The RRT and DQ data showed that all the seven illegal activities investigated occur in each of the five ranges, hence there is no variation in the type and/or number of illegal activities across the park (Figure 4.7 and 4.8). However, there is a significant difference between the numbers of villagers engaging in various illegal activities within each range according to the RRT data (Table 4.9). Therefore, the hypothesis was rejected.

Table 4.9 The result of Kruskal Wallis test comparing the number of villagers engaged in illegal activity across the 5 ranges in OONP. Illegal activity; Chi Square = χ^2, P = level of significant (*)

Illegal activity	χ^2	P
Entered the park last week	21.30	.000***
Collected firewood	250.19	.000***
collected plants and vegetables	87.78	.000***
Hunt animal	88.51	.000***
Went fishing	143.63	.000***
Grazed livestock	100.23	.000***
Entered to view animals without seeking permission	17.45	.002**

Degree of freedom for Kruskal Wallis is 4. *Sig at 5% level or $P \leq .05$; **sig at 1% level or $P \leq .01$; ***sig at $P \leq .000$; “not significant (ns) at $P \geq .05$.

Across the range, the household heads in Tede were significantly more likely to be involved in hunting of wild animals while Oyo-Ile heads were more likely to be involved in taking livestock to graze in the park.

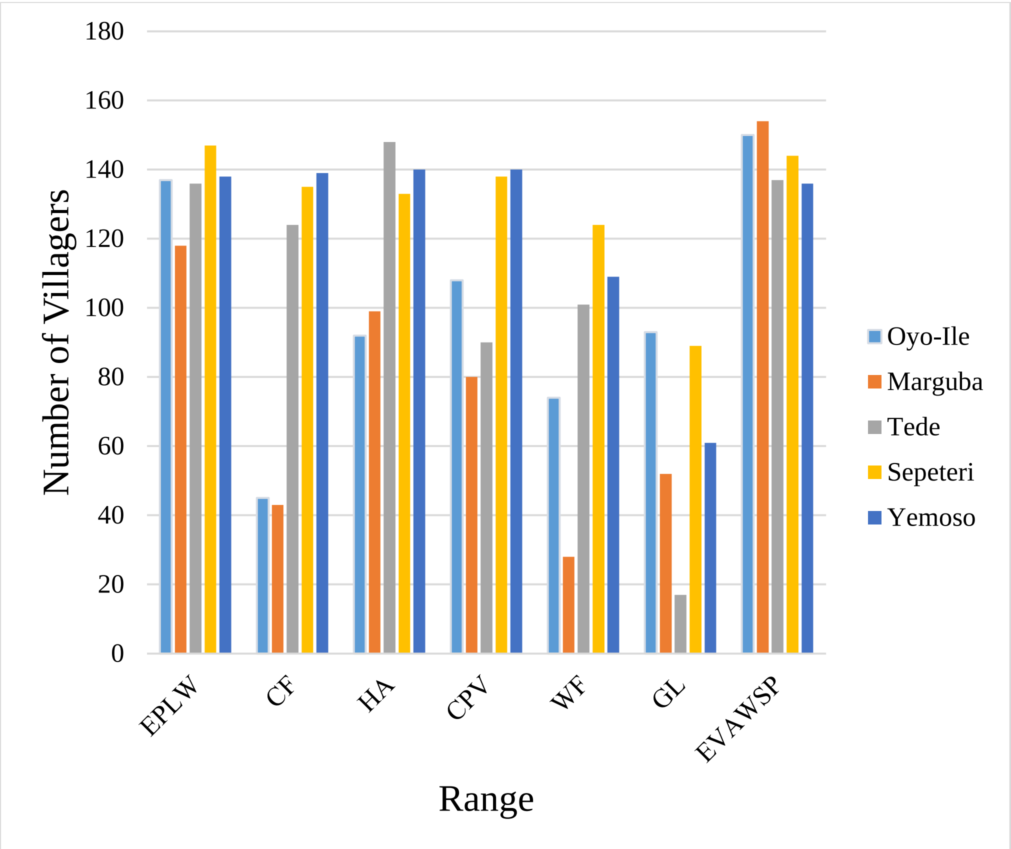


Figure 4.7 Number of villagers indicated entering the park to engage in illegal activities within 12 months prior to the survey period in each range in OONP (data from RRT survey). Key: EPLW, Entered the park last week; CF, Collected firewood; HA, Hunted animal; CPV, Collected plants and vegetables; WF, Went fishing; GL, Grazed livestock; EVASWP, Entered to view animals without seeking permission.

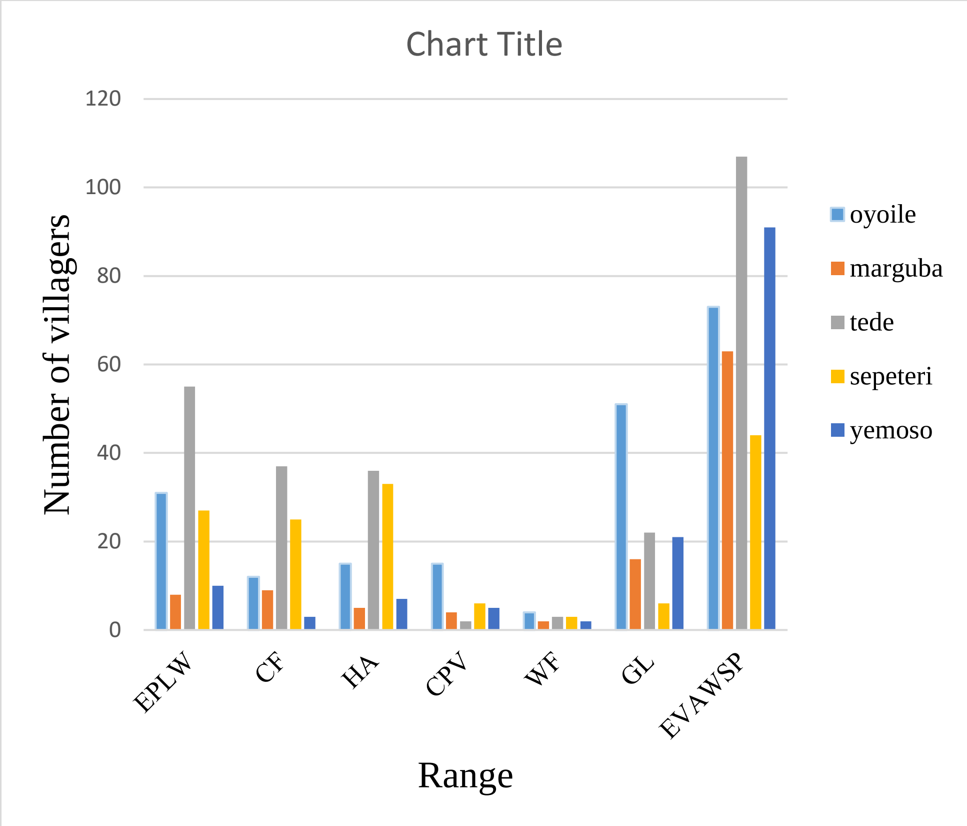


Figure 4.8 Number of villagers indicated entering the park to engage in illegal activities within 12 months prior to the survey period in each range in OONP (data from DQ). Key: EPLW, Entered the park last week; CF, Collected firewood; HA, Hunted animal; CPV, Collected plants and vegetables; WF, Went fishing; GL, Grazed livestock; EVASWP, Entered to view animals without seeking permission.

4.3.7 Rangers' perceptions of illegal hunting

The majority (40%) of the rangers were of the perception that hunters acquire bushmeat from the park every day, followed by every year (24%), every six months (20%), every month (11%) and every week (5%). A higher proportion of rangers perceive that illegal hunting is mostly carried out by people from neighbouring villages (43%) followed closely by people living far away from the park (40%). The average distance travelled by poachers to the park, as indicated by the rangers, is perceived as follows: 0-10km (11%), 11 -20 km (46%), 21 -40 km (24%) and above 40 km (19%). Besides bushmeat, rangers' perception was not obtained on other illegal activities in the park.

4.3.8 Perceptions of illegal hunting trends

A high proportion of villagers (76.87%) and rangers (66%) indicated that illegal hunting has increased over the last five years in the park (Figure 4.9). Rangers' perception of trends in other illegal activities in the park were not obtained.

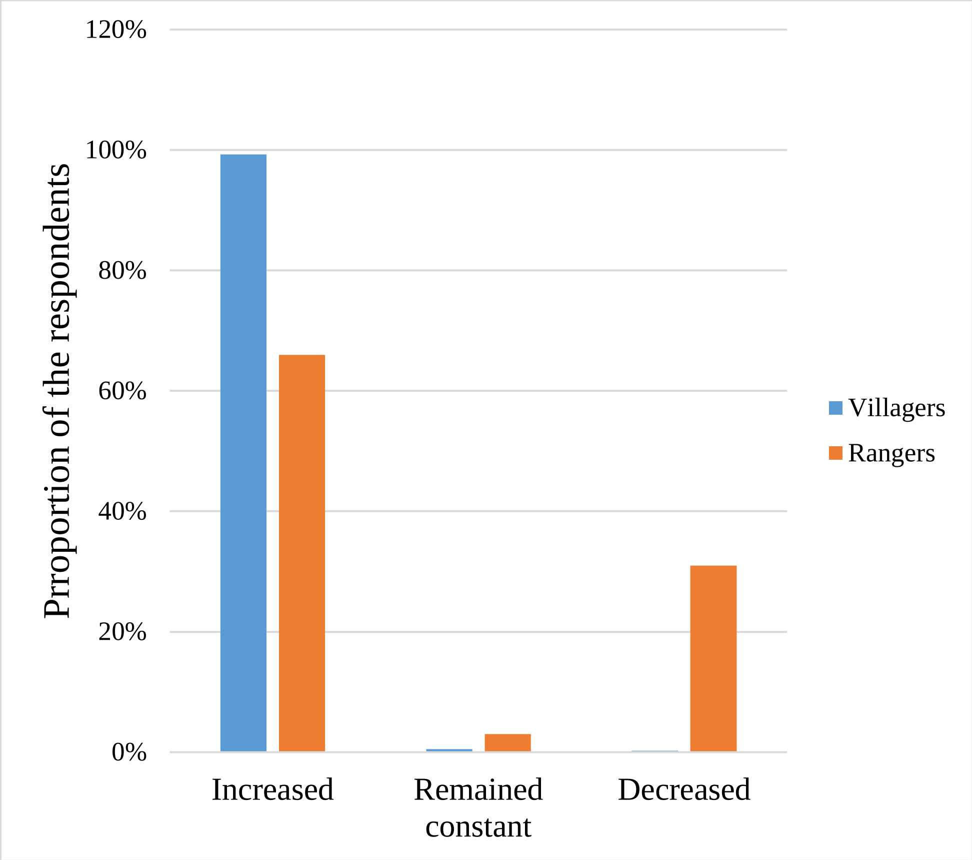


Figure 4.9 Trends in illegal hunting activities in OONP, over the last five years.

4.3.9 Recorded offences of illegal activity

Past records obtained from the litigation department of OONP revealed that ten types of illegal activity occurred in the park between 2004 and 2013. There has been an increase in the number of offences recorded over this 10 year period (Table 4.9), and the majority of offences relate to grazing domestic cattle (53.17%) followed by illegal hunting of wild animals (27.88%).

Table 4.10 Past records of offences and number of arrests of illegal activities in OONP from 2004 to 2013.

Offence	Arrests each year										
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total
Hunting	13	33	33	33	64	10	19	32	0	53	290
Grazing	5	21	42	50	79	104	81	47	63	61	553
Logging	7	6	6	2	0	0	3	3	9	5	41
Honey trapping	1	1	0	0	0	2	0	0	2	10	16
Mining	20	46	12	0	0	0	0	0	0	16	94
Farming	0	0	3	0	6	3	0	0	0	13	25
Fishing	0	0	0	2	1	0	0	0	0	2	5
Wandering	0	0	0	0	0	0	0	1	0	0	1
Charcoal making	2	0	0	0	0	0	0	0	0	8	10
Collection of fruits	0	0	1	0	0	0	0	1	0	3	5
Total	48	107	96	87	150	119	103	83	74	173	1040

4.3.10. Ranger motivation and job satisfaction

Findings from the rangers' survey on their job revealed that all respondents were clear of their role as a ranger, although a third were unsure/did not know how their performance was judged (see Appendix 2 and Table 4.10). Of the nine statements on motivation, five of the statements were rejected by more than half of the rangers. These generally related to working conditions and benefits. However, 97% of rangers felt a sense of personal satisfaction when they did their work. Nevertheless, 73% of respondents were not happy with their present job. Reasons for this are unclear but the rangers seem to get verbal recognition for good performance rather than any monetary incentives.

Table 4.11 Proportion of rangers that accepted or rejected statements to elucidate information on motivation, job satisfaction, recognition and role clarity. Results are presented in frequency and percentages (%) in parentheses.

Statement	Accepted	Unsure	Rejected
Motivation			
I feel a sense of personal satisfaction when i do my work.	97 (97)		3 (3)
I feel that the job I do gives me a good status	23 (23)		73 (73)
I feel that my Superior always recognizes the work done by me	94 (94)		6 (6)
Financial incentives motivate me more than non-financial incentives	65 (65)		35 (35)
Good physical working conditions are provided in this organization	42 (42)	2 (2)	56 (56)
The employees in the organization feel secure in their job	58 (58)	4 (4)	38 (38)
The medical benefit provided in the organization is satisfactory	41 (41)	6 (6)	53 (53)
I am given health insurance coverage or reimbursed for expenditures on health	40 (40)	5 (5)	55 (55)
I am given adequate risk allowance	33 (33)	8 (8)	59 (59)
Job satisfaction			
I am happy with my present job	27 (27)		73 (73)
I will like to give up this job for another with equal conditions of service	41 (41)		53 (53)
My salaries are regularly paid	91 (91)		9 (9)
I am contented with the present salary structure	59 (59)	6 (6)	35 (35)
I receive encouragement in my work	58 (58)	3 (3)	39 (39)
I receive adequate supervision in my work	79 (79)	1 (1)	20 (20)
I receive adequate support for my work	67 (67)	6 (6)	27 (27)
I am tired of my job	17 (17)	1	82 (82)
I have the opportunity to use my skills and abilities in my job	85 (85)	7 (7)	8 (8)
Recognition			
I receive verbal recognition for good performance from my supervisors when necessary	86 (86)		14 (14)
I am financially sponsored on trips, training conferences, etc. as a show of appreciation for good performance	21 (21)	5	74 (74)
I am given a monetary reward as a show of appreciation for good performance	22 (22)	4	74 (74)
Role clarity			
I understand the goals of the wildlife division	100 (100)		
I know what my job responsibilities are	100 (100)		
I know what is expected of me in my day-to-day work as a ranger	100 (100)		
I know how my performance is judged in the organization	66 (66)	8 (8)	26 (26)

Note: Results were transformations as specified in section 4.2.4

4.4 Discussion

The findings of the three methods employed reveal that various illegal activities, particularly the grazing of domestic cattle and hunting of wild animals, occur in OONP, indicating widespread illegal activity. Despite this, it is worth noting that the villagers are aware of the reasons for the park's existence and that entry for whatever purpose is illegal. In addition, the rangers are cognizant of their role in biodiversity conservation in OONP.

4.4.1 Grazing of domestic cattle

Grazing of domestic cattle was the only illegal activity recorded during the line transect survey. Findings from the present camera trap and RRT survey respectively indicate that grazing of domestic cattle is the second and fifth most occurring illegal activity. Evidence from the empirical field survey show that herds of cattle graze in the park and most of this activity occurrs during the day. The villagers recognise grazing livestock as an illegal activity. The rate at which illegal grazing activities were detected by the camera traps and 42 herds of cattle sighted during the line transect survey across the park, indicates weak law enforcement that might be linked with rangers' patrol effort.

It is interesting to note that the presence of domestic cattle was highest in Oyo-Ile range compared to other ranges. This finding may be explained by the fact that the range is located in the north of the park, making it (and its associated vegetation type) prone to the influx of nomadic herders (seasonal movement of cattle from northward to southward) in search of forage with most of the herders being resident (Iro 2009, Bollig, Schnegg and Wotzka 2013, Kubkomawa, *et al*. 2015). The failure of the camera traps to detect domestic cattle in Yemoso range could be linked to the small area covered during the survey as a result of the speculated pre and post-election crisis in Nigeria that led to a reduction in number of days to conduct the survey (four instead of 6 weeks) in the range.

Although previous occupancy estimates for domestic cattle are lacking, the estimates in this study are high compared to the estimates obtained from similar studies conducted in other African countries such as Tanzania (Caro 1999) and Uganda (Rannestad, *et al*. 2006). Although the addition of covariates did not have a significant effect on occurrence models, the presence of domestic cattle was more likely when there was greater proximity to rivers, villages and rangers' stations. The presence of cattle near rivers could probably be for water as a result of low moisture gained through foraging during the dry season (Smit, Grant and Devereux 2007). Past authors have documented the concentration of large wild herbivores (with physical and feeding behaviour similar to that of cattle) and their use of landscape near permanent source of water (Valeix 2011). Other past studies have noted that the river influences the surrounding vegetation by contributing to the formation of unique assemblages of plant communities different from the upland areas (Kauffman and Krueger 1984, Case and Kauffman 1997). However, the presence of cattle and their continuous use of the sites close to the river will alter the vegetation structure and can result in a decline in faunal communities (Case and Kauffman 1997, Borchard and Wright 2010). The trampling caused by livestock grazing can reduce herbaceous cover and compact the soils leading to erosional and runoff problems that ultimately reduces the regeneration capacity of native plant species suitable for grazing by wildlife. The result of this study that found the possibility of cattle being present close to villages could be that the domestic cattle found might be resident and within ashort distance (within 10km) from the park, hence, the cattle can easily move in and out of the park to graze. Past studies have noted that pastoralism could take either a sedentary or a nomadic pattern. The sedentary pattern is based on limited movement around a home base, while nomadism involves a larger spatial (change of the environment) movement (Shettima and Usman, 2008, Ofuoku and Isife, 2009). The pattern of pastoralism common in the study area was not investigated but the findings from the RRT survey indicate many residents near the park use it for grazing therefore sedentary is likely. Although, there is no empirical evidence for nomadism, there are instances (two occasions) where large herds of cattle (> 500 individuals) were observed moving away from the park boumdary at Tede and Yemoso range (Pers. Observation).

The presence of cattle near rangers' stations could be explained by the fact that the majority of domestic cattle found in the study area may not be resident or new to the area. Cattle owners (pastoralists) could therefore access the park unaware of the various locations of rangers' stations across the park (Mkutu 2009, Lyamuya, et al. 2016, Bond and Mkutu 2017). Some of the pastoralists are equipped with modern weapons and therefore are difficult to apprehend by the rangers (Pers. Comm. With Oyo-Ile administrative range head, Mr Chidi Abere). Likewise, some of the cattle might be resident and may not be at all times guarded by the herdsmen because they already know their route to the park and back to the village (Pers. Comm with Sepeteri administrative range head Mr Sunday Adegbola). In addition, pastoralists have political support that gives them the courage to enter PAs to graze their cattle. For example, Bollig, Schnegg and Wotzka (2013) reported that pastoralists (Maasai) in Kenya and Tanzania were supported by political leaders who backed their claims for emergency access to national parks, reserves and forests. Indeed, pastoralists are experts at establishing claims over water and pasture through implicit threats of force (Scoones 1995, Bukari and Schareika 2015).

The presence of domestic cattle can have both positive and negative impacts on wildlife (Prins 2000, Vavra 2005, Austrheim, *et al*. 2016). However, there can be more negative than positive effects on species depending on the season and density of livestock (Schieltz and Rubenstein 2016). For example, Austrheim, *et al*. (2016) found evidence of declines in runoff water, plant productivity and carbon storage as a result of increasing the density of livestock. In addition, illegal grazing can also have detrimental impacts on native wildlife through direct competition and indirect factors such as habitat fragmentation and modification (Otuoma, *et al*. 2009). For example, competitive displacement from illegal grazing in Kenya PAs has led to a decline in over two thirds of wildlife populations and the complete disappearance of buffalo (Ogutu, *et al*. 2011, Ogutu, *et al*. 2016). Likewise, the persistence of eight endemic native species in Asia has been threatened by increased production and grazing of livestock (primarily goats) due to the economic motivation of the cashmere industry (Berger, Buuveibaatar and Mishra 2013).

In this study, the density of cattle (85.3 individuals/km^2) far exceeded that of native wildlife ($\leq$14.85 individuals/km^2 for ungulates). In fact, the density of cattle is higher than that reported in other studies (around 50 individuals/km^2) in 25% of PAs in India (Kothari, *et al*. 1989), the Katavi ecosystem of western Tanzania (Caro 1999) and Lake Mburo National Park in Uganda (Rannestad, *et al*. 2006). Nigeria has been reported as one of the top four producers of beef and milk in sub-Saharan and West African countries (Jahnke, *et al*. 1988, Ndambi, Hemme and Latacz-Lohmann 2007). For example, in 1992 a population of over 12 million cattle was found drifting southward, with 296,000 of these cattle reported in Oyo state where the present study area is located (NPDL record, 1992 as cited in (Iro 2009)). However, these figures were reported during the rainy season, when the north of the country has an abundance of forage and moisture (Iro 2009). Therefore, a higher influx of cattle will be expected southward during the dry season when forage and water are scarce in the north. Presently, there has been a gradual shift from seasonal transhumance to the sedentarization in pastoralism in Nigeria (Kubkomawa, *et al*. 2015). The present study area was located in the southern part of Nigeria and this may explain the high density of cattle observed in this study. High levels of illegal grazing activities have also been observed and stated in the study area previously, but no estimates have been provided (Afolayan, Milligan and Salami 1983, Akinyemi and Kayode 2010, Oyeleke, Odewumi and Mustapha 2015). However, given that the domestic cattle density in this study was based on a limited number of observations, and transects were located in few localised areas, the findings should be treated with caution.

The findings from RRT reveal that 36% of villagers grazed their cattle in the park. This figure could be true for villagers who are sedentary pastoralists. Given the average cattle herd size of 70 heads per pastoralist household in Nigeria as documented by past researchers (Adisa and Badmos 2010, Akpa, Alphonsus and Abdulkareem 2012, Okoli, *et al*. 2012), the evidence provided across the methods used in this study reveal that OONP is under an intense livestock grazing activity that could have detrimental impacts on conservation of native species (Madhusudan 2004, Lunt, *et al*. 2007). The persistence of native grazers hinge on the effort and the ability of park managers to design evidence-based interventions that reconcile the societal benefit of livestock grazing and its ecological impact (Briske, *et al*. 2011). This includes the ability of the government to provide sustainable and acceptable options for grazing livestock, such as public grazing areas or reserves (Wangchuk 2002, MacLeod and McIvor 2006). In addition, as observed in Tanzania, stricter laws, fines and confiscation of livestock have made rule-breakers weigh up the costs and benefits before taking livestock to graze inside PAs, (Nyahongo, *et al*. 2005).

Findings reveal that the rangers need to focus their effort in the north of the park, where most cattle were sighted. To do this more effectively, park management should endeavour to provide modern equipment and training on the use of firearms to enable rangers to work without any fear of attack from herdsmen that frequently go about with sophisticated weapons for defence against possible attacks on their lives and livestock.

4.4.2 Illegal hunting

Illegal hunting is the most common illegal activity in the study area as evidences from the camera trap and RRT survey. The camera trap survey reveals that most illegal hunting activities occurred at nighttime, presumably to avoid detection by rangers who only work through the day and when probability of arrest is low. The villagers recognise that the park is established to protect and preserve wild animals. However, the findings from the RRT survey and the number of offenders (hunters arrested) documented in the parks records indicate that the villagers' are still willing to practice illegal bush meat hunting. It is interesting to note that involvement in illegal hunting of wild animals differed significantly across the five ranges based on the RRT survey, where villagers from Tede indicated entering the park to hunt more frequently than the remaining four ranges. This could be explained if Tede is heavily populated with Yoruba and Others (PRC) ethnic groups that were traditionally inclined to hunt wild animals for taste or to safeguard against malnutrition. This substantiates previous findings that cultural value influences involvement in bushmeat hunting and consumption (Holmern, Muya and Røskaft 2007, Jambiya, *et al*. 2007, Fischer, *et al*. 2014). Conversely, RIA for illegal hunting from the camera trap survey did not differ statistically across the ranges, although it was highest for Tede. This could be linked to the effect of season that may have influenced the activities of hunters and the choice of hunting zone across the park. Instances of illegal hunting activity documented across the survey methods employed in this study is worrisome and a continuous practice may result in the depletion of wildlife species population and in severe scenario may lead to the loss of species(Milner-Gulland and Bennett 2003, Robinson and Bennett 2004, Corlett 2007, Bhattarai, Wright and Khatiwada 2016).Clearly, there is a need for more protection across the park and, more importantly, at core areas where wild animal populations concentrate during the dry season, as these places will be hotspots for hunting activities (Wato, Wahungu and Okello 2006, Peres and Palacios 2007, Harrison 2011).

The occupancy estimates for hunters were high across the park, with 97% of sites showing evidence of bushmeat extraction. This is much higher than 88% that was recorded in a similar study at South Wildlife Sanctuary of the Sundarbans in Bangladesh (Hossain, *et al*. 2016). Furthermore, the occupancy estimate and RIA for hunters in OONP was higher than that of most native wild species of large mammal, except for civet, bushbuck and kob (see Chapter 3). This may be due to easier access into OONP due to the influx of domestic cattle, which have established a series of passages and animal tracks across the landscape (pers. obs.). Indeed, roads have been found to increase accessibility to remote areas of protected landscapes, making them more susceptible to human activities (van der Ree, Smith and Grilo 2015). For example, considerable illegal wolf hunting was observed in habitats accessible to humans in Southeast Alaska, USA (Person and Russell 2008). Also, the increased access for hunters through forest fragmentation may make the protection of wild species more challenging (van der Ree, Smith and Grilo 2015).

Historically, the presence of humans and human related disturbance (including active poaching of animals) has been documented in PAs (Binlinla, Voinov and Oduro 2014, Khorozyan, *et al*. 2014). The high occurrence of hunters in OONP, and the report that hunting constituted 27.88% of offences recorded in OONP in the last decade, supports earlier studies that found hunting activities to be prevalent in West and Central Africa (Brashares, *et al*. 2004, Kuehl, *et al*. 2009). Indeed, the number of offences reported for illegal hunting was higher than all other activities except for grazing of domestic cattle. However, the number of offences may not depict the true extent of hunting activities in the park, as illegal hunting of wild animals is mostly carried out at night when hunters are less likely to be apprehended by rangers (Pers. Obs). Poachers living in close proximity to the park may escape arrest, while those that travel long distances may be frequently apprehended (Eliason 2008). For example, the ranger survey indicated that most poachers travelled over 10km from the park boundary, which could influence the low frequency of offences recorded for illegal hunting compared to illegal grazing.

The trend in hunting activities from 2004 to 2013 suggests that illegal hunting has increased, which is in agreement with the villagers' and rangers' opinions that illegal hunting has increased in the park in the last five years. However, a perceived trend in illegal hunting was not strongly substantiated by the park records. Increases in illegal hunting activities will have detrimental effects on wild animal populations as suggested from past studies from West African regions (Brashares, *et al*. 2004, Campbell, *et al*. 2008, Craigie, *et al*. 2010, Jimoh, *et al*. 2013, Lindsey, *et al*. 2013, Henschel, *et al*. 2014). In addition, most species' declines and extirpations reported in African PAs are attributed to hunting including the 59% decline in large mammal species abundance in 78 African PAs between 1970 and 2005 (Craigie, *et al*. 2010).

Furthermore, 2 species of duiker were extirpated in Oban Hills of Cross River National Park, Nigeria, (Jimoh, *et al*. 2013), the lion population in Nigeria dropped from 44 individuals to 34 between 2009 and 2011 (Henschel, *et al*. 2014), and there was over a 60% decline in the ungulate population in Comoe National Park, Ivory Coast (Fischer and Linsenmair 2001), all as a result of illegal hunting. These levels of decline have contributed to extinction rates that represent the endpoint in a long sequence of population declines from local, national and regional levels (Collen, *et al*. 2011). Therefore, the problem of illegal hunting should be tackled locally by identifying the drivers of this activity, in order to aid conservation process and increases the existence and population of wild species.

4.4.3 Villager survey

Both RRT and direct questioning estimates of the proportion of respondents to answer 'yes' to the control question (did you grow your own crop) and a sensitive question (since the national park has been established, have you ever entered the park) were somewhat similar. The villagers were expected to indicate that they grow crop, however, it was surprising that almost everyone had been in the park. This findings indicates that the villagers are faced with a difficult livelihood and the resources inside OONP contribute to their nutritional need and economic stability, especially during the dry season and/or crop failure as the crops grown are mostly for subsistence. Despite the villagers' high level of park awareness, and the reasons and laws guiding its existence, it appears that the respondents regard the sensitive question as non-sensitive, as all other sensitive questions (eg have you hunted animals in the park) produced much lower proportions of 'yes' responses. Although entering the park is a sensitive question, the illegality regarding entering the park was probably flouted by the respondents despite their high level of awareness about the regulations governing the park. This confirms the notion that people disagree with specific regulations because they doubt the soundness of such regulations and hence violate the rules (Muth and Bowe Jr 1998, Eliason 1999, Eliason 2004). The villagers could see the park as open access (Jambiya, *et al*. 2007, Muhumuza and Balkwill 2013), believing that their use of the resource therein should not be restricted (Caro, *et al*. 2013, Muhumuza and Balkwill 2013), hence resulting in the conduct of prohibited activities. Conversely, responses for both RRT and DQ were contrasting for the "have you entered the park to view animals/sight-seeing without seeking permission". Although, the villagers regard entry into the park as illegal, but openly disobeyed by entering it and consider any opportunities to view wild animals as not needing permission. A similar observation was reported in a study to estimate rule-breaking for different fly-fishing rules in the United Kingdom, where RRT and DQ produced similar estimates for questions perceived as less sensitive by respondents (St John, *et al*. 2010). Findings from this study support the ideas clearly stated by past researchers that the RRT approach should not be used to investigate topics that are not perceived as sensitive by the respondents (Razafimanahaka, *et al*. 2012).

The RRT returned much higher estimates (2-7 times higher) of illegal activities such as hunting animals and collecting plants/vegetables, than the conventional DQ in this study. This finding is similar to those of past studies on non-compliance of conservation rules (Solomon, *et al*. 2007, John, *et al*. 2010, Razafimanahaka, *et al*. 2012). The RRT estimates that over 84 % of locals had entered the park during the week prior to the survey, and that over 60 % had hunted animal or fish, grazed livestock, and/or gathered firewood or plants and vegetables during the year prior to the survey are worrying given the ecological implications of the effect of this level of extraction on the flora and fauna resources of the park. Irrespective of the reasons for entering a park, the presence of humans causes disturbance to wild animals (Frid and Dill 2002, Green and Giese 2004, Khorozyan, *et al*. 2014).

4.4.4 Ranger survey

It is interesting to note that rangers in this study were perceived to be motivated in their work, an indication of increased effectiveness in an organisation. Past research suggests that motivation reduces labour problems and absenteeism and increases effective utilization of resources with resultant increase in productivity (Chaudhary and Sharma 2012). Despite this level of motivation, rangers still found their physical working conditions, medical and health insurance benefits provided in the organisation not to be adequate. This can lead to lack of enthusiasm, frustration, emotional exhaustion and as a result reduce efficacy within the work place. These observations suggests that rangers should be provided with good physical working conditions like good accommodation in the field, modern anti-poaching equipment (including vehicle and fuelling), camping equipment and good medical facilities.

Pertaining to recognition, there was little tangible cash rewards as a show of appreciation for good and/ or outstanding performance. The recognition received was verbal. As previously noted non-cash rewards are more effective as it differentiate recognition from pay (Long and Shields 2010). However, recognition provided should also have financial value that provides employees with a sense that their contributions are appreciated by the organisation (Aktar, Sachu and Ali 2012).

Recognition drives positive behaviour in an organisation (Long and Shields 2010). Management of an organisation should endeavour to provide recognition that have financial value to enable the memory of the achievement to last long (Aktar, Sachu and Ali 2012).

With respect to role clarity, rangers indicated that they understood the goals of the wildlife protection unit of national park and how their roles fitted in with the conservation goals. They were clear about their job responsibilities and have knowledge of what is required to achieve the organizational goals. However, they are generally unhappy in their roles.

The findings also suggests that the current enforcement in OONP is ineffective in preventing illegal activities and safeguarding wild species. This is evident as the number of offences reported in the park are lower compared to the high level of illegal activities recorded in this study. The rangers appear to lack the ability to undertake effective enforcement due to a lack of training, adequate modern equipment and risk allowances. Consequently, some of the rangers are demotivated. In addition, some are involved in practices that are against the ethics of their job (Pers. Obs). Although rangers were not questioned directly on this aspect, it agrees with the notion from past authors that, due to poor working conditions of the law enforcement staff, reserve officials connive with poachers to perpetuate illegal activities within the reserves (Usman and Adefalu 2010). Therefore, the high level of illegal activities observed in this study, and the rangers who are in themselves demotivated in carrying out their roles effectively, may hinder the success of biodiversity conservation in OONP.

4.5. Conclusions and implications

The findings in this chapter strongly indicate the park is threatented with considerable anthropogenic pressure, as an increasing proportion of the villagers enter the park to commit various illegal activities (as shown by RRT) while few offenders are being apprehended by the rangers who are mostly armed with one or two rifles and a can-do spirit (Pers. Obs). Therefore, the management strategies in place are probably not strong enough to reduce threats and sustain the remaining wild animal populations. Among the illegal activities considered, hunting was the most intense, and coupled with evidence of declining mammal richness and abundance is unlikely to be sustainable. The findings here may not depict the true extent of all illegal activities occurring in the park. For example, the concealed nature of illegal hunting (mostly conducted at night), makes it likely that the number of people entering the park to hunt wild animals is an underestimate, related to the number who are apprehended. In addition, law enforcement is limited by human, equipment and financial resources, as well as patrols mostly occurring during the day. Hence, there is a need for rangers to have more resources, focus on wildlife hotspot parts of the reserve and conduct more night patrols. The use of technologies such as camera trapping may help improve the detection rate of poachers and supplement field patrol effort (Hossain, *et al*. 2016). In addition, there is a need for the park management to promote public awareness of the issue of wildlife hunting and its impacts on the ecosystem and rural livelihood. Such programmes must be consistently raised in villages surrounding the park and extended to places where bushmeat is sold and consumed. Furthermore, as law enforcement helps to deter non-compliance of wildlife laws among rule breakers, enforcement should be considered last after designing and implementing a conservation intervention that involves the local communities in decision making and provides them with livelihood security. One way to achieve this is to identify drivers of illegal hunting among the villagers in OONP which will be the focus of the next chapter.

Chapter 5: Drivers of illegal hunting in Old Oyo National Park, Nigeria

5.1 Introduction

As shown in Chapter 4, many anthropogenic activities were happening in the Old Oyo National Park (OONP) during the time this study was conducted. Of the various illegal extraction of wildlife resources and/or behaviour commonly exhibited by the villagers, a considerable proportion of them were entering the park to hunt animals. The primary aim of this chapter is to identify the drivers of this illegal hunting behaviour.

An identification of the drivers of illegal hunting in OONP is important since numerous empirical studies across the world, including the African continent, indicate that illegal hunting is a major cause of species extinction, especially of large mammals (Walsh, *et al*. 2003, Robinson and Bennett 2004, Schenck, *et al*. 2006, Corlett 2007, Fa, *et al*. 2009, Lindsey, *et al*. 2011, Jayeola, *et al*. 2012, Henschel, *et al*. 2014, Luiselli, *et al*. 2015). Many large mammal species have been targeted for subsistence and commercial purposes resulting in population decline and/or extirpation in their natural habitats across Africa, including, for example, in Mozambique (Fusari and Carpaneto 2006, Lindsey and Bento 2012), Tanzania (Masanja 2014, Nielsen 2006) and Zambia (Becker, *et al*. 2013). Illegal hunting is detrimental to the existence of large-bodied mammals as they are the most commonly hunted species. For instance, bush pig (*Potamochoerus larvatus*) and abbot’s duiker *(Cephalophus spadix)* have been extirpated from Udzungwa Mountains, Tanzania (Nielsen 2006). Lindsey and Bento (2012) observed that human disturbance through illegal hunting has led to the extirpation of five species within two years in the Save Valley Conservancy, Mozambique. Likewise, the impact of by-catch on non-target species has been found to threaten the persistence of the remaining population of elephant, lion (*Panthera leo*) and wild dog (*Lycaon pictus*) with an offtake of 32%, 11.5% and 20%, respectively, within five years in Zambia (Becker, *et al*. 2013).

The problem of illegal hunting of wild animals, as described above, also prevails in Nigeria which many authors (Bitanyi *et al.*, 2012; Lindsey & Bento, 2013) found as a major threat to wildlife conservation in the country. Many species have been extirpated from their natural habitats and those still found have their population declining (Usman and Adefalu 2010, Jayeola, *et al*. 2012, Henschel, *et al*. 2014). For instance, large and medium size herbivores and apex predators are restricted to few protected areas with indication of decline in their number owing to unsustainable extraction through illegal hunting (Henschel, *et al*. 2014, Luiselli, *et al*. 2015).

Despite such well-documented empirical evidence of the negative impacts of illegal hunting in Nigeria, little is known as to what factors drive such behaviour in the country. Although a few studies (Fusari and Carpaneto 2006, Wilfred and MacColl 2010, Moro, *et al*. 2013) have been able to identify the drivers of illegal hunting in some other African countries, far little attention has been paid to this issue in Nigeria – a country in which such practices have been pervasive (as shown in Chapter 4). Investigating the factors that cause individuals, households or communities to engage in illegal hunting of wild species is an essential first step towards tackling the rate of this behaviour (Brashares, *et al*. 2011, Duffy, *et al*. 2016).

As such, the main purpose of this chapter is to determine the effects of selected factors on the illegal hunting behaviour of the villagers neighbouring the OONP. In the next section (5.2) an analytical framework that could potentially explain the drivers of illegal hunting behaviour is provided. Based on the framework, specific hypotheses are proposed (Table 5.1). The data and methods used in testing the hypotheses are provided in section 5.3. In section 5.4 the results of the study are presented. The findings of this study are discussed in section 5.5 and lastly in section 5.6 the key conclusions are drawn and their implications discussed.

5.2 Literature review and hypotheses

The problem of illegal hunting can be explained by behavioural theories, of which there are two major schools of thought – rational choice and cultural choice (Von Essen, *et al*. 2014, Singleton and Fielding 2017). Recently, studies on illegal hunting have mostly approached this enquiry from a rational choice perspective which assumes that individuals are rational, profit-maximising agents (Lunt 2006, Tucker 2007). Consequently, individuals are frequently engaged in illegal hunting when opportunity presents itself.

First, where a variety of certain goods is available, individuals will begin with the premise to choose the preferred alternatives (Green 2002). Second, is the presence of constraint which is an important element in the procedure for making choice (Green 2002). The decision to make a choice depends on the constraint imposed on an individual as determined by individuals' income and the price of the goods (Green 2002). As a result, the need to maximize profit and minimize cost or risk therefore leads to individuals' level of satisfaction received through income either by spending less or a meal of bushmeat (Janssen, *et al*. 2010, Ostrom 2010). A typical means to effectively find solutions to the constraint require decisions/actions that cause changes in circumstances such as changes in income or in the prices of goods (Green 2002). For instance, illegal hunting and/or trading of wildlife is the third most valuable illegal market in the world after drugs and firearms (Ayling 2013). This is a consequence of the overwhelming reliance on the wildlife by human societies for economic reasons (Barnes, *et al*. 2016). The severity and threat of illegal hunting is on the increase due to economic benefit derived and the associated low cost of hunting and poor law enforcement (Masanja 2014).

However, poverty has been suggested as a key driver of illegal hunting, with many involved in illegal hunting for subsistence or as a source of additional income (Fa, Ryan and Bell 2005, Duffy and St John 2013, Duffy, *et al*. 2016).

Rational choice perspectives are often criticised as being a simplistic evaluation of human behaviour, as they fail to recognise historical, cultural and geographical features of local socio-economics (Hodgson 2012). As such, cultural factors can be important drivers of human behaviour (Scott 1987). For example, particular species may be preferred by local people during ceremonies, such as the utilization of red river hogs (*Potamochoerus porcus*) during circumcision ceremonies in Gabon (Van Vliet and Nasi 2008). Also, the need for an alternative source of income to cover household essentials such as food and clothing motivates the women to have a preference for hunting men as partners or husbands in Tanzania (Lowassa, Tadie and Fischer 2012). Consequently, they encourage the men to hunt using verbal and non-verbal appreciation and encouragement (Lowassa, Tadie and Fischer 2012).

Within the above assumptions, studies in other African countries (Knapp 2007, Polasky, *et al*. 2009, Moro, *et al*. 2013) have examined the effects of various demographic, economic and socio-cultural factors, as well as animal protein and/or nutritional source on illegal hunting behaviour (Wilfred and MacColl 2010, Jenkins, *et al*. 2011, Gandiwa 2011, Lindsey, *et al*. 2011, Moro, *et al*. 2013, Fischer, *et al*. 2014).

Age is one of the major demographic factors that has been found to influence bushmeat hunting behaviour (Lindsey, *et al*. 2011), with a greater proportion of young people participating in illegal hunting than older ones. Young adult men are presumed to have the inclination and opportunity to hunt as they are physically strong enough to spend long periods of time during hunting and have higher catch success (Kümpel, *et al*. 2010).

Past empirical studies have shown that illegal hunting is linked to lower **level of education** (Wilfred and MacColl 2010, Foerster, *et al*. 2011, Moro, *et al*. 2013). An educated individual has a better chance to get stable employment (East, *et al*. 2005, Gubbi and Linkie 2012). Such employment provides individuals with a stable and higher income and hence, the ability to afford household expenditures. As a result, they are less likely to rely on income from hunting for sustenance (Wilfred and MacColl 2010, Gubbi and Linkie 2012). However, some other studies provide contradictory evidence suggesting that illegal hunting can be more prevalent among educated individuals (Nuno, *et al*. 2013, Nadhurou, *et al*. 2017) because they have opportunities to acquire the resources necessary to invest in bushmeat exploitation (Coad 2008).

Income is another factor that has been found to influence illegal hunting among rural people (Shrestha and Alavalapati 2006, Wilfred and MacColl 2010). Past studies have reported that the majority of people living in rural areas are poor and belong to the low-income class that lives on less than $1 per day (Chen and Ravallion 2004, Garnett, Sayer and Du Toit 2007). This has led to the inability of rural people to obtain daily nutritional needs and encourages their involvement in illegal hunting (Lindsey, *et al*. 2011). In vulnerable households, hunting is more important for income than food consumption in areas with few alternative income sources (Schulte-Herbrüggen, *et al*. 2013). For instance, illegal hunting provides between thirty to over ninety percent of the total cash income earned by individual hunting households in Ghana (Schulte-Herbrüggen, *et al*. 2013). In Cote d'Ivoire, an average hunter can earn annual income of over $ 10, 000 from bushmeat, an income greater than the average cash crop farmer (Bitty, *et al*. 2015). Therefore, illegal hunting is driven by the need to get additional income for sustenance and/or to augment livelihoods, with those involved being regarded as poor and/or impoverished rural people (Gandiwa, *et al*. 2013, Moro, *et al*. 2013, Duffy and St John 2013, Duffy, *et al*. 2016, Mendonça, Washington Carlos Da Silva, *et al*. 2016, Knapp, Peace and Bechtel 2017).

However, under certain circumstances those with disposable income may be more likely to engage in illegal hunting (Knapp, Peace and Bechtel 2017, Moro, *et al*. 2013, Twinamatsiko, *et al*. 2014). For example, it has also been highlighted that illegal hunting increases with increasing income as individuals are able to invest their income in new and more efficient hunting which increases harvest rates (Wilkie, *et al*. 2005, Jenkins, *et al*. 2011, Duffy and St John 2013). Furthermore, individuals ascribed more value to some goods for cultural reasons e.g. some ethnic groups are culturally inclined to eating bushmeat, therefore choices are made irrespective of their geographical location and/or cost from obtaining the goods (bushmeat) (Thaler 1980, Brashares, *et al*. 2011, Morsello, *et al*. 2015). Based on this context, illegal hunting is not always driven by the need for economic gain. Individuals with considerable income may also be engaged in illegal hunting to supplement their needs and diversify their livelihood strategies rather than relying on it as a sole or primary means of income (Kaltenborn, Nyahongo and Tingstad 2005, Knapp, Peace and Bechtel 2017).

Many studies have identified **occupation** as a predictor of illegal hunting behaviour (Gandiwa 2011, Jenkins, *et al*. 2011, Abernethy, *et al*. 2013). Farming, which is the predominant occupation in rural communities neighbouring protected areas in Africa, has been found to be associated with illegal hunting (Jenkins, *et al*. 2011, Rao, *et al*. 2010, Rao, *et al*. 2011, Abernethy, *et al*. 2013). Crop farmers, for example, may be vulnerable to crop raiding by wild animals and invariably incur economic loss (Nepal and Weber 1995, Hill 2004). Such losses to wildlife can force the farmer into illegal hunting to protect their livelihood. In Africa, primates and other large herbivores were considered as problem animals which caused a considerable damage to farm crops and, as such, were killed (Loudon, Howells and Fuentes 2006, Hill and Webber 2010). For example in Cameroun (Weladji and Tchamba 2003, Granados and Weladji 2012), Mozambique (de Boer and Baquete 1998), Nigeria (Warren, Buba and Ross 2007, Eniang, *et al*. 2011), Tanzania (Kendall 2011) and Uganda (Tweheyo, Hill and Obua 2005). In the rural setting, crop farming is at subsistence level with the activities and production influenced by seasonal variation (Holmern, Muya and Røskaft 2007, Borgerson 2015). Crop farmers are fully engaged with farm activities during the wet season with enough produce for consumption and sale. A collapse in the livelihoods of farmers during the dry season results in economic hardship (income shortages), so illegal hunting becomes the safety net for the local people neighbouring PAs (Brashares, *et al*. 2011).

Also, livestock farmers may engage in illegal hunting activities when their livestock are attacked by wild animals. Such human-wildlife conflicts have led to the persecution and retaliatory killing of wild animals particularly the predators in the developing world (Kissui 2008, Inskip and Zimmermann 2009). Additionally, livestock farmers can engage in illegal hunting for subsistence and cash income (Kiffner, *et al*. 2015). Moreover, livestock may be treated as savings and insurance as opposed to regular dietary items (Wilkie, *et al*. 2005) and therefore bushmeat is consumed more in households that keep livestock compared to those that engage in crop farming (Mgawe, *et al*. 2012). Other authors (Moro, *et al*. 2013) however provide contradictory evidence by showing that an increase in livestock numbers reduced the probability of engaging in illegal hunting in Tanzania.

Ethnicity, a proxy to culture, has also been linked with bushmeat hunting (Holmern, Muya and Røskaft 2007, Jambiya, *et al*. 2007, Mfunda and Roslash 2010, Fischer, *et al*. 2014). Traditionally in Africa, ethnic groups that are farmers are also hunters (Kaltenborn, Nyahongo and Tingstad 2005, Falola and Agwuele 2009, Mfunda and Roslash 2010, Ceppi and Nielsen 2014). For example, 43% of the Wanguu tribe (farmers) also hunted in Tanzania (Ceppi and Nielsen 2014).

In Nigeria, the Yoruba ethnic group are mostly farmers and supplement their diet with wild animals (Falola and Agwuele 2009). They believe that animals are created for their consumption and that any meal without meat is like eating ‘emptiness’ (Ajibade

2006). As such, they do everything possible to have meat on their table (Ajibade 2006) and hence have the inclination to illegally hunt animals. Conversely, the Fulani tribes are pastoralists and also cultivate crops such as maize, millets and vegetable. Traditionally, they eat less meat but consume more dairy products from their cattle alongside their staple foods (Tyrone Lockett, Louis E. Grivetti, Cassius 2000). Moreover, Fulanis, being Muslims, will not eat meats that are not properly killed in line with Islamic rituals (Bonne and Verbeke 2008). Past authors have also found that the need for survival and sustenance influenced the immigrants that newly inhabit communities surrounding conservation areas to be involved in wildlife exploitation (Jambiya, *et al*. 2007, Duffy, *et al*. 2016).

Some authors (Fa, Currie and Meeuwig 2003, Jenkins, *et al*. 2011, Foerster, *et al*. 2011, Mgawe, *et al*. 2012) found that the wildlife-based **protein consumption habits** of local people in Africa may be a driver of illegal hunting. This reliance on wild animals can be due to lack of available and affordable alternative protein sources from domestic animals, as observed, in Congo, Gabon, Madagascar, and Tanzania (Fa, Currie and Meeuwig 2003, Jenkins, *et al*. 2011, Foerster, *et al*. 2011, Mgawe, *et al*. 2012). Other authors have found that individuals that have access to domestic animal protein engaged in illegal hunting (Kiffner, *et al*. 2015). For example, the ownership of chicken and other domestic animal protein sources increased the likelihood of individuals' involvement in illegal hunting and bushmeat consumption in Tanzania (Mgawe, *et al*. 2012). Presumably farmers keep animals for sustainable production (for example milk and egg) and not to be killed for consumption but considered as savings against urgent and special needs (Nasi, *et al*. 2008). However, past researchers have reported that bushmeat is mostly consumed as the cheapest of all animal protein sources available to the people neighbouring the PAs (Foerster *et al.* (2011). Therefore, the absence of cheaper and affordable alternative animal protein sources other than illegally-sourced bushmeat will increase the number of hunters and their activities (Lindsey, *et al*. 2011, Nielsen, Jacobsen and Thorsen 2014). Sometimes, however, the reliance may originate from the belief that wild meat is healthier and nutritious than domestic meat (Ndibalema and Songorwa 2008, Wilkie, *et al*. 2016). Hence, even those that consume other animal proteins would still hunt wild animals for their taste (Schenck, *et al*. 2006).

Based on the above review, seven hypotheses are proposed (see Table 5.1) and tested in this Chapter to identify the factors that affect the illegal hunting behaviour of the villagers neighbouring the OONP.

Table 5.1 Hypothesised effects of selected factors on the illegal hunting behaviour of villagers around the OONP

Hypotheses No.	Independent variables	Expected direction of effect	Rationale	Sources
H_1	Age	Negative	Young adults are able to hunt and engage in any economic activities, since they are physically stronger than older people. So, the likelihood of engaging in illegal hunting will decline with increasing age.	(Loibooki, *et al*. 2002, Gandiwa 2011, Lindsey, *et al*. 2011, Friant, Paige and Goldberg 2015)
H_2	Education	Positive and/or Negative	Uneducated individuals will be more likely to engage in illegal hunting because they may not be able to get stable jobs with adequate income. However, educated individuals may also likely to engage in illegal hunting because they can secure better job, earn higher income to invest in bushmeat exploitation	(East, *et al*. 2005, Wilfred and MacColl 2010)
H_3	Income	Positive and/or Negative	Illegal hunting can either increase or decrease with higher income. Low-income villagers would be more likely to engage in illegal hunting, because they are unlikely to afford household nutritional needs. On the contrary, high-income villagers can afford animal protein substitutes rather than depending on wild meats. However, higher income may increase illegal hunting as well, since wealthier villagers could afford modern hunting equipment.	(Lowassa, Tadie and Fischer 2012, Moro, *et al*. 2013, Twinamatsiko, *et al*. 2014, Knapp, Peace and Bechtel 2017)

Table 5.1 continued

H_4	Primary occupation (Crop farmers and other seasonal occupation)	Positive	Individuals that are agrarian (crop farming and/or mixed farming) and/or have other type of seasonal employment will be more likely to engage in illegal hunting compared to the livestock farmers, since the former occupation groups may have lower income as a result of crop failure due to drought and during the lean period.	(Jenkins, *et al*. 2011, Abernethy, *et al*. 2013).
H_5	Ethnicity (Yoruba and Migrants)	Positive	Yoruba's will be more likely to engage in illegal hunting because they are traditionally inclined to consume bushmeat. The same will be the case for the migrants from other regions and/or countries (PRC) as wildlife resources remains their primary source of food and income since they are new in the area. On the contrary, pastoralist tribes such as the Fulani's will be unlikely to be involved in illegal hunting.	(Holmern, Muya and Røskaft 2007, Jambiya, *et al*. 2007, Fischer, *et al*. 2014)
H_{6a}	Protein consumption (fish)	Positive	Those having access to alternative animal proteins such as fish would be less likely to engage in illegal hunting.	(Wilkie, *et al*. 2005, Moro, *et al*. 2013, Fischer, *et al*. 2014)
H_{6b}	Protein consumption (bushmeat)	Positive	Given that the forest is seen as an open access and bushmeat as free meat, the cost of acquiring bushmeat is cheaper than other animal protein substitute by the rural people, therefore, those that consume bushmeat tends to be engaged in illegal hunting.	(Brashares, *et al*. 2011, van Vliet, Nebesse and Nasi 2015)

5.3 Methods

5.3.1 Data and variables

The Direct Questioning (DQ) data on illegal hunting activity and/or behaviour of the villagers and their other characteristics were used. The sampling and data collection related to these variables have already been described in detail in Chapter 4 (see section 4.2.3). For this chapter, some variables in the original data set – including education, income, occupation and ethnicity – were transformed and collapsed into binary and/or three to four categories to remove redundancy. The measurement of the variables for this study are provided in Table 5.2.

Table 5.2 Lists of variables, questions and the scales used for collecting data on the variables used in this chapter

Variables	Questions	Scales
Dependent variable		
Engagement in illegal hunting activities	In the last 12 months did you ever enter the park to hunt?	Yes/No
Independent variables		
Age	Which of the age groups do you belong to?	Under 30 years 31 – 50 years 51years and above
Level of education	What is your level of education?	Primary level Secondary level Tertiary level No formal education Due to very few respondents falling within some categories this variable was re-categorised to: Not educated Educated
Income	Which of the following income groups do you belong to?	Low income (< N300, 000) High income (≥ N300, 000)
Primary occupation	Please indicate your primary occupation	Crop farmer Livestock farmer Mixed farmer Other artisans
Ethnicity	Which of the following ethnic groups do you belong to?	Yoruba Immigrant Fulani
Protein consumption (fish)	How often do you eat the following in your household?	Scales re-categorised as explained in Chapter 2 to: Consumed /Not consumed
Protein consumption (bushmeat)	How often do you eat the following in your household?	Scales re-categorised as explained in Chapter 2 to: Consumed /Not consumed

5.3.2 Analyses

To elucidate information on the characteristics of the villagers, descriptive statistics (e.g. counts and percentages) for each variable were computed and are detailed in Chapter 2 (Table 2.3). A bivariate analysis (Cross tabulation) was conducted to explore the association between the villagers' attributes and their illegal hunting activities inside OONP. To identify the predictors of illegal hunting activities, a binary logistic regression was performed, since the dependent variable of this study (illegal hunting) was in dichotomous format i.e. yes/no (Hosmer Jr, Lemeshow and Sturdivant 2013).

Prior to selection of the predictor variables for binary logistic modelling, a multicollinearity diagnostic test was conducted on all the seven variables (as per the six proposed hypotheses in Table 5.1) to identify multicollinearity (Midi, Sarkar and Rana 2010) . This was done in order for the analyses to be valid and to get good estimates of the distinct effects of important independent variables (villagers attributes) on the dependent variable (illegal hunting). A correlation coefficient cutoff value r > ±0.5 (Donath, *et al*. 2012, Dormann, *et al*. 2013, Vatcheva, *et al*. 2016) was used to discard variables with a medium (r > ±0.5) or even high (r > ±0.7) correlation with other variables (Table 5.3). The variable 'ethnicity' was strongly correlated with 'primary occupation', 'income' and 'protein consumption (fish)' and exceeded the cut-of value. Hence, ethnicity was discarded. The predictor variable fish consumption was also discarded due to multicollinearity with occupation (Table 5.4). Primary occupation was retained because of its importance to the topic under investigation. A total of five predictor variables – including age, education, income, primary occupation and bushmeat consumption – were finally fitted into the binary logistic model to test their effects on households' illegal hunting behaviour.

Table 5.3 The collinearity diagnostics table for the predictor variables. The threshold of **r** > ± 0.5 for Spearman's rho was used as a threshold for multicollinearity (Donath, *et al*. 2012, Dormann, *et al*. 2013, Vatcheva, *et al*. 2016). The values exceeding the threshold are highlighted in bold.

	Age	Education	Income	Primary occupation	Ethnicity	Consume fish	Consume bushmeat
Age	1	-0.169**	0.314**	0.145**	0.062	-0.045	0.017
Education		1	-0.113**	-0.196**	-0.264**	0.208**	0.207**
Income			1	0.438**	**0.572****	0.399**	-0.182**
Primary occupation				1	**0.797****	**-0.785****	-0.296**
Ethnicity					1	**-0.831****	-0.424**
Consume fish						1	0.467**
Consume bushmeat							1

The values in the table are for Spearman's rho
*Sig at 5% level or P ≤ 0.05; **sig at 1% level or P ≤ 0.01; ***sig at P≤ 0.001; ns "not significant"

Table 5.4 The collinearity diagnostics table for the predictor variables after the removal of the strongly correlated variables (ethnicity and fish consumption). The threshold for multicollinearity is ± 0.5 for Spearman's rho (Donath, *et al*. 2012, Dormann, *et al*. 2013, Vatcheva, *et al*. 2016)

Predictor variables	Age	Education	Income	Primary occupation	Consume bushmeat
Age	1	-0.169**	0.314**	0.145**	0.017ns
Education		1	-0.113**	-0.196**	0.207**
Income			1	0.438**	-0.182**
Primary occupation				1	-0.296**
Consume bushmeat					1

The values in the table are for Spearman's rho
*Sig at 5% level or P ≤ 0.05; **sig at 1% level or P ≤ 0.01; ***sig at P≤ 0.001; ns "not significant"

Model fits were determined based on whether or not the % of correctly classified cases increased in the final model and also whether or not the Hosmer Lemeshow test statistic was significant. Hosmer Lemeshow is a statistical test for goodness of fit for logistic regression models. The test assesses whether or not the observed event rates match expected event rates in subgroups of the model population. In addition, Nagelkerke R^2 was used to understand the explanatory power of the model. Data were analysed using the Statistical Package for Social Sciences (SPSS) version 22 software.

5.4 Results

5.4.1 Descriptive statistics of the variables

The existence of illegal hunting, the dependent variable of this study, is already described in Chapter 4, section 4.3.3 As shown, 28 % of the respondents indicated that they had entered the park to hunt animals within a twelve months period (from DQ data).

The summary statistics of the predictor variables were provided in the Chapter 2 (Table 2.3).

A total of 800 male respondents completed the questionnaires across the 5 administrative districts. The highest proportion (46.4%) of the respondents were under 30 years of age, while 40.1% fell into age group 31-50 years and 13.5% above 50 years. The higher percentage (> 40%) of young adults in this present study is similar to those reported in other African studies that young and middle aged adults between the ages of 21 to 50 engage in illegal hunting (Kaltenborn, Nyahongo and Tingstad 2005, Lindsey, *et al*. 2011, Bitanyi, *et al*. 2012, Gandiwa, *et al*. 2014).

Only 11.4 % of the respondents had had formal education (primary level). There is a similarity between the proportion of the non-educated in this study and that reported in Zimbabwe (Gandiwa 2011). However, past researchers found a lower proportion (≤ 20 %) of non-educated in studies conducted in other countries (Bitanyi, *et al*. 2012, Gubbi and Linkie 2012).

The majority of the respondents (89%) fell within the low income category and the remaining 11% in the high income category. This shows that the vast majority of the local people in this current study could be regarded as poor. The proportion of low income is higher compared to that (58%) reported in Tanzania (Knapp 2012).

The occupation of the respondents includes crop farming which was practised by 49.6%. Livestock farming (pastoralism) was practised by 30.4% while mixed-farming and other forms of employment (artisans) were practised by 16.6% and 3.4% respectively. The proportion of crop farmers as the predominant occupation in this study was somewhat similar to the proportion reported in past studies (Gandiwa 2011, Jenkins, *et al*. 2011, Mgawe, *et al*. 2012). Higher proportions of crop farmers were reported in other studies compared to this present study (Loibooki, *et al*. 2002, Gandiwa 2011, Gubbi and Linkie 2012). In addition, the proportion of those engaged in livestock farming in this present study was lower compared to that (78 %) in Zimbabwe (Bitanyi, *et al*. 2012). Past authors have also reported few mixed farmers and other artisans in their studies (Ebua, Agwafo and Fonkwo 2011, Ceppi and Nielsen 2014).

The ethnicity of the sampled households was more skewed to the Yoruba (indigenous) tribe (59.4%). The Fulani (30.8%) and others i.e. migrant – people from other regions and countries (PRC) (9.9%) constitute the remaining population. Similar observation of skewness to a particular tribe (the hunter-gatherer) in other African studies was reported by past researchers (Kaltenborn, Nyahongo and Tingstad 2005, Bitanyi, *et al*. 2012, Ceppi and Nielsen 2014).

On the animal protein consumption, 43.9 % and 70.1 % of the villagers respectively indicated that they consumed bushmeat and fish. Past authors have reported the frequent consumption of animal protein substitute mostly from the wild source in rural communities neighbouring conservation areas (Loibooki, *et al*. 2002, Mgawe, *et al*. 2012, Ceppi and Nielsen 2014).

5.4.2. Bivariate analysis of illegal hunting and predictor variables

Of the predictor variables, primary occupation, income, ethnicity and bushmeat consumption had significant associations with illegal hunting activities, whilst age and level of education had no significant associations.

Overall, hunting activities prevailed in all age groups. Of 28.5 % of the respondents involved in illegal hunting12.9 % were under 30 years of age, 12.4 % belonged to the age group 31-50 years, and 3.3 % were above 51years (Figure 5.1A). The association between illegal hunting and age groups was not statistically significant (χ^2= 2.01, df =2, P= 0.368).

The non-educated constituted 24.90 % of the respondents involved in illegal hunting of wild animal while 3.6 % were educated (Figure 5.1 B). There was no significant association between the respondents' level of education and illegal hunting activities (χ^2= 0.572, df =1, P = 0.45).

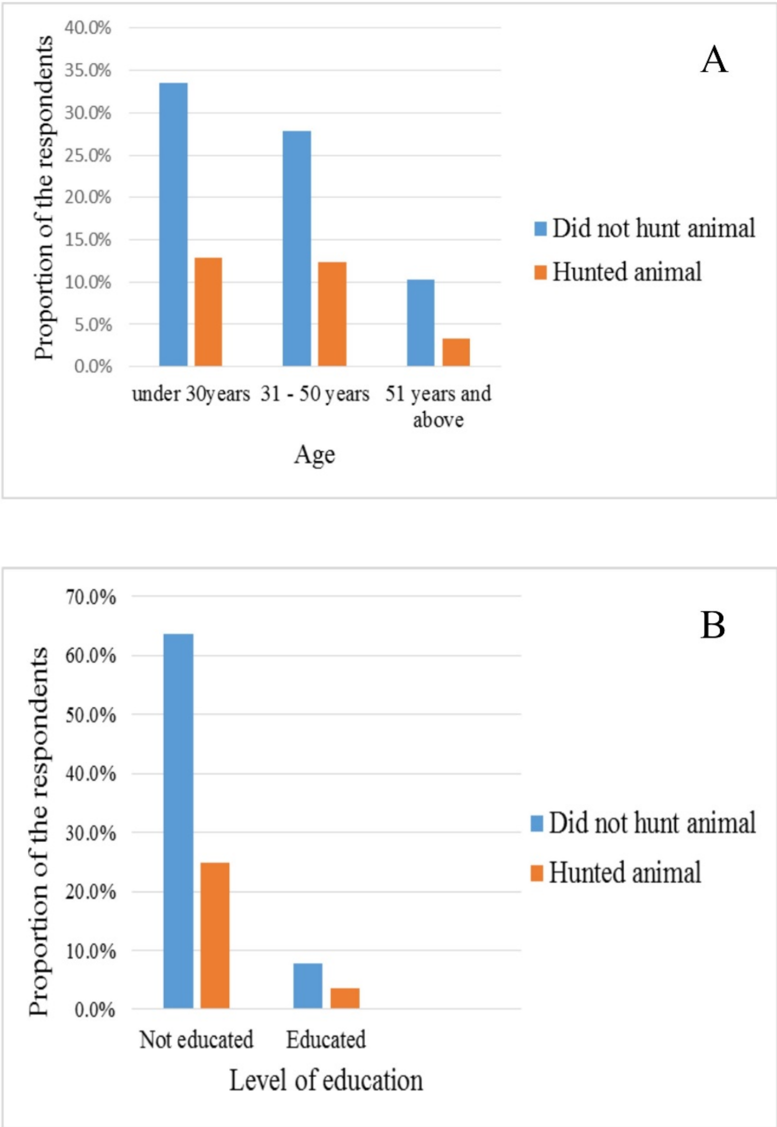
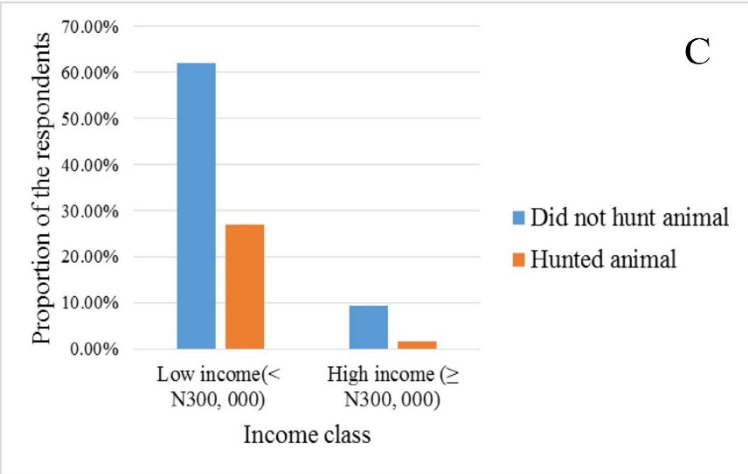


Figure 5.1 Bar chart representing the illegal hunting behaviour in relation to respondents (a) Age and (b) Level of occupation as indicated during the 2015 Villagers survey in OONP (in percent).

As shown in Figure 5.2 C, the income of the respondents was significantly related to the illegal hunting activities; 26.9 % and 1.6 % for low and high income class respectively (χ^2= 9.143, df =1, P = 0.002***).

In relation to occupation, majority (19 %) of the illegal hunters were crop farmers, while 5.3 %, 3 % and 1.5 % respectively were mixed farmers, livestock farmers and those in other types of work/or other artisans. This was significant (χ^2= 62.137, df =3, P = 0.000***). See Figure 5.2 D



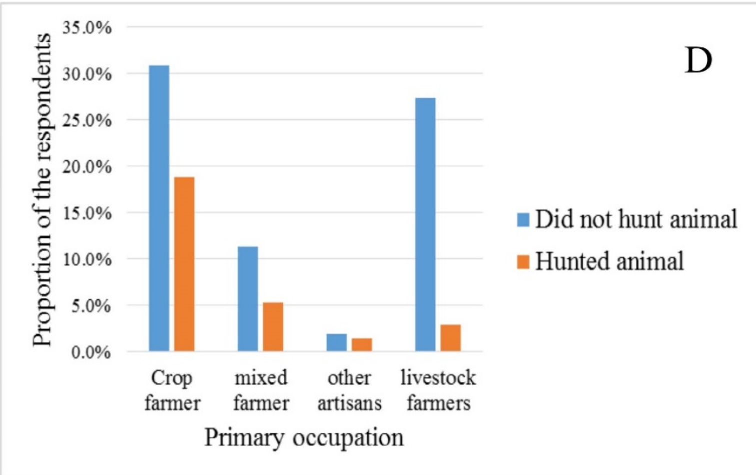


Figure 5.2 Bar chart representing the illegal hunting behaviour in relation to respondents (c) Income and (d) Primary occupation as indicated during the 2015 Villagers survey in OONP (in percent).

Ethnicity of respondents was also significantly associated with the illegal hunting activities (χ^2= 92, df =2, P = 0.000***). Of the total respondents in this study, 19.3 % of those engaged in illegal hunting activities were Yoruba, 6.3 % were migrants (PRC) and 3 % were Fulani (Figure 5.3E).

There was a significant association between bushmeat consumption and illegal hunting activities (χ^2= 14.32, df =1, P < 0.001***). Those that reported consumption of bushmeat constituted 13 % of the respondents involved in illegal hunting of wild animals while those that denied consumption of bushmeat and illegally hunt wild animals were 15.5 % (Figure 5.3F).

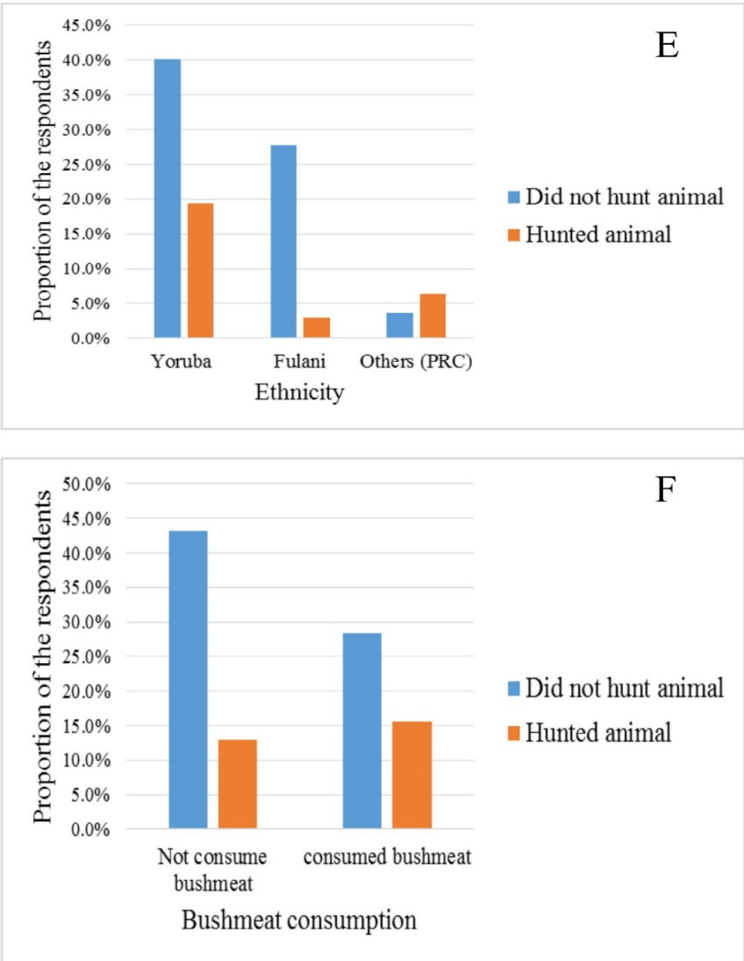


Figure 5.3 Bar chart representing the illegal hunting behaviour in relation to respondents (e) Ethnicity and (f) Bushmeat consumption as indicated during the 2015 Villagers survey in OONP (in percent).

5.4.3 Factors affecting illegal hunting activities

Of the five predictor variables fitted into the binary logistic regression model, only primary occupation was found to significantly predict illegal hunting activities, while the other four variables – age, education, income and bushmeat consumption – did not statistically predict illegal hunting activities. Therefore, hypotheses H_1, H_2, H_3 and H_5 were rejected and hypothesis H_4 was accepted.

Table 5.5 Summary on the hypothesis tested, the direction of effects and decision

Hypotheses	Predictor variables	Hypothesised effects	Decision
H_1	Age	Positive	Hypothesis rejected.
H_2	Education	Negative	Hypothesis rejected.
H_3	Income	Positive	Hypothesis rejected.
H_4	Primary occupation(Crop farmers and other seasonal occupation)	Positive	Hypothesis accepted.
H_5	Ethnicity (Yoruba and Migrants	Positive	Dropped from subsequent anlysis due to multicollinearly problem
H_{6a}	Consumption of fish	Positive	Dropped from subsequent anlysis due to multicollinearly problem
H6b	Consumption of bushmeat	Positive	Hypothesis rejected.

The estimates of the binary logistic regression analysis, including regression coefficients, the level of significance, as well as the odds ratios (Exponential of Beta) are provided in Table 5.6. The odds ratios are used to compare the relative odds (likelihood) of the occurrence of the outcome of interest (illegal hunting), given exposure to the variable of interest (e.g. occupation). The significant effect of primary occupation on illegal hunting activities suggest that the individuals in the occupation categories of *crop farming*, *mixed farming*, and *other artisans*, were significantly more likely to be involved in illegal hunting compared to those in the *livestock farming* category (the reference category). The odds ratios (rounded) were 8 for other artisans, 7 for crop farming and 5 for mixed farming, respectively. This means that when other predictors are held constant, individuals that practice other type of employment (other artisans), are crop farmers, and are mixed farmers, would be 8, 7 and 5 times more likely, respectively, to illegally hunt wild animals compared to those engaged in livestock farming (Table 5.6).

The result of Nagelkerke R squared estimates (best R for logistic regression) specify that the whole model explained 47% of the variance that can be predicted from the independent variables. The model correctly classified 75.8 % of cases and the Hosmer and Lemeshow test (.78) was not significant ($P = 0.05$). These suggested that the model was a good fit to the data.

Table 5.6 Effects of selected predicting variables on Illegal hunting activities/behaviour in OONP. Key: B=estimated coefficient; Standard error; P=level of statistical significance, * denote statistical significance and Exp (B) = odds ratio

Independent variables	B	Standard error	Sig.	Exp(B) (Odds Ratio)
Age (reference category- Above 51 years)				
≤30 years	0.116	0.278	0.68 ns	1.124
31-50 years	0.301	0.268	0.26 ns	1.351
Education (reference category- not educated)				
Educated (primary level)	-0.229	0.253	0.37 ns	0.796
Income (reference category-low income-(< N300, 000)				
High income (≥ N300, 000)	0.487	0.411	0.24 ns	1.627
Pry occupation (reference category- Livestock farming)				
Crop farming	1.879	0.304	0.000***	6.547
Mixed farming	1.575	0.354	0.000***	4.83
Other-artisans	2.062	0.476	0.000***	7.859
Consume bushmeat - yes (reference category "no")	0.161	0.356	0.356ns	1.175
Constant	-2.117	0.363	0.000	0.120

*Sig at 5% level or P ≤ 0.05; **sig at 1% level or P ≤ 0.01; ***sig at P≤ 0.000; ns "not significant" at P ≥ 0.05

5.5 Discussion

The findings of this study provide important perspectives about the characteristics of the villagers neighbouring the OONP and the influence of socioeconomic and demographic factors on illegal hunting. From descriptive analyses it is seen that the majority of the household heads resident in the study area are younger men below 50 years of age. Over 88 % of these men are not educated and hence are engaged in seasonal employment such as farming (crop farming, mixed farming, livestock farming) and other artisans. Crop farming is the predominant occupation among the villagers and mostly practised at subsistence level in OONP (Pers. Obs). Most of the men can be classed as poor, as the majority fall into the low-income category without alternative employment opportunity to generate cash income all year round.

The level of education, occupation and income depict the general socioeconomic conditions of villagers in most African countries (Loibooki, *et al*. 2002, Coad, *et al*. 2010, Lindsey, *et al*. 2011, Gandiwa 2011, Jenkins, *et al*. 2011, Mgawe, *et al*. 2012). Previous studies have similarly shown villagers in close proximity to PAs as mostly subsistence farmers (crop or livestock) with low income in Cameroun (Makoudjou, Levang and Chupezi Tieguhong 2017), Cote d'Ivore (Bi, et al. 2017); Equitorial Guinea (Kümpel, *et al*. 2010, Cronin, *et al*. 2015), Gabon (Van Vliet and Nasi 2008), Tanzania (Mfunda and Roslash 2010, Bitanyi, *et al*. 2012, Knapp 2012, Ceppi and Nielsen 2014, Knapp, Peace and Bechtel 2017) and Zimbabwe (Gandiwa 2011, Lindsey, *et al*. 2011, Gandiwa, *et al*. 2013). This suggests that the people surrounding PAs are prone to livelihood hardship and this may influence their heavily dependence on forest resources for consumptive and economic purpose.

In addition, this study suggest that certain characteristics of the villagers were associated with the illegal hunting activities in OONP. Exploratory bi-variate analyses indicate that these characteristics are the villagers' occupation, income, ethnicity and bushmeat consumption.

Similar to that observed in the current study, income is often found as one of the factors related to illegal hunting. Previous studies in other African countries have shown that hunters are low income earners, impoverished and constraint by food insecurity. This present findings further highlight the link between income and illegal hunting (Duffy 2010, Ayling 2013, Challender and MacMillan 2014). In addition, this study found 89 % of household heads in the low income category. A possible explanation for this may be that the farming occupation practised at subsistence level and the associated effect of season on the quantity of produce available for sale prevents them from earning a higher and stable income. Evidence from several other African countries suggest that poor rural people are faced with a difficult livelihood and therefore, will engage in any economic activities that will ease their suffering (Nielsen 2006, Duffy and St John 2013, Nielsen, Jacobsen and Thorsen 2014, Duffy, *et al*. 2016).

In an attempt to make every effort to get income and sustenance, many households became involved in illegal hunting in Gabon (Coad, *et al*. 2010), Tanzania (Nielsen 2006) and Zimbabwe (Lindsey, *et al*. 2011). The increasing demand for bushmeat and the significant monetary rewards for engaging in illegal hunting in comparison with earnings from other typical employment further exacerbate the rate of involvement and practice of this illegal activity (Knapp 2012, Friant, Paige and Goldberg 2015, Bi, et al. 2017).

Ethnicity was also found to be another important factor associated with illegal hunting activities. Various studies have revealed a high frequency of poaching among the indigenous rural people in Africa (Kaltenborn, Nyahongo and Tingstad 2005, Mfunda and Roslash 2010). These studies suggests that the need for animal protein consumption and socio-cultural reasons (hunters gaining respect from the community for a successful hunt) motivates individuals to take into illegal hunting of wild animals. The present findings are similar to these studies as the ethnic representation of illegal hunters are more skewed to the Yoruba who are mostly crop farmers. Traditionally, the Yoruba have an inclination to hunt due to historical accounts of hunting as part of their lifestyle and belief that wild animals were created for their use (Falola and Agwuele 2009, Friant, Paige and Goldberg 2015). Certainly, Yoruba were easily influenced by the agricultural cycle that appeared to dictate periods of intensive hunting (Falola and Agwuele 2009, Friant, Paige and Goldberg 2015). The other ethnic group (PRC) i.e. migrants from other regions and countries was identified to engage in illegal hunting. This result further confirms the previous findings that reported the involvement of immigrants in illegal hunting (Poulsen, *et al*. 2009, Duffy, *et al*. 2016). The migrants in OONP are mostly from regions that were faced with political and religious crisis (Pers. Obs.). Hence, the need for survival and food security in a new environment possibly influenced their illegal hunting behaviour.

It is interesting to find that the Fulani also engaged in illegal hunting. This finding is consistent with the result of previous studies that found a higher proportion (16 %) of the Masaai who are pastoralist involved in illegal hunting of wild animals in Tanzania (Kiffner *et al*. 2015). Other studies have revealed that the pastoralist households see livestock as savings and do not depend on it as a sole source of income and improve their income through off-farm activities like illegal hunting (Loibooki, *et al*. 2002, Huber 2012, Mgawe, *et al*. 2012, Majekodunmi, *et al*. 2014). Therefore, the Fulani may probably hunt to generate cash income.

In general, similar to that observed in this study, illegal hunting has been linked to bushmeat consumption in other African countries (Loibooki, *et al*. 2002, Lindsey, *et al*. 2011, Moro, *et al*. 2013). In fact, it is common with rural populations in developing countries in general as protein is rarely consumed and when consumed is mostly from wild sources (Bwibo and Neumann 2003, Brashares, *et al*. 2011, Mgawe, *et al*. 2012). Given that the villagers in this current study are low income earners, individuals might made the choice to illegally hunt animals in order to reduce the amount spent on acquiring animal protein substitutes. Money saved from such hunting expenditure can be diverted for other uses. For instance, past authors have highlighted income from illegal hunting was used to finance farming inputs and farm labour to further increase earnings derived from agricultural production (Davies and Brown 2008, Wilfred and MacColl 2010). Furthermore, the price of other available protein substitutes (not part of this present study) could be too high and therefore cause a shift to bushmeat consumption as the cheapest source of animal protein. Consequently, this probably contributes to an increase in the number of illegal hunters as many people will be motivated to hunt since the cost of acquiring bushmeat is low, especially during the dry season when there is less forest cover and good visibility that aids hunting and increases hunter off-take.

Whilst, the exploratory bivariate analyses based on chi-square showed associations between illegal hunting and other socio-economic characteristics of the villagers, the results of the logistic regression analysis indicated that not all of those factors were not significant in predicting the likelihood of illegal hunting. The only characteristic that appeared to be significant was ‘primary occupation’, with crop farmers and other artisans being significantly more likely to engage in illegal hunting compared to livestock farmers. The present results support some past studies which found that engaging in farming as a source of livelihood influenced local people to engage in illegal hunting in Mozambique and Tanzania (Fusari and Carpaneto 2006, Nielsen 2006, Duffy, Emslie and Knight 2013). Several previous studies have identified crop farming and other related jobs that are seasonal, and/or allocate time for other activities as a driver of illegal hunting in Gabon (Coad, *et al*. 2010), Ghana (Schulte-Herbrüggen, *et al*. 2013), Mozambique (Fusari and Carpaneto 2006), Tanzania (Loibooki, *et al*. 2002, Kaltenborn, Nyahongo and Tingstad 2005, Wilfred and MacColl 2010, Mgawe, *et al*. 2012) and Zimbabwe (Gandiwa 2011, Lindsey, *et al*. 2011, Gandiwa, *et al*. 2013).

There are two possible explanations for this present finding that crop farmers tend to be engaged in illegal hunting activities. One probable explanation is that crop farming in African rural areas is mostly at subsistence level with low income and lack of alternative opportunities to legally generate income during the agricultural lean season (the drought or dry season when there is little or no produce for sale) (Loibooki, *et al*. 2002, East, *et al*. 2005, Wilkie, *et al*. 2005, Fusari and Carpaneto 2006, Mgawe, *et al*. 2012). Since crop farming is the primary source of income for those that practiced it, lack of crops for sale during the dry season or as a result of crop failure can influence individuals to engage in illegal hunting for food and for generating cash income. To exemplify, 32 % of those whose primary source of income is farming, engaged in bushmeat hunting in Tanzania (Loibooki, *et al*. 2002). Also, Gandiwa and colleagues (2011) observed that local residents who were majorly agrarian were involved in illegal hunting to alleviate poverty by acquiring protein and cash through the sale of wild meat and products in Zimbabwe.

Other authors highlighted that those whose occupation is farming are probably involved in hunting (hunter – farmer) by investing their income from agricultural activities to get new hunting equipment (Duffy, *et al*. 2016). As indicated by the descriptive statistics (Table 2.3), the villagers in this current study belong to the low income class and hence may engage in illegal hunting for food and cash income.

Further more, there is a possibility that crop farmers experience loss of crops to wild animals as species roam freely in and out of the park (Pers. Comm. with the park research officer, Mr Ola Kazeem) which may reduce the income generated from agricultural produce. Previous authors have observed that crop farmers whose field and farms are at close proximity to conservation areas are vulnerable to crop raiding and hence incur economic loss (Hill 1998, Hill and Webber 2010). The loss can be direct (crop damage) and/or indirect (increased need to guard field). Such loss can lead to a hostile attitude of farmers against wild animals depending on the degree of damage and/or if their livelihoods depend only on agriculture for income. The magnitude of damage depends on the size of the farm, distance and frequency of crop raid (Nepal and Weber 1995, Hill 2004, Webber and Hill 2014). Other authors have identified crop raiding intensity at farms closer to the PAs boundary (Tweheyo, Hill and Obua 2005, Hill and Webber 2010). Typically, most farmlands in the present study area are at very close proximity (less than 50 metres) to the park (Akinyemi and Kayode 2010, Osunsina and Fagbeyiro 2015). The displeasure as a result of crop losses to wildlife has been noted to force farmers into illegal activities (Hill 1998, Hill and Webber 2010). Nevertheless, crop raiding has been found to be a driver of illegal hunting in communities neighbouring PAs. For example, 11 % of villagers surveyed indicated protection of crop damage from wildlife as the reason for engaging in illegal hunting in Zimbabwe (Gandiwa 2011). Similarly, 90 % of farmers perceived that the existence of a park is more detrimental to their livelihood due to wildlife crop raiding, of which one third indicated to have employed protection through the use of guard dogs and gun in communities around Seblat National Park, Sumatra (Linkie, *et al*. 2007). A significant proportion of farmers also indicated loss of agricultural crops to wildlife and declared their aggressiveness towards the troublesome species in Comoros (Nadhurou, *et al*. 2017). Although wildlife crop raiding was not investigated in this study, there is a need for further study of this topic.

Mixed farming (crop cultivation and livestock rearing) is another type of farming occupation identified in the literature to influence illegal hunting (Loibook *et al*., 2002; Wilkie *et al* 2005). Despite the opportunities of alternative sources of protein and income for mixed farmers in this study, the result shows that they are more likely to engage in illegal hunting. Past researchers highlighted that livestock's such as chicken, goats and pigs serves as savings and insurance and not as regular dietary items (Wilkie, *et al*. 2005). This suggests that a mixed farmer probably treats their livestock as a saving towards a period of food shortage rather than for consumption. Furthermore, wild food constitutes a higher proportion (24%) of rural household income compared to agricultural production (12%) in Congo (De Merode, Homewood and Cowlishaw 2004). Therefore, hunting of wild animals can provide source of income to ensure food supply during the lean season while the livestock may be kept for emergency need of cash to cover expenses of medical treatments or family occasions.

Furthermore, Villagers in other type of employment (other artisans) in this study also tended to engage in illegal hunting activities. Past studies have found that illegal hunting provides considerable income (USD 425) higher than a combination of other legitimate trades in small business, livestock and agricultural sales (USD 258) per annum in Tanzania (Knapp 2012). Similar findings were found in Nigeria whereby

73% of rural people engaged in illegal hunting for income generation and consumption as the market price of one of the preferred species (red-river hog - *Potamochoerus porcus*) was $106 in Nigeria (Friant, Paige and Goldberg 2015). This price is twice the monthly minimum wage – ($50) of civil servants (Government employee). Such relatively high income associated with bushmeat can encourage more people to be involved in illegal bushmeat hunting. The current findings suggest that other sources of income may not be sufficiently attractive to compete with the opportunities provided by hunting to local people (Nuno, *et al*. 2013). However, cash obtained from other employment may facilitate hunting through procurement of modern hunting equipment.

Variables such as ethnicity and fish consumption were dropped because of collinearity with occupation to fulfil the conditions of logistic regression, but these correlations do provide interesting insights. The bivariate analyses provides further explanations. For instance, a strong positively significant association between occupation and ethnicity indicates that the crop farmers are mostly the Yoruba who are traditionally more inclined to hunt wild animals for ritual, medicinal and consumption reasons whilst the livestock farmers are mostly the Fulani who less likely to hunt for consumption due to religious reasons. The collinearity matrix also shows that there is a significant positive association between occupation and the two socioeconomic variables i.e. education and income. This implies that there is some evidence that crop farmers are mostly the non-educated and the low income earners who are faced with food insecurity during the agricultural lean season. Furthermore, a negative significant association with bushmeat and fish consumption suggests that crop farmers see fish and bushmeat as potential substitute I.E. if one is not available, or more expensive, farmers will replace with and/or consume the other. This further support the notion that fish and bushmeat are dietary substitute in the rural area. However, the source of the fish consumed was not investigated but the findings in the previous chapter indicates that a considerable proportion of the villagers enter the park to fish.

Certainly, crop farming as the predominant occupation and the sole source of income with the associated low financial status in this study expose the villagers to economic hardship. This invariably increases the rate of illegal hunting activities in the communities surrounding the OONP.

The correlations between villagers' occupations and other attributes indicate that there is a need to develop new conceptual categories by combining several of the villagers' attributes together and a term to describe them. For example, ethnicity and occupation have been termed occupational segregation by ethnicity. The segregation perspective has been widely adopted in sociology research, particularly in the western societies (Cohen and Huffman 2003, Alonso-Villar, Del Río and Gradín 2010, Zhang and Wu 2017), but less often in research on rural people. However, further studies should attempt at solving this by using advanced modelling techniques like Multivariate Structural Equation Modelling.

Other features including age, level of education, income and bushmeat consumption investigated in the present study did not significantly predict illegal hunting. This is in contrast to previous studies that found the effect of age, education, income and bushmeat consumption on illegal hunting (Loibooki, *et al*. 2002, Lindsey, *et al*. 2011, Nuno, *et al*. 2013, Nielsen, Jacobsen and Thorsen 2014, Knapp, Peace and Bechtel 2017, Nadhurou, *et al*. 2017). The only explanation for this result could be that illegal hunting is wide spread and it practice depends on the circumstances confronting individuals.

5.6. Conclusion and implications

The aim of this chapter was to determine the effect of selected factors on the illegal hunting behaviour of the villagers neighbouring the OONP. Among the potential drivers of illegal hunting proposed in the hypotheses, this study found in agreement with others (Loibooki, *et al*. 2002, Nielsen 2006, Lindsey, *et al*. 2011, Moro, *et al*. 2013) that the type of occupation villagers are involved in significantly affects their likelihood of engaging in illegal hunting activities in the conservation area. However, occupation was found to be a significant predictor. Bivariate and multivariate correlation analyses show that the picture is rather complex, since occupation is linked with ethnicity, income, education, fish and bushmeat consumption. Villagers in OONP engaged in illegal hunting possibly due to little or no income generated during the agricultural lean season, as crop farming remains the only legal source of income for the vast majority in the area. Aside from the need to generate cash income, the need to improve their dietary protein intake and to reduce the household meat expedition for savings may probably influence the villagers to illegally hunt wild animals.

The present findings advance the extant literature that have reported illegal hunting as a threat to conservation (Meduna, Ogunjinmi and Onadeko 2009, Lindsey, *et al*. 2011, Ripple, *et al*. 2016, Knapp, Peace and Bechtel 2017). The current findings shows specific farming type that can influence illegal hunting activities. It is also demonstrated that it’s a complex issue and linked with several other variables. These are not explained to this depth in the existing literature.

The findings have several key implications for conservation policy and practice in Nigeria. Since farming as an occupation is associated with illegal hunting, conservation authorities and Federal Government should provide incentives in the form of farm inputs (fertilizers, herbicides) and modern equipment (tractor and tillage implement) to crop farmers. Although over the years the Nigerian Government has provided these incentives to farmers at the local and national level (Rapu, *et al*. 2013), there is a need for close monitoring to ensure that these incentives are rightly allocated, disbursed and distributed to the stakeholders (farmers) and not converted/diverted to personal use among the political and implementing officers (Pasha 2002, Graham, Amos and Plumptre 2003, Usman and Adefalu 2010). Modern storage facility is greatly needed and should be provided by the Government as this will reduce food wastage and improve food security among villagers surrounding protected areas in the country. Availability of good storage facilities will also prevent rural farmers from selling their farm produce at ridiculous prices left with nothing for sale to earn income during the dry season, and hence faced with a difficult livelihood.

The present findings indicate that the Yoruba are significantly more inclined to engage in illegal hunting. This suggests that the Yoruba ethnic groups need most of the support. Therefore, the Yoruba should be the primary target when designing and implementing conservation interventions.

In addition, there is need to enhance crop farmers' ability to be resilient against environmental shocks and stresses (e.g. droughts) and cope during the lean seasons. Since the vast majority of farmers' livelihoods in Africa are dependent on rainfed agriculture the associated effect of seasonal variation has a large impact on the poor as well as that of the nation's economy. It is imperative to find a proactive approach to solving the problem of rainfed agriculture and the associated risks through the following:

- The development of several drought tolerant hybrids of crop varieties. Such varieties can provide a decent harvest under reduced rainfall and insurance against the risks of drought or crop failure. Although national and international research institutions e.g The International Institute of Tropical Agriculture (IITA) has recorded successes in improving the drought tolerance of major crops in Africa However there should be continuous development and evaluation of other grains from IITA across African regions to improve performance and provide a decent harvest under reduced rainfall and insurance against the risks of drought. Such hybrid crops should be made available in large quatities to replace the existing varieties to improve the livelihoods of the rural farmers.
- Strategies that aid retaining and efficient use of variable rainfall; (large scale irrigation projects) should be implemented in order to improve food security in regions that are dependent on rainfed agriculture.
- The use of locally available inputs and practices such as intercropping and rotational cropping, use of manure and organic fertilizers should be encouraged in areas with little or no access to funds to purchase adequate fertilizers and other agricultural inputs to improve crop productivity.

Further research is needed to identify other factors such as household size (Moro, *et al*. 2013, Fischer, *et al*. 2014), length of stay (Gandiwa 2011) and benefit sharing (Gandiwa 2011, Lindsey, *et al*. 2011) that were reported to be important to induce illegal hunting in communities neighbouring PAs but not included in this present study. Therefore, there is need to create a more theoretically robust analytical framework that combines several of the villagers' attributes to further understand and substantiate the drivers of illegal hunting. Bushmeat consumption did not significantly predict illegal hunting activities, but was significantly associated with illegal hunting and also with the significant predictor, occupation. Hence, there is need for more research to determine the drivers of bushmeat consumption among the villagers. Such information is essential for designing and implementing empirical base conservation interventions towards achieving an effective conservation process. This will be the focus of the next chapter.

Chapter 6: Factors affecting bushmeat consumption by villagers around the Old Oyo National Park in Nigeria

6.1 Introduction

As shown in Chapter 5, one of the factors associated with illegal hunting activities in the Old Oyo National Park (OONP) includes bushmeat consumption of the villagers in communities surrounding the park. In addition, as detailed below, bushmeat consumption is an extremely important and widely-reported cause of wildlife decline globally. Therefore, the primary aim of this chapter is to identify the factors affecting this bushmeat consumption among villagers surrounding the OONP. Such an understanding is vital in developing interventions for achieving sustainable and effective conservation of exploited species (Brashares, *et al*. 2011, Duffy, *et al*. 2016).

The term 'Bushmeat' refers to non-domesticated terrestrial mammals, birds, reptiles and amphibians harvested for food (Nasi, *et al*. 2008). Bushmeat harvesting is one of the key human threats to wildlife worldwide, especially in African tropical regions where a large number of people depend heavily on wildlife for bushmeat, driving wildlife populations to local extinction (Robinson and Bennett 2004, Corlett 2007, Singh and Sharma 2009, Bennett 2011, Wilkie, *et al*. 2011).

Often, bushmeat represent the cheapest source of animal protein for rural communities and is significant to their food security where other sources of animal protein are scarce or prohibitively expensive (Pinstrup-Andersen 2009). Bushmeat increases the dietary diversity of consumers (Sunderland, *et al*. 2013) and serves as a nutritional safety net by increasing the quality of food and nutrient requirements (hidden hunger) during agricultural lean seasons and/or during periods of economic hardship (Kümpel, *et al*. 2010, Sneyd 2013, Golden, *et al*. 2014, Reuter, *et al*. 2016). Because of this importance, the poorer and/or remote communities with fewer and/or no alternatives to animal protein sources have unsustainably extracted wild species not only for consumption, but also for income generation (Milner-Gulland and Bennett 2003, Craigie, *et al*. 2010, Lindsey, *et al*. 2013). As such, thousands of tonnes of bushmeat are consumed annually in different parts of the world (Bennett 2002, Fa, *et al*. 2006, Nasi, Taber and Vliet 2011)

Such unsustainable practices have led to the extirpation of wild species (Fa, Currie and Meeuwig 2003, Kümpel, *et al*. 2010), including population declines in large mammals (Lindsey, *et al*. 2013). It is predicted that in central Africa, the supply of bushmeat is expected to drop by 81% by 2050 due to overhunting (Fa, Currie and Meeuwig 2003). Likewise, in many other areas bushmeat will not be available in the future (Bennett 2002). The lower availability and/or scarcity of bushmeat and nutrient deficiencies are likely to seriously impact upon those whose food security and livelihoods depend on these resources (Fa, Currie and Meeuwig 2003, Butchart, *et al*. 2010, Lindsey, *et al*. 2013, Ripple, *et al*. 2015). Since there are no viable populations of large mammals outside African protected areas, hunters are moving inside of protected landscapes for bushmeat (Lindsey, *et al*. 2013).

Nigeria is one of the African countries affected by bushmeat consumption (Anadu, Elamah and Oates 1988, Fa, *et al*. 2006, Jimoh, *et al*. 2013). The reliance of local communities neighbouring protected areas (PAs) on bushmeat is increasing following the socio-economic and political challenges that Nigeria is currently facing (Usman and Adefalu 2010, Ofoche 2012, Eme, *et al*. 2014). Consumption of bushmeat cuts across all income groups in the country (Martin 1983) with higher rates of consumption and trade in rural communities (Fa, *et al*. 2006, Macdonald, *et al*. 2011).

The bushmeat crisis is increasingly unsustainable (Thaler 1980) as extraction of wild animals is carried out through the use of guns and other modern hunting equipment and camping, with a resultant decline in large mammal population (Anadu, Elamah and Oates 1988, Fa, *et al*. 2006, Eniang, Eniang and Akpan 2008). However, few empirical studies, if any, have been conducted to understand the drivers of bushmeat consumption among the local people in Nigerian PAs.

Therefore, the aim of this Chapter is to fill this knowledge gap by identifying the demographic, economic and geographical factors that influence bushmeat consumption in villages neighbouring the Old Oyo National Park in Nigeria. In the next section (6.2) of this chapter a set of hypotheses regarding bushmeat consumption is provided based on a review of the literature. In section 6.3 the study methods are described. Section 6.4 contains the results of the study. In section 6.5, the findings of this study are interpreted and discussed and lastly in section 6.6, the key conclusions are drawn and their implications discussed.

6.2 Literature review and hypotheses

Bushmeat consumption is a human behavioural problem and therefore behavioural theories can be used as frameworks to explain this problem. Although there are many behavioural theories from a range of disciplines to draw upon, recent studies on bushmeat consumption have mostly approached this enquiry from a prospect theory (Thaler 1980) perspective which assumes that individuals have a perfect way of making decisions influenced by the prices of certain goods and income/wealth (Thaler 1980, Baron 2004, Levin and Milgrom 2004). Therefore, an individual constrained by difficult livelihoods, availability of animal proteins, and some demographic and socio-economic factors, will make decisions to consume goods by weighing the cost (selling price) and the pocket (income earned). This stimulates their preference for the consumption of animal protein substitutes that are cheaper and/or regarded as free gift (Thaler 1980, Fa, Currie and Meeuwig 2003, van Vliet and Mbazza 2011, van Vliet, *et al*. 2012).

In particular, income (a proxy to wealth) is a key factor in prospect theory and is closely related to many other factors that affect acquisition and consumption of bushmeat. Other factors associated with income that influence bushmeat consumption include: age (Mgawe, *et al*. 2012), education (Junker, *et al*. 2015, Randriamamonjy, *et al*. 2015, Ordaz-Németh, *et al*. 2017), occupation (East, *et al*. 2005, Shrestha and Alavalapati 2006b), cultural values (Fa, *et al*. 2002, East, *et al*. 2005, Ndibalema and Songorwa 2008, Mgawe, *et al*. 2012) and immigration (Poulsen, *et al*. 2009). However, few studies have examined the influence of these factors on bushmeat consumption.

Age is one of the potential factors that could affect bushmeat consumption among the villagers neighbouring protected areas. For example, in Vietnam, however, bushmeat was mostly consumed by younger men (Drury 2011). Past findings indicates that bushmeat is consumed by people of all ages (Drury 2011). A large number of studies, on the contrary, found a non-significant effect of age on bushmeat consumption (Fa, *et al*. 2002, Golden, *et al*. 2016, Mendonça, *et al*. 2016). For instance, age did not influence individuals' consumption of bushmeat in West Africa (Fa, *et al*. 2002), Southern Africa (Mendonça, *et al*. 2016) and in South America (Golden, *et al*. 2016).

Other studies have identified **education** as a variable influencing bushmeat consumption among rural people (Foerster, *et al*. 2011, Jenkins, *et al*. 2011, Mgawe, *et al*. 2012). Empirical studies have shown that educated people earn higher incomes and are likely to afford other sources of animal protein when compared with those that are not educated, hence, the educated do not depend on the wild for meat (Wilfred and MacColl 2010, Gubbi and Linkie 2012). A higher level of education provides full-time employment that is sufficiently attractive to compete with the opportunities for engaging in bushmeat hunting and consumption (East, *et al*. 2005, Gubbi and Linkie 2012, Razafimanahaka, *et al*. 2012). In Tanzania, having a lower level of education was associated with illegal hunting and bushmeat consumption (Moro, *et al*. 2013)

Household **income** can be a reason for bushmeat consumption. For many rual people, wildlife is an essential source of free animal protein that otherwise would have to be raised or bought (Robinson and Bennett 2013). As such, bushmeat serves as a safety net for poorer people with livelihood difficulty and/or economic vulnerability (Lindsey, *et al*. 2013). Even when bushmeat is not free, it tends to be cheaper and affordable than domesticated animal meat (Nasi, Taber and Vliet 2011, Smil 2013). This is why bushmeat is considered to be important in decreasing hidden hunger among poorer rural households in many countries, including Nigeria (Sneyd 2013).

Occupation has been cited by various researchers to have an influence on bushmeat consumption (Loibooki, *et al*. 2002, Willcox and Nambu 2007, Jenkins, *et al*. 2011, van Vliet, Nebesse and Nasi 2015). Consumption of bushmeat has been associated with agriculture-related occupations. Past studies have found a significant relationship between farming as an occupation and bushmeat consumption in other African countries, including Cameroon (Willcox and Nambu 2007, Wright and Priston 2010), Congo (van Vliet, Nebesse and Nasi 2015), Ghana (Schulte-Herbrüggen, *et al*. 2013) and Tanzania (Martin, Caro and Mulder 2012). In some countries the proportion of the farming population who consumes bushmeat can be overwhelming. For instance, 70% of the rural people classified themselves as crop farmers of which 95% admitted to consumption of bushmeat in Madagascar (Jenkins, *et al*. 2011). Furthermore, children from rural communities whose fathers' profession was crop farming more frequently consumed bushmeat than those whose fathers were in salaried jobs in urban areas in the Democratic Republic of Congo (van Vliet, Nebesse and Nasi 2015). Bushmeat contributes immensely to the livelihood of farmers not only through consumption but also through savings by reducing the purchase of other animal protein substitutes especially during the lean season when farmers' income is limited (Schulte-Herbrüggen, *et al*. 2013).

Many studies have indicated **ethnicity** as an important predictor of bushmeat consumption among rural people (Poulsen, *et al*. 2009, Mbete, *et al*. 2011, Mgawe, *et al*. 2012, Kiffner, *et al*. 2015), since ethnicity is associated with local peoples' culture, traditions, and food preferences (Fa, *et al*. 2002, Ndibalema and Songorwa 2008). Bushmeat consumption could be explained by the variation between different African ethnic groups. For example, in Nigeria, the Yoruba are known to have a preference for bushmeat while the tradition and religion of the Fulani does not permit consumption of wild meat as explained in Chapter 5 (p 184). In addition, bushmeat has also been found to be highly consumed by the people that migrated to communities around conservation areas (Poulsen, *et al*. 2009). Most meals containing animal protein were consumed by migrants who hunted 70% of bushmeat found in neighbouring towns in the Democratic Republic of Congo (Poulsen, *et al*. 2009). Since most immigrants are left with no livelihood and/or support from government (Duffy, *et al*. 2016), the forest remains the safety net from acute and chronic malnutrition which can result in death (Mofya-Mukuka and Simoloka 2015, van Vliet, Nebesse and Nasi 2015).

Based on the above insights in the literature, this study proposes the following hypotheses in Table 6.1 in order to identify the factors that affect the consumption of bushmeat by the villagers around the OONP in Nigeria.

Table 6.1 Hypothesised factors affecting bushmeat consumption among villagers around the OONP

	Independent variables	Expected direction of effect	Rationale	Sources
H_1	Age	Negative	Young adults are presumed to consume bushmeat more than older adults. However bushmeat consumption cut across all age group and hence there is likelihood that age will not have effect on bushmeat consumption.	(Fa, *et al*. 2002, Golden, *et al*. 2016, Mendonça, *et al*. 2016)
H_2	Education	Positive and or negative	Uneducated people are engaged in insecure or low-income jobs. Consequently, they will tend to consume bushmeat, which is the cheapest source of animal protein in rural communities. Equally, the level and nature of education determine the type of employment and income earned. The employment opportunity available for individuals with primary level of education is often seasonal with its associated low and unstable income. This motivates their preference to consuming cheaper and/or virtually free animal protein substitute. Therefore, a primary level educated individuals tends to consume bushmeat.	(East, *et al*. 2005, Wilfred and MacColl 2010)
H_3	Income	Positive and/or negative	People who belong to lower income groups will tend to consume bushmeat more compared to higher income groups because the former may not be able to afford other sources of animal protein which tend to be more expensive.	(Jenkins, *et al*. 2011, Godoy, *et al*. 2010, Mgawe, *et al*. 2012)
H_4	Occupation	Positive	Crop farmers will tend to consume bushmeat more compared to other occupation groups because crop farmers have low or uncertain income as a result of seasonal variation in production, crop failure and/or crop raiding by wild animals.	(Jenkins, *et al*. 2011, Abernethy, *et al*. 2013)
H_5	Ethnicity	Positive and/or Negative	The Yoruba who are the indigenous people are inclined to eat meat obtained from the wild. Therefore, they tend to consume bushmeat more than the Fulani and the migrants (PRC). Similarly, in order to satisfy hidden hunger and to generate cash income the migrants (PRC) depend on wildlife resources and hence, tends to consume bushmeat more than the Fulani. For tradition and religion reasons, the Fulani are less likely to consume bushmeat more than other ethnic group.	(East, *et al*. 2005, Poulsen, *et al*. 2009, Mgawe, *et al*. 2012)

6.3 Methods

6.3.1 Data and variables

As shown in Chapter 5, bushmeat consumption is one of the factors associated with illegal hunting activities among the villagers in communities surrounding the Old Oyo National Park (OONP). To determine the factors that affect bushmeat consumption of the villagers in this study, the direct questioning (DQ) data on bushmeat consumption and other villagers' characteristics previously listed and described in Chapter 5 (section 5.3) was used.

6.3.2 Analyses

Initially, an exploratory bivariate analysis (Cross tabulation) was conducted to explore the associations between the villager's characteristics and their bushmeat consumption. Afterwards, a binary logistic regression was conducted in order to identify the factors that predict bushmeat consumption. The choice of binary logistic was because the dependent variable is a dichotomous variable. As per the five proposed hypotheses, five predictor variables were considered for the model. Prior to final selection of the predictor variables, a multicollinearity diagnostic test was conducted on all the five predictor variables to identify multicollinearity – a necessary condition that needs to be fulfilled for a logistic regression analysis (Midi, Sarkar and Rana 2010). A correlation coefficient cut-off value $r > \pm 0.7$ was used to discard variable that was strongly correlated with other variables (see section 5.3.2). One predictor variable, ethnicity, was removed from the analysis due to multicollinearity (Table 6.2and 6.3). Therefore, only four variables – age, education, income and occupation – were fitted into the logistic regression model to test their effects on household bushmeat consumption.

Table 6.2 The collinearity diagnostics table for the predictor variables. A threshold value of r >± 0.7 for Spearman's rho (Donath, *et al*. 2012, Dormann, *et al*. 2013, Vatcheva, *et al*. 2016) was used in detecting collinearity. Values exceeding the threshold are highlighted in bold.

Predictor variables	Age	Education	Income	Occupation	Ethnicity
Age	1	-.169**	-.314**	.145**	.062
Education		1	.113**	-.196**	-.264**
Income			1	-.438**	**-.572****
Occupation				1	**.798****
Ethnicity					1

*Sig at 5% level or P ≤ 0.05; **sig at 1% level or P ≤ 0.01; ***sig at P≤ 0.000; ns "not significant" at P ≥ 0.05

Table 6.3 The collinearity diagnostics table for the predictor variables after the removal of strongly correlated variables (ethnicity). A threshold of >± 0.7 for Spearman's rho was used in detecting collinearity (Donath, *et al*. 2012, Dormann, *et al*. 2013, Vatcheva, *et al*. 2016).

Predictor variables	Age	Education	Income	Occupation
Age	1	-.169**	-.314**	.145**
Education		1	.113**	-.196**
Income			1	-.438**
Occupation				1

*Sig at 5% level or P ≤ 0.05; **sig at 1% level or P ≤ 0.01; ***sig at P≤ 0.000; ns "not significant" at P ≥ 0.05

Model fits were determined based on whether or not the % of correctly classified cases increased in the final model and also whether or not the Hosmer Lemeshow test statistic was significant. In addition, Cox & Snell R^2 and Nagelkerke R^2 were used to understand the explanatory power of the model. Data were analysed using the Statistical Package for Social Sciences (SPSS) version 22 software.

6.4 Results

6.4.1 Descriptive statistics of the variables

The summary statistics of the outcome and predictor variables have been described in the previous chapter (see sub-section 5.4.1 Chapter 5).

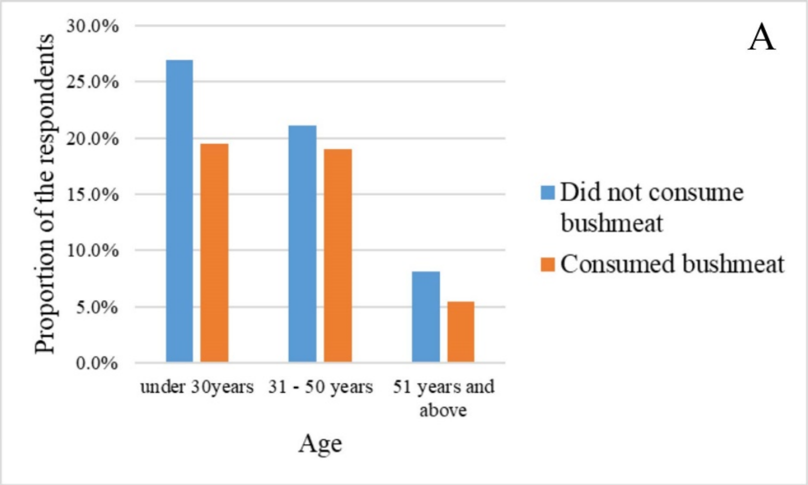
6.4.2. Bivariate analysis of bushmeat consumption and predictor variables

Statistically, education, income and occupation of the villagers have been found to have significant associations with bushmeat consumption. Age had no significant association.

The result shows that bushmeat consumption cut across all age groups with no significant association with age (χ^2= 2.80, df =2, P= 0.246). Of 43.9 % of the respondents that consume bushmeat, 19.5 % were under 30 years of age while 19 % and 5.4 % respectively were in age group 31 – 50 years and above 50 years

(Figure 6.1 A).

Level of education was strongly associated with bushmeat consumption. Figure 6.1 B show that bushmeat was consumed by 35.6 % and 8 % of the respondents that were non-educated and educated respectively (χ^2= 34.23, df =1, P = 0.000***).



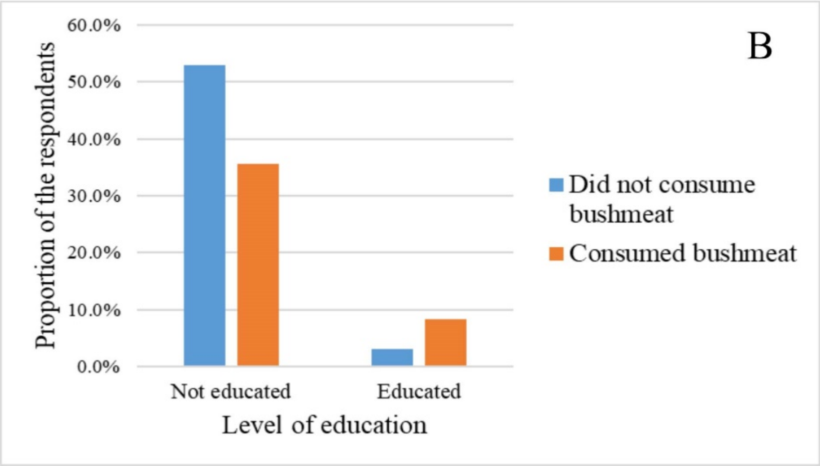
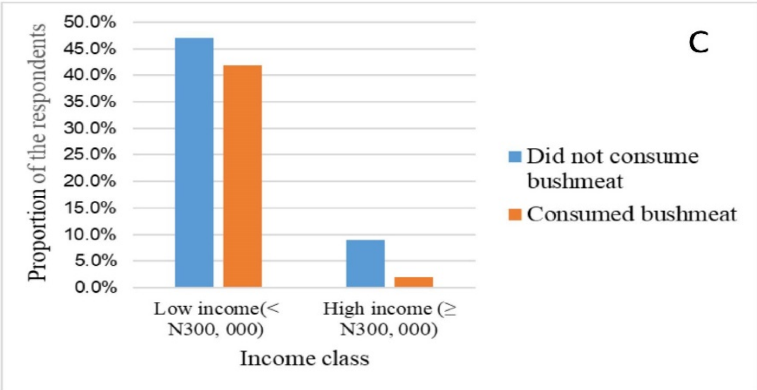


Figure 6.1 Bar chart representing bushmeat consumption of the respondents in relation to (a) Age and (b) Level of education as indicated during the 2015 Villagers survey in OONP (in percent).

Income was another variable associated with bushmeat consumption (χ^2= 26.51, df =1, P = .000***); 41.9 % and 2 % of the respondents in low and high income class respectively consumed bushmeat (Figure 6.2 C).

As shown in Figure 6.2 D below, the occupation of the respondents was significantly associated with bushmeat consumption (χ^2= 140.23, df =2, P = 0.000***). The majority (26.3 %) of those that consume bushmeat were crop farmers, while 11.4 %, 4.1 % and 2.1 % were mixed farmers, livestock farmers and those engaged in other type of employment.



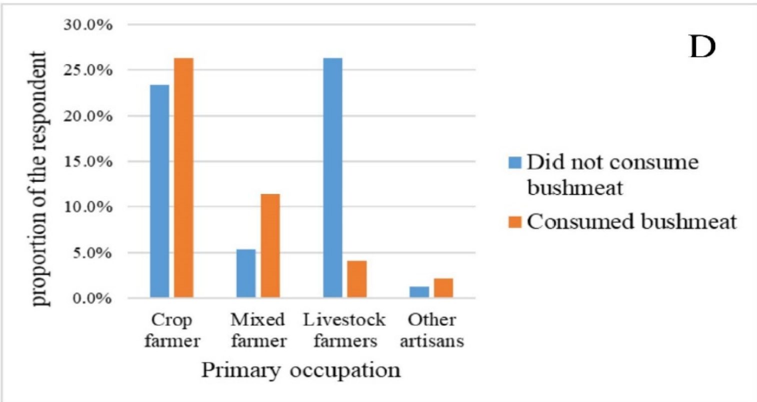


Figure 6.2 Bar chart representing the bushmeat consumption by the respondents in relation to (c) Income and (d) Primary occupation as indicated during the 2015 Villagers survey in OONP (in percent).

The ethnicity of the respondents was significantly related to bushmeat consumption (χ^2= 144.25, df =2, P =.000***). The Yoruba constitutes the highest proportion (36 %) of the respondents that consume bushmeat, followed by the Fulani (4.4 %) and the remaining 3.5 % were migrant – PRC i.e. people from other regions and countries (Figure 6.3 E).

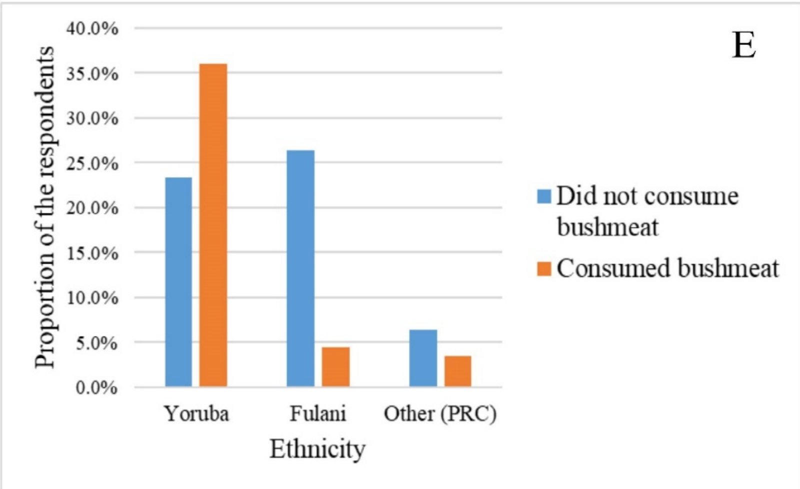


Figure 6.3 Bar chart representing the bushmeat consumption by the respondents in relation to ethnicity as indicated during the 2015 Villagers survey in OONP (in percent).

6.4.3 Factors influencing bushmeat consumption

The results of the binary logistic regression indicate that education and occupation were the best predictors for explaining bushmeat consumption while the two remaining variables (age and income) had no significant effects. These effects and corresponding decisions are summarised in Table 6.4

Table 6.4 Summary of the hypotheses tested, the direction of effects and decision

Hypotheses	Predictor variables	Hypothesised effects	Decision
H_1	Age	Negative	No significant effect was found. Age has no significant effect on bushmeat consumption.
H_2	Education	Positive	Hypothesis accepted. Individuals' with primary level of education were significantly more likely to consume bushmeat.
H_3	Income	Positive	Individuals that belongs to high income class are not significantly more likely to consume bushmeat
H_4	Primary occupation	Positive	Hypothesis accepted. Individuals that practice crop farming, missed farming and other artisans are significantly more likely to consume bushmeat
H_5	Ethnicity	Positive	Dropped from subsequent analysis due to multicollinearly problem

The estimates of the regression analysis are presented in Table 6.5. Of the three occupation groups, as hypothesized (H_4 in Table 6.4), 'mixed farming' was the strongest predictor of bushmeat consumption and it recorded an odds ratio of 13 followed by other-artisans with an odds ratio of 10 while 'crop farming' recorded an odds ratio of 7. This indicates that, when other predictors are held constant, an individual who practiced mixed farming, other type of employment and crop farming would be 13, 10 and 7 times, respectively, more likely to consume bushmeat than a person who practiced livestock farming. Therefore, the hypotheses H_4 was accepted.

Likewise, education, as hypothesized (H_2), significantly predicts bushmeat consumption and it recorded an odds ratio of 3 (for educated). This indicates that when other predictors held constant, an educated individual would be 3 times more likely to consume bushmeat than a non-educated person. Hence, the hypotheses H_2 was accepted.

The Nagelkerke R squared estimates specify that the whole model explained 26 % of the variance that can be predicted from the independent variables and correctly classified 68.8 % of cases. The Hosmer and Lemeshow test (.21) was not significant p=0.05. This shows that the model was a good fit to the data.

Table 6.5 Effects of socio-demographic predicting variables on bushmeat consumption in OONP. Key: B=estimated coefficient; SE=Standard error; P=level of statistical significance; * denote the statistical significant and Exp (B) = odds ratio.

Independent variables	B	SE	Sig.	Exp(B)
Age (reference category- above 51 years)				
≤30 years	-.024	.264	.924ns	.977
31-50 years	.296	.255	.246ns	1.344
Education (reference category – not educated)				
Educated (primary level)	.918	.260	.000**	2.505
Income (reference category – low income- - <N300, 000)				
High income (≥ N300, 000)	.233	.373	.532ns	1.262
Occupation (reference category – Livestock farming)				
Crop farming	1.955	.537	.000***	7.061
Mixed farming	2.571	.580	.000***	13.078
Other-artisans	2.395	.459	.000***	10.968
Constant	-2.072	.331	.000	.126

6.5 Discussion

As previously noted by Golden (2009) in a study of local people neighbouring a protected area in Madagascar, bushmeat serves as a source of animal protein for the local people. Findings in this current study presented in this chapter indicate that the situation is very similar in Nigeria whereby bushmeat, as an animal protein substitute was reported to be consumed in the communities surrounding the OONP. As reported in Chapter 5, more than a third of the respondents claimed to have frequently consumed bushmeat. The aim of this chapter was to identify the factors that influenced bushmeat consumption within the villagers around the OONP in Nigeria.

Of the five variables investigated, the effect of ethnicity on bushmeat consumption was not modelled due to a multicollinearity effect. However, chi-square analyses indicated that the variable had a strong association with bushmeat consumption. The Yoruba ethnic group appears to consume bushmeat more than the other ethnic groups in OONP. The findings corroborate with previous authors' suggestion that people whose rural tradition and /or religion include bushmeat consumption consume more of it because individuals often express positive feelings towards familiar food (Naughton-Treves 2002, Schenck, *et al*. 2006) . The unique culture and traditions of the Yoruba group seems to influence their food preferences. Traditionally, Yoruba have a taste preference for bushmeat (Ajibade 2006, Falola and Agwuele 2009). Culturally, Yoruba are crop farmers and believe that wild animals are created for their consumptive use (Ajibade 2006, Falola and Agwuele 2009). The Fulani, on the other hand, are settled livestock farmers whose religious values do not allow the consumption of many wild species as well as the animals that are not slaughtered according to Islamic rites (Majekodunmi, *et al*. 2014). Previous study shows that for religious reasons (adopting Muslim or Adventist beliefs) individuals stopped eating bushmeat in Madagascar (Reuter, Sewall and Di Minin 2017). This finding reinforces the suggestion that a considerable proportion of the variance in the quantity and types of food items consumed cannot be explained by accessibility or differences in socioeconomic status (Axelson 1986) but, such variations can be accounted for by culture and food preferences across ethnicities (East, *et al*. 2005, Schenck, *et al*. 2006, Mbete, *et al*. 2011, van Vliet and Mbazza 2011). The findings of the current study validate the ideas of Naughton- Treves (2002) and Schenck and colleagues (2006) who suggested that people whose rural tradition and/or religion include bushmeat consumption are more likely to eat it because individuals have soothing and familiar ties towards particular food items (Ajibade 2006, Friant, Paige and Goldberg 2015). However, restrictions on access to natural resources in PAs may be seen as a denial of the traditional rights by the residents, mostly the indigenous peoples that are culturally inclined to bushmeat consumption (Muhumuza and Balkwill 2013). The effect can cause a negative attitude towards conservation (Arjunan, *et al*. 2006, Tomićević, Shannon and Milovanović 2010).

The other ethnic group – PRC constituted by the migrants from neighbouring regions and countries consume bushmeat. Previous studies have reported similar observations as the immigrants admitted to bushmeat consumption (Golden and Comaroff 2015). This finding provides further empirical evidence to the premise that the immigrant populations may be engaged in illegal hunting to vie for food, income and sustenance (Jambiya, *et al*. 2007, Duffy, *et al*. 2016). Besides, a shift in lifestyle might be another reason for this result, as other (indigenous) cultures influence the daily lives of the immigrants.

The results of the binary logistic regression provide concrete evidence of the linear effects of the four selected predictor variables on the likelihood of bushmeat consumption. Although education has been found to be a significant predictor in this study, previous studies (East, *et al*. 2005, Wilfred and MacColl 2010, Gubbi and Linkie 2012, Mgawe, *et al*. 2012) have provided contradictory evidence about the effect of education on bushmeat consumption. For instance, the non-educated people were found to consume bushmeat in Gabon (Mgawe, *et al*. 2012), whilst in other parts of Africa, both educated and non-educated people were found to consume bushmeat (Foerster, *et al*. 2011, Jenkins, *et al*. 2011, Moro, *et al*. 2013). The current study suggests that an educated individual is more likely to consume bushmeat than uneducated person, which contradicts that observed in Equitorial Guinea, Gabon and Tanzania (East, *et al*. 2005, Mgawe, *et al*. 2012, Kiffner, *et al*. 2015). This is rather surprising because educated individuals are likely to have better awareness and favourable attitudes to wildlife (Gandiwa 2011, Nadhurou, *et al*. 2017) and this may make them reluctant to consume bushmeat (Nadhurou, *et al*. 2017). However, the educated in this study had completed primary school level of education only (see section 2.5 page 64) which is somewhat similar to the education level in the samples in the previous studies earlier mentioned. These past studies show no evidence that the level of schooling influenced bushmeat consumption. However, the current findings suggests that such poorly educated individuals may consume bushmeat due in part to the deficiencies in the school curricula in Nigeria. For instance, the primary education curricula in Nigeria lack topics that can positively influence individual attitudes towards the conservation of wild species (Omoogun, Onnogen and Ateb 2014, Norris 2016). This point is crucial as evidence from a past study in Comoros shows a significant positive attitude towards protected species in villages where environmental education were conducted, resulting in a decrease in the number of households that hunted and/or consumed bushmeat than in villages without environmental education

(Nadhurou, *et al*. 2017). Similarly, environmental education via extra-curricular activities in primary schools significantly increased students' environmental knowledge and positively influenced their attitudes towards nature in Cote d'ivore (Borchers, *et al*. 2014).

Another reason for the educated individuals consuming bushmeat could be the role of income and price of other animal protein substitutes and the ability to save for other household essentials by minimizing spending on animal protein. Previous studies have demonstrated that expenditure on bushmeat was lower than other types of animal protein in rural area (Kümpel, *et al*. 2010). Additionally, other studies have demonstrated that the bushmeat is lucrative and provides more income compared to farm and/or waged employment (Kümpel, *et al*. 2010, Knapp 2012, Schulte-Herbrüggen, *et al*. 2013, Friant, Paige and Goldberg 2015). Consequently, bushmeat remains the only option as the cheapest source of animal protein to the educated and non educated whose source of livelihood solely depend on farm employment (crop farming).

Nevertheless, this study did not find the support for the hypothesis that age and income affects bushmeat consumption. This might be attributed to low variance in consumption of bushmeat across the three age groups and the low levels and small variance in monetary income (see Sub-section 6.3.2 page 208) among the villagers.

6.6. Conclusion and implications

The aim of this chapter was to identify the factors that influence bushmeat consumption in villages neighbouring the Old Oyo National Park in Nigeria. The evidence suggests that a low level of education influenced individuals' determination to consume bushmeat due to the associated low and unstable income.

This study also concluded that ethnicity is an important factor in bushmeat consumption. African indigenous ethnic groups like the Yoruba nation are more given to bushmeat consumption because of their traditional beliefs, values and lifestyle (Ajibade 2006). Also, this study suggests that hunger may drive immigrants into bushmeat consumption (Jambiya, *et al*. 2007).

This study contributes to a growing body of literature on bushmeat consumption in the communities neighbouring protected areas in Nigeria. Previous studies have provided a summary of bushmeat consumption (Martin 1983, Friant, Paige and Goldberg 2015), but this current study has taken a step forward in predicting the possible factors influencing bushmeat consumption, which is important to conservation management not only in Nigeria but also in other countries. However, there is need for further research to explore factors that were not significant nor considered in this present study, for example household size, price of animal protein substitutes, number of livestock owned, taste preference and traditional taboos. Such findings can be more generalised and help in designing evidencebased management policies.

The present findings have important implications for wildlife conservation in Nigerian PAs and also the PAs in other countries with similar contexts. First, it is necessary to recognise that the forest-dependent livelihoods of certain ethnic groups, like the Yoruba, may suffer if management strategies restrict access to the use and/or extraction of wild animals without providing acceptable and commensurable alternatives. One such alternative might be encouraging the villagers to engage in the domestication of some preferred wild species such as cane rats as animal protein substitutes (Buchenrieder and Balgah 2013, Roe, *et al*. 2014). Beekeeping is another alternative to bushmeat harvesting in terms of market demands and earnings derived with little investment and small piece of land (Wright and Priston 2010). The effectiveness of beekeeping is still being evaluated but training has been given to many hunters in Cameroon (Wright and Priston 2010). In Nigeria, beekeeping has been identified as a lucrative and cost effective enterprise (Ja'afar-Furo, Suleiman and Hong 2006, Michael 2008). Therefore, beekeeping may not only improve livelihood security, but may further reduce the risk of food shortages and species extinction in the future.

Furthermore, the Government and authorities of conservation areas should provide environmental guidelines for establishing settlements/villages and camps 12-15km from PAs boundary (Jambiya, *et al*. 2007). Leaving a tract of about 15 km of land with no human activities between camps, villages and park boundary will act as buffer zone that will discourage poaching activities in the park (Wato, Wahungu and Okello 2006, Holmern, Muya and Røskaft 2007, Wilfred and MacColl 2010). Given the negative impact of upsurge in population growth around PAs on biodiversity, social vices, such as corruption, inequalities and favouritism should be discouraged in both local and international communities (Bragina *et al* 2015).

One way to do this is to intensify conservation education and awareness campaigns should be intensified by targeting the ethnic groups that are traditionally inclined to eating bushmeat. A community based adult education that covers the basic dietary requirements for humans and the various sources of nutrients including non-meat based proteins should be provided (Wright and Priston 2010). Topics that can positively influence conservation programmes should also be taught at village level. Similar topics and more environmental education related topics and programmes should be included in formal school setting across the country. Some Non-Governmental Organisations (NGOs) under the canopy of the Nigeria Conservation Foundation (NCF) have established school conservation clubs where students are informed of the benefit of PAs and in promoting the ecotourism and conservation potentials of the park (NCF 2013, Idowu and Morenikeji 2015). Although students in formal education were the main target of the NGO’s environmental education programmes, little or nothing is heard of such programmes in an adult/non-formal setting, since the NGOs were faced with financial challenges that impeded their progress. Hence, there is a need for the Government, conservation authorities and NGO’s to extend conservation and environmental education to local areas where violation of conservation laws is prevalent. Federal Government and International Conservation Bodies/agencies should provide financial assistance towards the successful implementation of programmes that will improve biodiversity conservation in Nigeria.

Chapter 7: General discussion

7.1 Summary

Multiple anthropogenic factors have caused large mammal populations to decline worldwide (Butchart, *et al*. 2010). The rate of decline has serious implications for ecosystem and human health, and ultimately socioeconomic well-being in the future (Patz, *et al*. 2012, Estrada, *et al*. 2017). The establishment of National Parks classified as Category II of the Protected Areas where no entry or utilization of resources is permitted are expected to be the last refuge for the remnant species of tropical large mammals from threats of extinction. This study demonstrated that Old Oyo National Park, an important National Park in south-western Nigeria is threatened by pressure exerted by the impoverished local people inhabiting areas around the park, and the inadequate institutional mechanisms for monitoring and controlling illegal activity in the National Park (Chapter 4). Similar patterns have been observed in other PAs across Nigeria (David 2008, Usman and Adefalu 2010).

In this study a multi-disciplinary approach was explored to provide a baseline estimate of large mammal assemblages in OONP and to identify key factors that influence the mammal populations living there. This study appears to be the first to quantify illegal activities and identify factors that drive large mammal population decline in OONP. Findings in this study will inform future conservation management by aiding targeted design and implementation of effective conservation measures.

7.2 Conservation implications

One of the first steps in halting the decline and rebuilding populations of large mammals is to assess the current conservation status of the populations, followed by the determination of factors that may be driving the population change. In this study, the species composition in OONP was observed to have decreased compared to previous studies (Afolayan, Milligan and Salami 1983, Oladipo and Abayomi 2014). Indeed, six large mammals (lion, leopard, spotted hyena, hunting dog, elephant and oribi) that were once resident in the study area (Afolayan, Milligan and Salami 1983, Anadu and Green 1990, Oladipo and Abayomi 2014) were not recorded in this study and are likely extirpated. In contrast, four new species (caracal, side striped jackal, pangolin and porcupine) that were not previously recorded in the park were found during this study. These findings suggests two possible outcomes: (i) it is possible that these species have been residents but not captured in previous studies, (ii) that these mammals have recently taken residence in the park. Considering that the previous studies used direct and indirect line transect surveys as well as being conducted during the day, it is possible that some species were not captured as they were nocturnal. The change in community composition and changes in mammal abundance highlight the need for robust monitoring of species in protected parks. Resource is needed for park management to be able to do this as part of routine duties. Mammal diversity and composition in OONP was limited before this study, thus the need for long term monitoring programmes that apply survey techniques effective in detecting species of different biological traits and habitats. This would greatly help the management of the park to identify when species are decreasing in abundance and to then inform decisions to help them.

For ease of administration, the OONP is divided into five ranges. This study observed variation in the species richness of mammals across the different ranges. The highest species richness was observed in Marguba (19) and the lowest was in Tede (11). Previous studies have identified variation in species richness in PAs (Kinnaird and O'brien 2012, Okiror, *et al*. 2012, Velho, Sreekar and Laurance 2016, Pinho, Ferreira and Paglia 2017). The species richness was two to five times higher in sites with adequate protection than sites with intense human activities in Uganda (Kinnaird and O'brien 2012, Velho, Sreekar and Laurance 2016). Although reasons for this variation were not investigated in this current study, there was an association between the intensity of illegal hunting in Tede in comparison to Marguba where illegal hunting was less. It is also possible that other cofounding factors such as habitat structure, presence of perennial sources of water and adequate protection may play a role in the richness of species in different parts of the park. These findings indicate that variation in illegal hunting activities (Chapter 4) and level of protection (Pers. Obs) would probably explain the observed species richness across the ranges. Past researchers have highlighted factors (of which some are beyond the scope of this present study) that the internal habitat structure (landscape structure, land cover and altitude) and disturbance mechanism along with competition processes determines the species richness on a protected landscape (Atauri and de Lucio 2001, Kinnaird and O'brien 2012). In OONP, ranges were created for an effective management and protection of the parks' resources. This level of protection is expected to lead to increased species richness across the five ranges. Based on this current findings, the most probable explanation for the low species richness is disturbance from human and livestock grazing activities coupled with weak law enforcement. Therefore more enforcement is needed in areas with lower richness in an attempt to re-establish species that may have been lost.

Generally, like in other countries of the world mammal abundance and diversity in protected areas is declining due to overexploitation (bushmeat) and illegal grazing (competition with livestock) (Scholte 2011, Ogutu, *et al*. 2014, Ogutu, *et al*. 2016). A similar trend was observed in this present study as occupancy and density estimates of most species detected were low concurrently with high level of illegal activities.

To gain further insight in relationships of variables probably affecting occupancy rates, environmental and anthropogenic variables were modelled. Such information is important for the management of the protected species (Ramesh and Downs 2015, Ramesh, *et al*. 2016). In this present study, none of the variables (covariates) modelled significantly predicts the species' occurrence. The lack of habitat covariate effects suggests the use of a broad range of habitat by the species. In such situation, the habitat specialist will first become locally extinct. The generalists remain because they can use a wider range of resources, or species which might suppress them (predators usually) are not residents of the area. This could lead to competition and a negative impact on habitat structure. In this current study, the loss of keystone species such as mega herbivores and large carnivores that function as ecological engineers, probably led to the persistence and high occurrence of the giant pouch rat. Large body sized mammals have community importance values and the loss can induce ecosystem changes compared to other smaller and medium size species (Mills, Soulé and Doak 1993). For example rodents are among the most active seed predators, and decreased population can have a major effects on seedling survival and forest regeneration (Peres and Palacios 2007, Brodie, et al. 2009).

However, habitat disturbance can influence species ecological flexibility (the use of broad range of habitat) and behavioural change (Cardillo, *et al*. 2004, Ramesh and Downs 2015).

Given the low population density of bushbuck (4.84 individuals/Km2) and kob (15.47 individuals/Km2) observed when compared to previous study where 5.97/Km^{-2} (bush buck) and 25.08/Km^{-2} (kob) as reported (Afolayan, Milligan and Salami 1983). The difference observed may be due to the negative impact of anthropogenic disturbance on large mammal populations.

Furthermore, it was clear that there was a difference in detection between the two method I used to quantify species abundance, in that camera traps detected more species than direct observation. Future monitoring should use camera traps as deployed in this study and where possible be placed throughout the park. Aside from baboon, bushbuck and kob which were captured by both techniques other species were hardly encountered in this study. Anthropogenic disturbance could possibly explain the reason for species elusiveness in the park. Past authors have reported behavioural change in giraffe as species fled a long distance to avoid human predation in Tanzania (Marealle, *et al*. 2010). Data from the villagers' and rangers' perception further substantiate the camera trap and line transect data by indicating that large mammals in OONP have declined in abundance (Chapter 3). Previous researchers have reported similar findings whereby the local residents correctly perceived wild animal abundance to have declined (Jayeola, *et al*. 2012, Tewodros and Afework 2014, Velho, Sreekar and Laurance 2016). The present findings from the villager and ranger surveys suggest that most species in OONP have declined in abundance during the last 5 years. This further confirms the notion that the management of protected areas is faced with the problems of wildlife population decline (Caughley and Gunn 1996, Sodhi, *et al*.

2004, Stuart, *et al*. 2004, Butchart, *et al*. 2010, Ripple, *et al*. 2016). In other protected areas, community participatory approach to conservation management and environmental/conservation education has been employed with support from NGOs and reserve authorities to mitigate decline in large mammals. This has yielded positive results. In Zimbabwe, following these interventions wild animal species such as elephant, spotted hyena, buffalo and lion were reported to have increased between 2009 and 2011(Gandiwa 2012). Similarly in Nepal, barking deer (*Muntiacus muntjak*) and Himalayan tahr (*Hemitragus jemlahicus*) increased after the inception of community based management of forest resources (Bajracharya, Furley and Newton 2005). Hence, this may be recommended in the OONP as such efforts can enhance local people's knowledge of the remaining wildlife resources and the capacity to take care of their local environment. Likewise, through awareness and knowledge regarding the current status of the reserve, community members will gradually realize the importance of preserving the remnant populations of wild animal species for their own well-being.

Identifying and quantifying illegal activities in protected areas is essential for designing and implementing effective conservation measures (Margules and Pressey 2000, Critchlow, *et al*. 2015, Wiafe 2016). Data from Chapter 4 suggests widespread illegal activities in OONP. Two major illegal activities were identified in this study: (i). domestic livestock grazing and (ii). illegal hunting activities detected during the empirical field survey (Chapter 3). Other illegal activities (fishing, collection of firewood, collection of vegetables and medicinal plants, charcoal making and unauthorised entry of any kind) occurred in the park as indicated by the villagers (Chapter 4). The types and extent of illegal activities identified in this study were relatively high for a conservation area expected to be fully protected from human activities. Therefore, illegal hunting and grazing of livestock appeared as the major challenges facing wildlife conservation in OONP. It will be beneficial to conduct similar investigations in other parks in Nigeria to determine if this phenomenon is widespread.

The findings from this study indicates remarkably high occupancy and density estimates of cattle in comparison their wild counterpart (larger grazers). This points to the likelihood that the high occurrence of cattle threatens the persistence of large herbivores such as roan antelope, water buck and western hartebeest that have similar body features and feeding habits or behaviour. Principally, livestock have been observed to cause major wildlife decline in PAs (Ogutu, *et al*. 2016). The findings from this study further provide field-based evidence as detection and occupancy of larger grazers were very low. In order to guide conservation efforts toward recovering and rebuilding the declining large mammal population, domestic cattle need to be excluded from PAs.

At present, transhumance is an on-going and an acceptable practice of livestock husbandry in Nigeria, while in other African countries such as Botswana, Kenya, and Zimbabwe livestock are kept in ranches in (Thomas, Sporton and Perkins 2000, Ogada, *et al*. 2003, Lindsey, Du Toit and Mills 2005). This could be the reason why illegal grazing activities are high in Nigeria. There is a need for a joint effort by the Federal Ministry of Environment and Natural resources, NGOs and the park authorities to provide conservation education specifically targeting the pastoralists. Topics on the negative impact of livestock grazing on biodiversity and the services provided for human well-being should be explained in detail to the targeted group in areas prone to pastoralism and also across the country. Furthermore, provision of grazing reserves for the pastoralists should be considered in developing countries such as Nigeria. Pastoralists should be encouraged to shift from transhumance to keeping their livestock in ranches and be motivated to grow high yielding varieties of fodder crops such as grass and leguminous plants in sufficient quantities to sustain the domestic animals. In future, the pastoralists will be able to keep livestock in zero-grazing mode (where grass is mechanically mown and brought to cattle). Conservation management should also intensify on effective law enforcement to prevent livestock grazing in Nigerian PAs.

Generally, law enforcement constitutes an important segment of wildlife conservation. This current study indicates that the rangers are not provided with adequate allowances, incentives and equipment for working in remote areas with physical hazards and difficult terrain. These contributed to a high level of dissatisfaction and the rangers are tired of their job. This further confirms previous studies that have highlighted rangers' poor remuneration and exposure to dangers with inadequate and out-dated patrol equipment (Oduro and Kwarteng 2000, Ogunjinmi, Umunna and Ogunjinmi 2008, Warchol and Kapla 2012). The present findings suggest that the rangers are not adequately motivated to perform the daunting tasks of protecting wildlife resources in park.

The present day poaching is highly organized with the use of more sophisticated methods across the National parks. It is important that the rangers are given greater support especially as illegal wildlife activities have become increasingly criminalised with the resultant increase in more deaths of vulnerable animals and threats to valiant rangers whose life are at risk on a daily basis. Therefore, it is imperative for the anti-poaching forces to be more sophisticated and potentially lethal via militarized methods and technologies in order to follow suit and keep up with the task ahead. To achieve this in Nigeria, the park rangers should be flagged up as para military forces as illegal activities across the National parks are now a militarized practice. Furthermore, the existing ranger stations and/or camps should be maintained instead of constructing new camps. At present, the ranger stations are substandard (lack basic amenities). This may contribute to the limited number of rangers on site (Pers. Obs.) as they cannot spend a full week in such accommodation. A well maintained camps with modern facilities (water, electricity, communication gadgets) will prevent absenteeism, make the rangers stay on site both day and night and act as a spur to increase their performance. In addition, adequate staff should be provided as well as modern mobile camping materials for use on extended and/or long range anti-poaching patrols. This will enable wide areas to be covered, increase the level of patrolling and its effectiveness.

One important finding that emerges from this study was the observed on-going exploitation of wild animal species which was attested to by villagers who engaged in bushmeat hunting. This study indicates that bushmeat hunting may constitute one of the factors influencing large mammal population declines in OONP. Drivers of illegal hunting examined in this study include age, education, income, occupation, ethnicity and bushmeat consumption. Of these, occupation of an individual appeared as a significant predictor of illegal hunting activities. Other factors earlier listed were also significantly linked to illegal hunting activities. Generally, hunters were identified to be mostly young, impoverished local people that are predominantly farmers surrounding the park. This observation was reported by previous studies which examined drivers of illegal hunting in Africa (Coad 2008, Jenkins, *et al*. 2011, Abernethy, *et al*. 2013) and Asia (Rao, *et al*. 2010, Rao, *et al*. 2011). The seasonal nature of farming as well as the predominance of subsistence farmers in the study area predisposes the human population to temporal nutritional and economic constraint.

Besides occupation, other parameters such as education and income which contribute to determining the economic status of villagers show that most villagers are underprivileged. The low financial status of the villagers that is associated with their occupation influenced illegal hunting behaviour and resulted in the high occurrence of hunters observed in Chapter 4 and low occurrence of wild species observed in Chapter 3.

Various studies have shown that conservation interventions that includes strict protection by strengthening law enforcement, awareness and education and community participation effectively cause a decline in illegal hunting activities (Infield and Namara 2001, Basset, *et al*. 2004, Ancrenaz, Dabek and O'Neil 2007, Holmern, Nyahongo and Røskaft 2007, Lee and Marsden 2008, Gandiwa 2011). These approaches caused a decline in illegal hunting between 2000 and 2008 in Zimbabwe (Gandiwa 2011). Furthermore, communitybased conservation management has been reported to create a positive change, and encourage local community participation in monitoring programmes and most importantly reduces illegal hunting in Botswana, Malaysia and Papua Guinea (Phuthego and Chanda 2004, Basset, *et al*. 2004, Ancrenaz, Dabek and O'Neil 2007). Conversely in Tanzania and Uganda, community conservation programmes yielded a positive attitude towards the park and wildlife. However, behaviour was not greatly changed as a high level of poaching continued due to insignificant changes to local people's livelihood and poor law enforcement activities (Infield and Namara 2001, Holmern, *et al*. 2002, Bitanyi, *et al*. 2012). Such approaches should be supported with conservation interventions that alleviate poverty by providing alternative opportunities that may decrease dependence on wildlife resources and strict protection against hardened violators. Past researchers have highlighted the positive impact of the use of village guard scouts which increases the patrol effort and number of illegal hunters arrested in Tanzania (Holmern, Muya and Røskaft 2007). Natural resource management in Nigeria should also employ the services of villagers as guards to police the forest as part of adaptive management that allows local people participation in decision-making as well as sustainable extraction of bushmeat. Simultaneously, conservation education should be continuously emphasized in communities known and/or identified to be inclined to bushmeat hunting. This will enhance local people's awareness and understanding of the role of biodiversity in ecosystem and human health. Implementation of such strategies requires adequate financial support from the Government in order to record successes. Invariably, people's minds can be transformed and re-aligned towards protection of biodiversity and consequently, conservation will trickle down from people's own initiatives.

Besides income, the present findings indicate that bushmeat is regarded as an important source of animal protein and its high levels of consumption played an important role in influencing illegal hunting activities in this study. Similar observations have been reported in other African countries (Loibooki, *et al*. 2002, Brashares, *et al*. 2004, Lindsey, *et al*. 2011, Moro, *et al*. 2013, Rentsch and Damon 2013). The high rate of illegal hunting activities observed in this current study may drive a species population to low abundance, and where this rate of extraction exceeds the population growth rates, population decline is inevitable. For example, abbot's duiker (Cephalophus spadix), bush pig (*Potamochoerus larvatus*), hyrax (*Hyracoidea spp*.) and other large mammals were severely depleted due to illegal hunting in Tanzania (Nielsen 2006; Caro 2008).

The individual's decision to consume bushmeat has been found to be influenced by socio-economic and demographic factors, including the relative price of animal protein substitutes and individual income (Thaler 1980, Fa, Currie and Meeuwig 2003, van Vliet and Mbazza 2011, van Vliet, *et al*. 2012). The current study found an individual's level of education and occupation in a farming related job to have influenced the consumption of bushmeat in the area. Previous studies have demonstrated that the educated (Foerster, *et al*. 2011, Gubbi and Linkie 2012, Mgawe, *et al*. 2012), and the agriculturists (Foerster, *et al*. 2011, Mgawe, *et al*. 2012, Schulte-Herbrüggen, *et al*. 2013) and those in trade/unskilled employment (Drury 2011) mostly consume bushmeat. It appears that a complex relationship exist between education, occupation and income of the villagers' in this study on the high level of bushmeat hunting and consumption which probably resulted in low species richness and abundance (Chapter 3). In addition, the current study found a significant ($P < .05$) association with ethnicity and bushmeat consumption. The Yoruba ethnic group and the migrants-(i.e. people from other region and country- PRC) are the first and second highest consumers of bushmeat in this study. Previous studies have shown that the native local residents and immigrants consume more bushmeat than other ethnic group in Congo (Poulsen, *et al*. 2009), Madagascar (Reuter, *et al*. 2016) and Tanzania (Mgawe, *et al*. 2012). However, it is worth highlighting the unanticipated bushmeat consumers - the Fulani who by tradition and religion forbid eating wild meat not properly killed according to Islamic rites. The ethnic group Fulani constitute 30.80 % of the respondents in this study. Of the respondents that are Fulani, 14.23 % indicated they consume bushmeat, which suggests that they ate relatively little bushmeat. Similar observations have been reported for pastoralists (the Masaai) in Tanzania (Martin, Caro and Mulder 2012, Ceppi and Nielsen 2014, Kiffner, *et al*. 2015). The present findings suggests that bushmeat contributes to the villagers' livelihood and its consumption occurred across all ethnic groups in OONP. It is clear from the data that the Yoruba are important illegal hunters and consumers of bushmeat in OONP. To safeguard the remaining species in PAs and the future food security of those whose livelihood depend on wild animals, strategies that alleviate poverty and stringent wildlife laws should be fully employed. For instance, poverty alleviation through photographic tourism development led to an increase in sable antelopes and giraffes in Botswana (Mbaiwa 2011, Mbaiwa and Stronza 2011). Likewise, improving law enforcement effectiveness reduces illegal hunting and increases large mammals in Zimbabwe (Gandiwa 2011, Gandiwa, *et al*. 2014) and Tanzania (Hilborn, *et al*. 2006). As mentioned, stringent law enforcement that includes higher fines and probability of detection/arrest is inevitably required against poaching and other illegal uses of park resources. Such efforts will improve the population of declining species and hence promote the country's wildlife tourism sector as observed in other African countries like Kenya, South Africa and Zimbabwe where tourism is the largest earner of foreign currency. Such efforts will simultaneously increase commercial activities in the local communities and therefore provide alternative opportunities to generate cash income.

7.3 Conclusion

This study has provided the first baseline measure of large mammal assemblage and established that large mammals in OONP are declining in the face of two main anthropogenic threats, namely illegal grazing of cattle, and the hunting and consumption of bushmeat. The work have demonstrated the use of a multidisciplinary approach that combines ecological field survey and social survey to identify the problems in biodiversity conservation and sustainability (Muhumuza and Balkwill 2013, Dick, *et al*. 2016). Recommendations have been made to address these problems. The low abundance of wild animal species and high level of illegal activities found in this study show the high dependence of local communities on the wildlife resources of OONP due to their low financial status. This confirms that conservation measures must consider human well-being through poverty alleviation programmes for the local people and be co-ordinated across PAs. Such programmes should be evidencebased through scientific studies in order to understand and address factors that could prevent efforts towards poverty reduction. Furthermore, provision of grazing reserves for the pastoralists and the use of ranches should be considered in developing countries such as Nigeria. These will ensure the preservation of large mammas, especially the mega herbivores and, apex predators for the future.

This research is timely and represent an excellent initial step towards addressing the widespread decline of large mammal populations widely recognised as one of the challenges facing wildlife conservation, particularly in Africa. The findings in this thesis will stimulate further research to inform effective conservation strategies that rebuild the population of charismatic species for the valuable ecosystem services provided for the benefit of the future generations.

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Appendix 1: Questionnaire for the participants (Villagers) of the survey

The questionnaire used to gather some of the data that has been presented in this thesis is presented below

Section A

This survey is in two part (A and B). Part A will be completed in a slightly unusual way (in form of a game). [Hand over a bag of 8 white balls, 1 red ball and 1 black ball]. The rules of this survey ensures that you remain anonymous, as none of your answers can be traced back to you. Let's do the example: dip your hand into the bag and shake the balls together, pick a ball – (what colour of ball did you pick? Ok. Now, I will read to you from this card the rules of this game. If you choose a white ball, you must answer the question truthfully. If you pick red, you must answer 'Yes' irrespective of your truthful answer to the question. Remind the respondent that I don't know the colour of the ball they have picked and they don't have to show me or tell me the colour. If you pick the black ball, you must say 'No' to the question no matter what the truthful answer is. I am going to ask you a question after which you pick a ball and you answer the question by saying to me 'yes' or 'no'. Please remember to follow the rules of the game (hand over the card in which the rules are written to the respondent).

Question:

Do you know how to play draft?

☐ Yes
☐ No

Is that clear to you or would you like to do the example again?

Now, let us do the survey, remember to follow the rules, they are written on the card so you do not need to remember them. Do not worry the survey is not going to take long. Respondent to complete RRT question 1 – 9 Thank you

From the list of the questions below, please indicate by answering Yes/No

Q1. Do you grow your own crop

☐ Yes
☐ No

Q2 Since the National Park has been established in 1991, have you ever entered the park

☐ Yes
☐ No

Q 3. Did you enter the National Park last week
☐ Yes
☐ No

Q4. In the last 12 months did you ever enter the park to get fire wood
☐ Yes

☐ No

Q5. In the last 12 months did you ever enter the park to hunt
☐ Yes
☐ No

Q6.In the last 12 months did you ever enter the park to get plants and vegetables

☐ Yes
☐ No

Q7.In the last 12 months did you ever enter the park to fish

☐ Yes
☐ No

Q8.In the last 12 months did you ever take livestock into the park to graze
☐ Yes
☐ No

Q9.In the last 12 months did you enter the park to view animals/sight seeing without seeking permission

☐ Yes
☐ No

Section B

Respondent profile

Q1. Gender:

What is your gender?
☐Male
☐Female

Q2. Age
Which of the age group do you belong?
☐ Under 30 years
☐ 31 – 50 years
☐ 51years and above

Q3. Annual Income
Which of the following income groups do you belong to?
☐ N100,000 and below
☐ N110,000 – N200,000
☐ N210,000 – N300,000
☐ N310,000 – N400,000
☐ Above N410,000

Q4. Ethnicity
Which of the following ethnic group do you belong to?

☐ Yoruba
☐ Idoma
☐ Tiv
☐ Fulani
☐ Hausa
☐ Juku/bororo
☐ Ibariba
☐ Togolese
☐ Other

If other, please indicate......................

Q5. Level of education
What is your level of education?
☐ Primary level
☐ Secondary level
☐ Tertiary level
☐ No formal education

Q6. Occupation
Please indicate your primary occupation

☐ Crop farmer
☐ Livestock farmer
☐ Mixed farmer
☐ Trader
☐ Charcoal maker
☐ Fisherman

☐ Unemployed
☐ Other artisans

Q7. Occupation
Please tick the boxes which indicate you other occupations

☐ Crop farmer
☐ Livestock farmer
☐ Mixed farmer
☐ Trader
☐ Charcoal maker
☐ Bushmeat Hunter and trader
☐ Fisherman
☐ Unemployed
☐ Other artisans

Q8. **Awareness of the park**

Q8.1 Please indicate how much you agree or disagree with the following statements:

S/N	Statement	Agree	Disagree	Do not know
1	That the park is a source of food to you			
2	That the park is a source of medicinal plants or herbs			
3	That the park is a source of firewood			
4	That the park is a source of poles/ building materials			
5	That the park is a place for grazing livestock			
6	That the park is created to protect endangered animal			
7	That the park protects the communities against natural hazards like drought and floods			
8	That the park offers spiritual wellbeing			
9	That the park offers recreation experience			

10	That the park benefits local communities			
11	That a National park exists here.			
12	That the park is protected			
13	That entering the park without permission is illegal			
14	That permission is needed to enter the park			

Q8.2. How much do you agree or disagree with people from this village entering the

park to:

S/N	Statement	Agree strongly	Agree	Indifferent / undecided/ unsure	Disagree	Disagree strongly	No opinion
1	Fetch firewood						
2	Hunt animals						
3	Get poles and roofing materials						
4	Get wild vegetables						
5	Get medicinal plants and herbs						
6	Make charcoal						

Q8.3. Awareness of animals

Within the last 12 months which of these animals have you seen inside and outside the OONP. Indicate by ticking seen/not seen

S/ N	Name	Inside		Outside	
		Seen	Not seen	Seen	Not seen
1	Lion				
2	Civet cat				
3	Leopard				
4	Buffalo				
5	Kob				
6	Roan antelope				
7	Western hartebeest				
8	Warthog				
9	Primates				
10	Bushbuck				
11	Duiker				
12	Aadvark				
13	Hunting dog				
14	grasscutter				
15	Mongoose				
16	Fox				
17	hare				
18	If other specify				

Q9. Bushmeat consumption

Hunted species

How frequently do you think the following animals are eaten by people living in this

village?

S/N	Statement	Daily	once per week	At least once per month	Only once per year	Not at all
1	Bushbuck					
2	Roan antelope					
3	Kob					
4	Duiker					
5	Western hartebeest					
6	Primates					
7	Water buck					
8	Buffalo					
9	Aadvark					
10	Warthog					
11	Hunting dog					
12	Civet cat					
13	Mongoose					
14	Fox					
15	Hare					
16	Grass cutter					
17	Specify if others:					

Q10 **Hunting season**

Which season does most hunting happen?

☐ Rainy season
☐ Dry season
☐ Both seasons

Q11 **Source of protein consumption**

Please tick the box which best describes how often you eat the following in your household?

S/N	Source of protein	Every day	Once a week	Once a month	Not at all
1	Fish				
2	Egg				
3	Beef				
4	Bushmeat				
5	Poultry				
	Indicate other source below				
6					
7					
8					
9					

Q12. The trend and perception of hunting on status of large mammal

Q12.1 **Trends in hunting**

In your own opinion, what has happened to hunting frequency during the last five years

- ☐ Increased sharply
- ☐ Increased slightly
- ☐ Remained constant
- ☐ Decreased slightly
- ☐ Decreased sharply

Q12.2 Perception of animal population status

Please tick one box which best describes what you think has happened to the numbers of animals listed below during the last 5 years inside and Outside the OONP.

		Inside				Outside			
S/N	Species of animal	Increased	Remained unchanged	Decreased	Don't know	Increased	Remained unchanged	Decreased	Don't know
1	Bushbuck								
2	Roan antelope								
3	Kob								
4	Duiker								
5	Western hartebeest								
6	Primates								
7	Water buck								
8	Buffalo								
9	Aadvark								
10	Warthog								
11	Hunting dog								
12	Civet cat								
13	Mongoose								
14	Fox								
15	Hare								
16	Grass cutter								
17	Other:								

Q13. Drivers of hunting

Drivers of illegal hunting

To what extent do you think the following reasons cause people to hunt inside the park?

S/N	Reasons	Major cause	Minor cause	Not a cause at all
1	Unemployment			
2	Provision of an alternative source of livelihood			
3	Promoting alternative source of income			
4	Crop damage control			

5	Traditional rituals or cultural ceremonies			
6	Revenge for livestock depredation			
7	Hunting as a hobby			
8	Revenge killing following arrest by rangers.			

Q14. Attitudes towards hunting / wildlife

How much do you agree or disagree with the following statements:

S/N	Statement	Agree strongly	Agree	Indifferent/ undecided/ unsure	Disagree	Disagree strongly	No opinion
1	Wild animals should be protected						
2	Presence of animals is a sign of a healthy environment						
3	I think I should be allowed to kill any species of animals inside the park						
4	I think I should be allowed to kill any species of animals outside the park						
5	I should be allowed to trap or kill any wild animal that are found in the fields damaging crops or						

	attacking livestock						
6	These days, I think killing any species of animals inside the park is wrong						
7	These days, I should not be allowed to trap or kill any wild animal that are found in the fields damaging crops or attacking livestock						

From the list of the questions below, please indicate by answering Yes/No

Q1. Do you grow your own crop

☐ Yes
☐ No

Q2 Since the National Park has been established in 1991, have you ever entered the park

☐ Yes
☐ No

Q 3. Did you enter the National Park last week
☐ Yes
☐ No

Q4. In the last 12 months did you ever enter the park to get fire wood

☐ Yes

☐ No

Q5. In the last 12 months did you ever enter the park to hunt

☐ Yes

☐ No

Q6.In the last 12 months did you ever enter the park to get plants and vegetables

☐ Yes

☐ No

Q7.In the last 12 months did you ever enter the park to fish

☐ Yes

☐ No

Q8.In the last 12 months did you ever take livestock into the park to graze

☐ Yes

☐ No

Q9.In the last 12 months did you enter the park to view animals/sight seeing without seeking permission

☐ Yes

☐ No

Thank you for participating.

Appendix 2: Questionnaire for the participants (Rangers) of the survey

The questionnaire used to gather some of the data that has been presented in this thesis is presented below

Q1. Gender:

Which of the following sex groups do you belong to?
- ☐ Male
- ☐ Female

Q2. Age
Can you please indicate your age in years? ☐

Q3. Level of education
What is your level of education?
- ☐ Primary level
- ☐ Secondary level
- ☐ OND
- ☐ HND
- ☐ University degree
- ☐ None

Q4. Annual Income
Which of the following income groups do you belong to?
- ☐ Up to N250,000 per year
- ☐ N251,000 – N450,000 per year
- ☐ above N451,000 per year

Q5. Length of service
Can you please indicate your total length of service as an employee in National Parks? ☐

Q6. Motivation
Please indicate whether you strongly disagree, disagree, are unsure, agree or strongly agree with the folliwng statements

S/N	Statements	Strongly disagree	Disagree	Indifferent/unsure	Agree	Strongly agree
1	I feel a sense of personal satisfaction when I did my work					
2	I feel that the job I do gives me a good status					

3	I feel that my superior always recognizes the work done by me					
4	Financial incentives motivate me more than non financial incentives					
5	Good physical working conditions are provided in this orgnization					
6	The employees in the organization feel secured in their job					
7	The medical benefit provided in the organization are satisfactorily					
8	I am given health insurance coverage or reimbursed for expenditures on health					
9	I am given adequate risk allowance					

Q7. Job satisfaction

Please indicate whether you strongly disagree, disagree, are unsure, agree or strongly agree with the folliwng statements.

S/N	Statements	Strongly disagree	Disagree	Indifferent/unsure	Agree	Strongly agree
1	I am happy with my present job					
2	i will like to give up this job for another with equal conditions of service.					
3	My salaries are regularly paid					
4	I am contented with the present salary structure					
5	i receive encouragement in my work					
6	I receive adequate supervision in my work					
7	I receive adequate support for my work					
8	I am tired of my job					
9	I have opportunity to use my skills and abilities in my job					

Q8. Recognition

Please indicate whether you strongly disagree, disagree, are unsure, agree or strongly agree with the folliwng statements.

S/N	Statements	Strongly disagree	Disagree	Indifferent/unsure	Agree	Strongly agree
1	I receive verbal recognition (e.g praise) for good performance from my supervisors when necessary					
2	I am financially sponsored on trips, training conferences, etc. as a show of appreciation for good performance					
3	I am given monetary reward as a show of appreciation for good performance					

Q9. Role Clarity

S/N	Statements	Strongly disagree	Disagree	Indifferent/unsure	Agree	Strongly agree
1	I understand the goals of the wildlife division					
2	I know what my job responsibilities are					
3	I know what my job responsibilities are					

4	I know what is expected of me in my day-to – day work as a ranger					
5	I know how my performance is judged in the organization					

Q10. Prevalence/occurrence of hunting and in and around OONP

How frequently do hunters acquire bushmeat in and around OONP?

- ☐ Every day
- ☐ Every week
- ☐ Every month
- ☐ Every 6 months
- ☐ Every year

Q11. Scale of hunting

Species mostly targeted

Can you rank as 1, 2,.in order of most common species of animals mostly targeted during
hunting activity/purchased for sale

- ☐ Bushbuck
- ☐ Roan antelope
- ☐ Kob
- ☐ Duiker
- ☐ Western Hartebeest
- ☐ Primates
- ☐ Water buck
- ☐ Buffalo

If others, please specify……………………………………………………………………

Q12. Demographic of poachers/Extent of illegal hunting

Q12.1 which of the following age group does the bushmeat hunters arrested in the park belong to?

- ☐ Less than 20 years
- ☐ 21 – 30 years
- ☐ 31 – 40 years
- ☐ 41 – 50 years
- ☐ Greater than 50 years

Q12.2 Please choose the option that describe your opinion about the statement below

Illegal hunting in the park is mostly carried out by

S/N	statement	Strongly agree	Agree	unsure	Disagree	Disagree strongly

1	People living far away from the park					
2	People from the neighboring villages					
3	Both					

Q12.3 How far in terms of average distance do local poachers mostly come from?

……………………………………………..Km

Q13. Nature of hunting

Q13.1 **Hunting style**

For each of the options below, which best describes the hunting style used by Hunters inside and outside OONP.

		Inside				Outside			
S/n	Options	Always	Some times	Rarely	Never	Always	Some times	Rarely	Never
1	Group hunting								
2	Individual hunting								

Q13.2 **Hunting season**

Which of the season does hunting being carried out most?

☐ Rainy season
☐ Dry season
☐ Bothseason

Q14. Awareness of animal

Within the last 12 months which of the species of animal listed below you have seen inside and outside the OONP. Indicate by ticking seen/not seen

S/N	Name	Inside		Outside	
		Seen	Not seen	Seen	Not seen
	Lion				
	Civet cat				
	Aardvark				
	Buffalo				
	Kob				
	Roan antelope				
	Western hartebeest				
	warthog				
	primates				
	Bushbuck				

	Duiker				
	Other:				

Q15. The trend and perception of hunting on status of large mammal

Q15.1 **Trends in hunting**

In your view during the last five years hunting activity in OONP has :

- ☐ Increased sharply
- ☐ Increased slightly
- ☐ Remained constant
- ☐ Decreased slightly
- ☐ Decreased sharply

Q15.2 **Perception of animal population status**

What do you think about the population status of the animals listed below inside and outside OONP.

		Inside			Outside		
S/ N	Species of animal	Increase d	Remained unchange d	Decrease d	Increase d	Remained unchange d	Decrease d
1	kob						
2	Roan antelope						
3	Western hartebee st						
4	buffalo						
5	Warthog						
6	primates						
7	rodents						
	Others:						

Q16. Drivers of illegal hunting

To what extent do you think the following factors drive illegal hunting?

S/N	Reasons	Major cause	Minor cause	Not a cause at all
1	Unemployment			
2	Provision of an alternative source of livelihood			

3	Promoting alternative source of income			
4	Crop damage control			
5	Traditional rituals or cultural ceremonies			
6	Revenge for livestock depredation			
7	Hunting as a hobby			
8	Revenge killing following arrest by rangers.			

Thank you for participating.

Appendix 3: Species richness in each of the five ranges from the empirical field survey

Species richness and distribution at each of the five ranges of the study area from camera trapping and line transect survey, where 1 = present and 0 – not present .

Species	Oyo Ile	Marguba	Tede	Sepeteri	Yemoso
aadvark	0	0	1	0	0
baboon	1	1	0	0	0
bush pig	0	1	0	0	0
bushbuck	1	1	1	1	1
caracal	0	0	1	0	0
civet	1	1	1	1	1
duiker	1	1	1	1	0
giant rat	1	1	1	1	1
grass cutter	1	1	1	0	1
ground squirrel	1	0	0	0	1
hare	1	1	0	1	0
jackal	1	0	0	0	0
kob	1	1	1	1	1
mongoose	1	1	0	1	1
pangolin	0	1	0	0	0
patas monkey	1	1	1	1	1
porcupine	0	1	0	0	0
red colobus	0	1	0	0	0
red flanked	0	0	0	1	1
roan antelope	1	1	1	0	0
tantalus monkey	0	0	0	1	1
warthog	1	1	0	1	1
water buck	0	1	1	1	1
Western hartebeest	0	1	0	1	1
Species richness	14	18	11	13	13

Key: presence=1 and absence =0