Bushmeat hunting in Gabon: Socio-economics and hunter behaviour

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Declaration

This dissertation is the result of my own work and includes nothing which is the outcome of work done in collaboration except where specifically indicated in the text and acknowledgements

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Abstract

Bushmeat hunting is a major issue in conservation, with numerous studies indicating the broad-scale unsustainability of the trade in West/Central Africa. At the same time, many of the world's poorest communities rely on bushmeat as a major source of protein. While urban market studies provide estimates of the size of the trade, our understanding of the drivers and characteristics of bushmeat hunting at the village level is still poor. Using data collected from two villages in Central Gabon, from August 2003 to March 2005, this thesis explores the place of hunting in the context of village livelihoods. Spatial information on trapping offtakes from 76 hunters over one year, combined with hunter interviews, provides a detailed analysis of village landscape use by hunters, and the biological and social factors influencing hunting behaviour.

Whilst hunting is the main livelihood option for village men, hunters were predominantly from richer or middle-income households. However, household wealth is perceived to be more strongly related to ownership of plantations (managed by female members of the household) than to hunting. Although bushmeat was an important source of protein for families, a significant proportion of hunting incomes may not have benefited the household, as they were spent on luxury items.

Investigation of commodity chain characteristics from forest to market highlights problems with the use of market data as an indicator of hunting sustainability; Only 19 of the species in the original catch were represented in the animals destined for market, and three species accounted for 90% of the individual animals sold. Analysis of individual trap success showed catch rates for these larger-bodied, commercial species were highest in traps furthest from the village, in good quality forest, with low hunting pressure.

Hunting strategies and hunter distribution within the landscape were strongly related to hunter age, with hunters of middle age hunting further into the forest, investing more effort, and as a result gaining higher offtakes. The use of the landscape was influenced partly by catch rates, but also by changes in the fabric of the village community as old clan-based structures broke down.

This study is the first detailed investigation of trapping within a rural village landscape, investigating hunter decision-making with respect to trap placement, correlates of trapping success, and the role of hunting as within the village economy. It demonstrates that policy to tackle the bushmeat crisis requires a full understanding both of the socio-economic drivers and outcomes of bushmeat hunting and the factors that influence hunting behaviour and catches at the landscape level.

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Chapter 1:

An introduction to the bushmeat trade in Central Africa

Chapter 1

The term bushmeat means ‘the meat of any wild animal hunted for food’ (DEFRA, 2006), and refers to a wide range of species. Although the term originates from Africa, where the forest is often referred to as the ‘bush’, the subsistence and commercial use of wildlife is worldwide. With increasing human populations, the increasing commercialisation of bushmeat and increasing access to the forest, bushmeat hunting has become the most significant immediate threat to wildlife in many African and Asian countries (Robinson et al, 1999; Robinson and Bennett, 2000; Milner-Gulland and Bennett, 2003). Unsustainable levels of hunting threaten not only the survival of hunted species and their ecosystems, but also the livelihoods and food security of the rural poor who are dependent on wildlife as a protein resource (DFID, 2002; Brown, 2003). Bushmeat is therefore a crucial issue for both wildlife conservation and human development, and initiatives to tackle the crisis need to provide for both of these, often opposing, needs.

The impacts of an unsustainable bushmeat harvest have only recently become evident, and research has mainly focussed on documenting the effects of village hunting on local wildlife populations (Fitzgibbon et al, 1995; Fimbel and Curran, 2000; Blom et al, 2005), and quantifying the scale of the commercial trade using market surveys (Juste el al, 1995; Noss, 1998; Fa et al, 2000, Refish, 2005). Focus is now shifting from documenting impacts to understanding the drivers of the bushmeat trade, including the use of wildlife by local communities, in order to understand how local communities and local hunters will respond to and are likely to be affected by ecological, economic or social change (e.g. Apaza et al, 2002; Alvard, 2004; Starkey, 2005; Kumpel, 2006). This can then be used to inform local and national bushmeat policies and initiatives (Brown et al, 2007).

This thesis aims to use a case-study system to explore the place of bushmeat hunting in the context of local livelihoods, focussing on the social, cultural and economic factors influencing individual hunter behaviour. This has been achieved using data on individual trap offtakes for 76 hunters, combined with socio-economic surveys and hunter interviews, collected over two years from two villages in Central Gabon. In the following section I have provided an introduction to the current bushmeat literature, and this is then followed by the specific objectives and an outline of the thesis.

1.1 Bushmeat hunting and rural livelihoods

Rural forest communities are some of the poorest in the world. Of the 150 million people in West and Central Africa living under the poverty line, 120 million of these live in rural areas (IFAD, 2002). Bushmeat provides an important protein source for many rural communities for whom few other protein sources are available; estimates for the Congo Basin (Koppert et al, 1996) suggest that in rural communities 30 – 80% of protein, and almost all of the animal protein, is provided from bushmeat. Whilst agricultural products can provide most of the calories required (Wilkie and Carpenter, 1999), the main protein substitutes are fish and livestock, which are often more expensive (Gally & Jeanmart, 1996).

The sale of bushmeat can provide a large proportion of incomes in rural areas; a recent study in rural Gabon reported that hunting accounted for between 15% to 72% of household incomes, with the proportion increasing for more remote communities (Starkey, 2004). Livelihood alternatives to hunting can be scarce in rural villages (DFID, 2002), and short-term and unpredictable where available, which can even lead young men to choose hunting over a potentially more profitable activity (Solly, 2001). However, Gally and Jeamart (1996) found that hunting can be lucrative; estimations of hunting incomes for six hunters in Cameroon found their hunting incomes to be well above the national average income.

Although there is consensus that bushmeat is an important protein source for the rural poor as a group, there is less agreement on who within these communities are the hunters and consumers of bushmeat, and more specifically whether these bushmeat users represent the poorest sections of the community (e.g. Brown and Williams, 2003; Starkey, 2004). Similarly, there is little information as to how these rural communities use the incomes produced through the sales of bushmeat. These questions lie at the heart of the development/conservation debate, and answers are required to determine how bushmeat is used within rural communities, which sections of the community are likely to be affected by reductions in hunting, and what these effects are likely to be. A full review of this topic can be found in Chapter 4, where these questions have been addressed in a comprehensive rural case study of bushmeat hunter and consumer characteristics, livelihood options and the use of hunting incomes.

1.2 The urban demand for bushmeat

The urban trade in bushmeat has very different drivers to the rural trade. Towns and cities have access to alternative forms of protein, from livestock such as beef and poultry, and from frozen imports. Unlike in rural areas, where the consumption of bushmeat is of very low direct cost to the hunter, bushmeat in urban areas can be relatively expensive compared to the alternatives (Bahuchet and Ioveva, 1999). Whether bushmeat is a necessity or luxury item in urban areas is under debate. Earlier studies have indicated a deep-rooted preference for bushmeat, with consumers willing to pay a higher price, making bushmeat a luxury good (Trefon, 1998; Chardonnet et al. 1995). More recent studies from Libreville, Gabon (Starkey, 2004; Wilkie et al, 2005) and Bata, Equatorial Guinea (East et al, 2005) have suggested that urban bushmeat consumption responds to changes in the price of bushmeat and in the price of alternative protein sources. While fresh meats, including bushmeat, are often preferred to frozen meats they are more expensive and therefore consumed less often. Consumers show preferences for certain type of meats, including cane rats in Benin and Ghana (Adu et al, 1999), and porcupines in Libreville, Gabon (Shenck et al, 2006), creating a market demand for these species.

Measurements of per capita consumption of bushmeat in Central Africa, compiled from the literature by Wilkie and Carpenter (1999), suggest that current consumption of bushmeat per capita is approximately ten times lower in urban areas than in rural areas (an estimated 0.013 kg/person/day, compared with 0.13 kg/person/day). Although Central Africa has become highly urbanised since the 1970s, this higher per capita rural consumption means that rural areas in all Central African countries are still consuming more bushmeat overall than urban areas. However, with urbanisation rates of over 3% per year in the Congo Basin (UN, 2006), it is the commercial trade that is often perceived to be the main driver of an increasingly unsustainable harvest (Bowen-Jones and Pendry, 1999).

The commercial demand in urban areas is supplied by in part by rural village hunters, and the high demand for bushmeat has increased the number of professional or commercial hunters, for whom hunting is not part of a village livelihood (Fa et al, 2000). The movement of bushmeat from the rural hunter to the urban consumer along the commodity chain is complex and poorly understood (Bowen-Jones *et al.*, 2002). Once meat leaves the hunter it may pass through the hands of a number of intermediary traders (many of whom are women (Anadu et al, 1988), as opposed to hunters, who are all men), before reaching the consumer. A large percentage of the meat consumed in urban areas does not pass through formal urban markets; in Takori, Ghana, 85% of sales were made through small restaurants (Cowlishaw et al., 2005; Mendelson et al., 2003), and Steel (1996) estimated that 95% of bushmeat consumed in Gabon did not pass through urban markets. Most research into the commodity chain has focussed on the market end of the trade (e.g. Mendelson et al, 2003; Cowlishaw et al, 2004, 2005,2005b), and there is therefore currently little information on how market demand is influencing rural supply and hunting patterns, although some studies suggest that larger bodied species may be sold in preference to smaller-bodied species as a result of market demand (Noss, 1998; Fa and Yuste, 2001). Chapter 5 of this thesis provides an in-depth analysis of the commodity chain from animal capture in the forest to the sale of the meat to market, including the characteristics of eaten and sold animals.

1.3 The biological impacts of bushmeat hunting

The majority of studies that have investigated the biological impacts of bushmeat hunting have done so using comparative studies of prey densities in hunted and unhunted areas (Lahm, 1994a; Peres, 2000; Hart, 2000) or with distance from a central place, such as a village (Ngnegueu and Fotso, 1996; Muchaal and Ngandjui, 1999) or road (Fimbel et al., 2000; Laurance et al, 2006). These studies have generally found depletion of prey in hunted areas, and in some cases local extinctions (e.g. Lahm, 1994b). The effects of hunting are species-specific, and these studies demonstrate that larger-bodied species with slower reproductive rates, such as primates or large antelopes, are more heavily depleted than smaller, fast-growing species such as rodents.

There are limitations to these studies, the most recurrent being problems with the accuracy of prey density estimates (Noss, 1998b). The limited number of hunted and unhunted areas that can be compared in an area (due to the high sampling effort required for good estimates) can also often mean that conflicting effects of habitat and other variables cannot be controlled for. Studies have generally been carried out in or around protected areas, and so provide a biased view of the effects of hunting in the majority of Central/West African locations. Although local reductions of prey densities due to hunting have often been demonstrated, studies have generally failed to take into account geographical scale (but see Hill and Padwe, 2000; Walsh et al, 2003). This thesis provides one of the only studies of village hunting away from a protected area. By collecting data on the catches of individual traps within the hunted landscape, a landscape-level assessment of the predictors of trap success has been realised, and these results are presented in Chapter 6.

Hunting can also have secondary effects on prey populations. Many species have demonstrated behavioural changes for hunter avoidance: monkeys are more secretive (Croes et al, 2007) and can fail to alarm call, leopards and buffalo switch from diurnal to nocturnal behaviour in hunted areas (P. Henschel, unpublished data), and duikers abandon their freeze response to predators in areas with hunters, instead fleeing to reduce their chance of being shot (Croes et al, 2007). Pursuit hunting is often biased towards adult animals, and towards males due to hunter preferences for larger animals, producing biased sex ratios, which can reduce female fecundity (Ginsberg & Milner-Gulland, 1994).

Reduced mammal densities can result in severe ecosystem changes; the removal of such a large section of the food web is bound to have cascading effects. Recent studies (Peres and Palacios, 2007; Beckman and Muller-Landau, 2007; Wang et al, 2007; Dirzo et al, 2007) have demonstrated the effects of hunting on animal-mediated seed dispersal, and the removal of large mammals through hunting has been shown to impact insect communities (Stoner et al 2007). Human predators have similar prey preferences to many animal predators, and P. Henschel (unpublished data) has found that leopard densities are severely depressed in hunted areas where leopard prey are targeted by humans, but not the leopards themselves.

1.4 Measuring hunting sustainability

Reductions in prey densities will always occur when the prey population is hunted, and do not necessarily infer that the population will continue to decline, or that the current hunting offtake in the area is unsustainable under current hunting offtakes. Under the assumption of logistic growth, all prey species are a harvestable resource, as the per capita population growth rate increases as population size decreases. The maximum production for a prey population is generally at around 60% of its carrying capacity (Milner-Gulland and Akcakaya, 2001). Any harvesting over the maximum production will result in declines in the population which are too large to be replaced by any increases in per capita production, and the prey species will become locally extinct.

Robinson and Redford (1991) have produced a crude sustainability index, using a variation of the logistic equation, with which to calculate the maximum production of a prey species:

$$P = 0.6K\ (R_{max} - 1)\ F$$

Where P is maximum production, K is the carrying capacity of the species, R max is the maximum growth rate for the species, and F is a 'recovery' factor, ranging from 0.2 for long-lived species, to 0.6 for short-lived (Robinson and Redford, 1994).

This equation is the most frequently used in the hunting literature, to compare P with observed village hunting offtakes (e.g. Fitzgibbon et al, 1996; Noss, 1998b; Muchaal and Ngandjui, 1999), although other similar indices have since been published which use current yield rather than maximum yield (e.g. The Bodmer index (Robinson and Bodmer, 1999); the National Marine Fisheries Service index (Johnston et al, 2000)).

The majority of these studies suggest that for larger-bodied species current harvesting rates are unsustainable (e.g. yellow baboons, (Fitzgibbon et al, 1995), and red duikers, (Muchaal and Ngandjui, 1999; Noss, 2000)). Market data has also been used to assess hunting sustainability using these indices, (Fa et al, 1995; Refish 2005), but since only a small proportion of the total offtake may have passed through a formal market these are likely to underestimate total offtake.

There are both practical and theoretical problems with the use of many of these sustainability indices. All indices require an estimate of prey abundance, and in tropical forests these estimates are notoriously prone to error. Plumtre (2000) suggests that common methods of estimating of prey abundance may fail to detect population changes of 30 – 50%. Milner-Gulland (2000) has highlighted the theoretical issues with the Robinson and Redford index, questioning the lack of explicit survival rates, and the use of R_{max} instead of the actual population growth rate. When tested under reasonable levels of uncertainty (such natural population fluctuations, and less than perfect knowledge of the prey population) the only index which did not result in local extinction after 50 years was the more precautionary National Marine Fisheries Service index (Milner-Gulland and Ackakaya, 2001).

Simple sustainability indices also fail to account for spatial heterogeneity. For example, unhunted areas adjacent to hunted areas, whether a protected area or simply remoteness, can have important impacts on sustainability. The migration of animals from unhunted areas, where prey populations can be at carrying capacity, into hunted areas can buffer exploitation (Hill and Padwe, 2000; Salas and Kim, 2002). This theory is behind the use of marine no-take areas as a tool for sustainable fisheries harvests, whereas to date terrestrial protected areas are generally set aside for conservation rather than harvesting (Milner-Gulland and Ackakaya, 2001).

Alternative monitoring techniques have been suggested. Measures of catch per unit effort (CPUE) are used by the fishing industry to measure the sustainability of fish stocks (Milner-Gulland, in press). CPUE has potential as a sustainability index for bushmeat harvesting, as data on catch and effort are often easier to obtain than estimates of prey densities. If the CPUE for a hunter, village or market stays stable, then this may indicate sustainability, although reductions in CPUE (and in the prey base) are always going to occur at the beginning of harvesting in a new area. However, using CPUE assumes that yield is proportional to effort and population size, and this is unlikely to always be the case. A stable CPUE could be observed as prey densities decline, due to changes in hunting techniques or hunting behaviour (including movement into new hunting areas). Similarly, a declining CPUE may be observed with a stable prey population, due to avoidance behaviour by prey species (Milner-Gulland and Ackakaya, 2001). The use of CPUE as an indicator of sustainability is discussed further in Chapter 7.

The ratio of rodents: duikers in bushmeat markets could also be used to measure harvesting sustainability over time (Rowcliffe et al, 2003; Jerozolimski and Perez, 2003). As large-bodied species are more prone to over-harvesting than small-bodied species, a reduction in the large to small ratio might suggest depletion of the former. However, as with measures of CPUE, the lack of information on the hunting catchment area, and the small percentage of bushmeat that passes through formal markets can cause problems with the use of market data for estimating sustainability, and this is discussed further in Chapter 5.

All of these indices consider biological sustainability in isolation. However, biological and economic optimum yields are often not identical; due to the costs of hunting the economically optimum population size is higher than the population producing the maximum sustainable yield, and by ignoring economic sustainability these biological limits are of little practical use (Clark, 1976). These indices are also static, assessing sustainability at one point in time. Changes in socio-economic variables (e.g. bushmeat prices, interaction with other industries, such as fisheries, hunter behaviour) and biological variables (e.g. prey population carrying capacities, interactions between prey species) and the interactions between the two will all affect harvesting sustainability over time. Bioeconomic models incorporating these variables and their interactions have recently been developed to assess sustainability of bushmeat harvesting in more realistic complex, dynamic systems (Rowcliffe et al, 2003), and have been used to test different enforcement policies (Rowcliffe et al, 2004). However, the predictive power of these models is currently limited by a lack of ecological knowledge of the prey populations, and the socio-economic behaviour of hunters.

1.5 Hunting strategies and hunter decision-making

A range of hunting techniques are used around the world, including traditional techniques such as pitfall traps, liana traps, crossbows, dogs, nets, glue, poison, and spears (Bennet, 1899; Hart, 2000; Alvard, 2000; Starkey, 2004) and more modern techniques such as wire snares, chemical poisons, and guns. In Central Africa today wire snares and shotguns are the main methods of hunting; the switch from traditional techniques to modern ones occurred during the early to mid 1900s, when wire (replacing traditional raffia snares) and guns were introduced by European colonists. The increased efficiency of these modern techniques, especially shotguns, has been shown through modelling and field studies to reduce hunting sustainability (Damania et al, 2005; Basset, 2005).

Snare hunting is a passive strategy, and is generally considered to be unselective (Noss, 1998b, Lee, 2000, Rao et al., 2005), although different types of trap can select for different sizes of prey, or prey with certain behaviours (e.g. arboreal/terrestrial, Noss, 1998b; Starkey, 2004), and some studies have also suggested that some selectivity is achieved by trap placement (Fa and Peres, 2001; Starkey, 2004; Kumpel, 2006). A high level of wastage can be common with trap hunting, due to its passive nature (Noss, 1998b; Muchaal and Ngandjui, 1999), with prey lost through decomposition, scavenging by other animals, or escaped prey that then may die of their wounds.

Gun hunting has very different characteristics. It is an active strategy, and pursuit hunting involves high selectivity of prey species by hunters, with small-bodied species only pursued once the chance of procuring a larger-bodied species has disappeared (Mithen, 1989; Alvard, 1993 and 1995, discussed in detail in Chapter 7). Prey choice may be influenced by market demand, or by traditional preferences and taboos (for example, in Nigeria the bushbuck is a taboo species; Anadu et al, 1988). Gun and trap hunting methods used in the study site are described in detail in Chapter 2.

Prey choice by pursuit hunters is the only instance where hunter decision-making has been studied in any detail; very little is known about the factors influencing trapping strategies, or the use of landscape by hunters. Kumpel (2006), working in Equatorial Guinea, has provided the first account of landscape use and trapping behaviour, showing that the location of trapping areas were changed every few months, possibly in response to changes in prey densities.

Knowledge of hunter behaviour, including a hunter's response to changes in prey abundance, to external changes in livelihood options, or to changes in the market, is required for a complete understanding of the effects of conservation and development policies on the conservation status of prey species, and on the livelihoods of hunters and hunting communities (Damania et al, 2005). For this reason, the behaviour of trap hunters and the role of hunting in their livelihood strategies are addressed in chapters 4 and 7.

1.6 The main drivers of an unsustainable trade

Despite the problems with estimating sustainability, it is widely accepted that in most countries the current scale of the trade in bushmeat is either unsustainable now, or will become so in the very near future, and both from a conservation and development perspective this represents a crisis (Bennett et al, 2007). However, hunting was not always unsustainable; humans have lived in tropical forests for thousands of years, and a reduction in prey species has only become apparent in the very recent past. The main driver of this is thought to be the rapid increase in human population densities. Tropical forests have very low productivity, in some cases 85% lower than savannahs, and can support the protein needs of approximately 1 adult male per km^2 (Robinson and Bennett, 2000), which means that even small increases in population densities can result in unsustainable hunting. In Cameroon, one of the Central African countries that has seen the most severe prey density reductions, the average rural forest population density is 12.1 people/km^2 (Bahuchet, 1992), compared with less populated countries such as Gabon (1.6/km^2) and Congo (1.1/km^2) where prey populations are thought to be in better shape (McShane, 1990). However, most countries in the Congo Basin have very high population growth rates (2 – 3%), and the population of Congo is predicted to double its population size between 2005 and 2050 (UN, 2006). In West Africa, where population densities are 4 – 5 timer higher than those in Central Africa, many species have become locally extinct due to hunting and loss of habitat (Eves et al, 2002).

The increased commercialisation of the bushmeat trade, as rural-urban migration increases urban demand, has been cited as another reason for increased unsustainability (Bowen-Jones and Pendry, 2002). However, studies have shown that urban dwellers consume less bushmeat per capita than rural inhabitants. In Chapter 2 the impact of urban demand is discussed, using the case study of Gabon, the most urbanised country in Central Africa.

Increased access into the forest, mainly due to logging, has been the greatest facilitator of the supply of bushmeat in Central Africa, and a number of studies have now documented the sharp increase in bushmeat harvesting with improved access to logging concessions (Eves and Ruggiero, 2000; Bailey, 2000; Auzel and Hardin, 2001). Good roads are needed for the extraction of timber and movement of vehicles, and in a typical concession in Central Africa logging roads are cut in order that no part of the concession is more than 1.5 km from a road (GFW 2000). These roads allow poachers access to once remote areas of the forest, and logging vehicles are often illegally used to transport bushmeat to the nearest markets (Wilkie et al, 1992). Logging company workers, and other economic immigrants attracted to the logging villages, also increase demand for bushmeat (Auzel and Wilkie, 2000).

With European colonial rule, the efficacy of hunting techniques has dramatically increased, with the introduction of wire snares and shotguns, enabling higher returns for less effort (Damania et al, 2005). Economic decline may also have a part to play in increasing offtakes; migration back into rural areas was observed in Gabon with the collapse in value of the Central African Franc in 1994, and many immigrants from urban areas, wishing to keep their urban lifestyles, turned to bushmeat as a quick source of income (Lahm, 1993, 2000). Hunting also increases in times of war, when hunting restrictions and penalties disappear, and people become more dependent on bushmeat for food and income (de Merode, 1998).

1.7 Policies for reducing the impacts of the bushmeat trade

Reducing the trade in bushmeat can be regarded as an economic problem of reducing the demand for and supply of bushmeat. However, the efficacy of the policies designed to do this will depend on our knowledge of the system, including prey dynamics, hunter behaviour, and the use of bushmeat by rural and urban consumers, without which our ability to predict the outcome of policy implementation on the consumers, hunters and prey is limited. In this section, I have outlined the potential strategies for reducing bushmeat harvesting, and the information required for each one in order to understand the outcome of its implementation.

1.7.1 Reducing urban consumption

Urban consumption has generally been the target of strategies to reduce bushmeat demand (Wilkie and Carpenter, 1999; WCS, 2005). This is partly because research to date suggests that urban consumers have access to alternative protein sources (Hoyt, 2004, Starkey, 2004), and therefore a reduction in urban supply is unlikely to have an impact on urban livelihoods. Urban markets are also thought to provide a bottleneck - there are often few traders and markets compared to the numerous hunters and consumers - and so the policing of markets is much more effective (Wilkie and Carpenter, 1999, but see Cowlishaw et al, 2005). Enforcement of hunting laws at the market level can increase the price of bushmeat, both in real terms and relative to the price of substitutes, and in situations where the demand for bushmeat is elastic this will reduce demand for bushmeat. Two methods of increasing market prices have been suggested; confiscation and taxation.

In all Central African countries, the market trade in bushmeat is illegal. This means that the current method available for increasing prices is to enforce the law, imposing fines on traders and confiscating meat. This can be achieved through market raids, or roadblocks on the main roads into markets. However, the number of enforcement officers available is usually prohibitive, and corruption can reduce the effectiveness of this strategy (Wilkie and Carpenter, 1999).

Taxation, or in effect the legalisation of the bushmeat trade, has been floated by Wilkie et al, (in press) as an alternative strategy. Enforcing laws for an illegal trade can force the trade underground, making market regulation more difficult. Legalising the trade and introducing a tax on bushmeat trade may allow for regulation, whilst also increasing prices and controlling demand.

Whilst these approaches do not reduce rural consumption of bushmeat, and therefore do not affect rural protein supply, up to 90% of captured bushmeat in rural communities is sold, bound for the urban markets (de Merode et al, 2004). Reducing urban demand for bushmeat is likely to reduce the profits from bushmeat that are received by rural communities, and therefore an understanding of the use of these hunting incomes, and the availability of alternative income-producing activities in rural communities, is required in order to predict the effect of policies aimed at urban markets on rural livelihoods. Chapter 4 provides an analysis of individual hunter and household purchases, looking at the use of hunting incomes by hunters and households, and how this compares to the use of other household incomes.

1.7.2 Increasing the production of bushmeat and alternatives

Increasing domestic substitutes (whether bushmeat species or more traditional livestock species such as cows, goats and chickens) can provide the cheaper alternative to bushmeat, which can reduce demand if it is elastic. Raising bushmeat species, such as cane rats and porcupines, can also supply the urban luxury market, which is driven by taste preferences. A number of bushmeat rearing projects currently exist in Central Africa (Jori et al, 1998, pers obs, Gabon), but there are many drawbacks to these projects. As with market enforcement, the effect on rural livelihoods, through reduced bushmeat incomes, is not currently known. The likelihood that rearing programs will produce enough cheap domestic meat to reduce demand for wild meat is in doubt; hunted species are often frugivores, which are expensive to feed, and have low reproduction rates (Jori et al, 1998), which often makes them uneconomical to farm. Reared stock have to be seeded from wild stock, and this can put pressure on wild populations; 90% of Ghana's cane rat farmers require wild stock (Asibey and Addo, 2000), and the removal of Siamese crocodiles for wild farming has led to local extinctions (Mockrin et al, 2005). Finally, persuading local people to run these projects is difficult as they take up a lot of time and capital compared with bushmeat where, under low enforcement conditions, costs are currently minimal. Mockrin et al (2005) suggest that while rearing projects are a useful commercial venture, supplying the urban rich with high quality meat, the meat that they produce is too expensive to be a substitute for wild meat for the larger urban middle-class and poor. An example of this problem is the Hopcraft game ranch in Athi, Kenya, where bushmeat ranching was only economically viable once they started selling meat to tourist hotels and restaurants (Stelfox et al., 1983).

A complementary approach to reducing urban consumption is to increase the production of wild meat in tropical forests. No take areas, which are already used in fisheries management (e.g. Williamson et al. 2004; Halpern, 2003), can supplement hunted areas through dispersal of prey from ‘source’ populations at, or nearing, carrying capacity. The theoretical increase in hunting yields and sustainability has been tested using models of tapir hunting (Novaro et al, 2000), and the practical advantages and disadvantages are currently being tested in the Congo, where the PROGEPP buffer zone project has been running since 1998 (WCS Congo, 2007). This project uses spatial management of bushmeat hunting, through the rotation of hunting and no-take zones, in conjunction with projects to reduce hunting by providing alternative protein sources, to sustainably harvest bushmeat around the Nouabale-Ndoki National Park. The advantage to this method is that, compared to the ineffective enforcement techniques in rural areas, this allows a sustainable solution with relatively little ongoing management (Wilkie and Carpenter, 1999). Buffer zones around protected areas could increase bushmeat productivity, but a number of studies suggest that without reducing urban demand, hunting around national parks will deplete source, as well as sink populations (Wilkie et al, 1998b). Currently, our knowledge of prey populations is so poor, and prey density estimates so prone to error that predictions of prey population dynamics, especially dispersal, in hunted and unhunted areas are of little value.

1.7.3 Controlling access

As areas of the forest are depleted, hunters will move onto new areas where yields are higher, but only when the transport costs do not outweigh the benefits. Logging companies have reduced transport costs for hunters, increasing road access and even providing vehicles. However, controls on access to logging roads and concessions can be effective. Companies can be economically motivated by the increasing demand for certified timber, or through a conservation bond system (Auzel and Wilkie, 2000). As 45% of the Congo Basin is thought to be under concessions (GFW, 2000) the impact of these controls could be extensive. Logging companies can be called on to reduce access to the forest by closing old roads and destroying old bridges, and having manned barriers on existing ones, to prevent commercial hunters from entering. Workers from logging companies can be prohibited from hunting bushmeat, if the company provides them with alternative farmed meat. Logging trucks are often used to transport bushmeat, but by regularly checking trucks, and fining or firing workers found to be transporting meat, this can be greatly reduced (Ape Alliance, 1998).

Community conservation schemes have also attempted to reduce the open access nature of hunting in villages by providing communities and families with land-rights. These schemes are by their nature small-scale and intensive, and for villages in the Congo Basin the main landowner is generally the government. However, local households often have *de facto* management control, and traditional systems were very closed, with family ownership of the forest (Wilkie and Carpenter, 1999). Even under a closed-access system, local communities must be small, impregnable to outside hunters, and must not discount the future at a high rate for sustainable management to occur (Becker and Ostrom, 1995), and there is little information on how rural communities currently manage their bushmeat resources.

1.8 Research questions

The aim of this thesis is to place bushmeat hunting in the context of village livelihoods, exploring the factors influencing hunter behaviour.

Its specific objectives are to:

1. Investigate the socio-economic characteristics of hunters and hunting households, the use of hunting incomes and the availability of alternative livelihoods.

2. Examine the characteristics of the trade in bushmeat from forest to market, and the economic decision-making of hunters.

3. Study the predictors of individual trap success, investigating the impact of hunting and landscape variables on catch rates.

4. Describe the hunting strategies of village hunters, and the social, cultural and economic factors that influence their behaviour and decision-making.

These four objectives will be addressed in four data chapters (Chapters 4 to 7). Chapter 2 provides an introduction the study area, and the characteristics of bushmeat hunting in Gabon and the study villages. The general methods used are then presented in Chapter 3. I conclude in Chapter 8 with a discussion of the main findings of this thesis and how they will influence further research and policy on the bushmeat trade.

Chapter 2 :

Study site

Chapter 2

2.1. Gabon

With up to 80% tropical forest cover, one of the lowest population densities in the world, and one of the highest per capita GDP's in Africa, Gabon has huge potential for biodiversity conservation. Development and population pressures have had a lesser impact on its forest cover or wildlife than some of its neighbouring countries, but with declining oil reserves and a high growth rate, commercial logging and bushmeat hunting are proving an increasing threat. In this chapter I will be introducing the history, politics and economics that have shaped Gabon, and describe how these have influenced the bushmeat trade and current hunting and conservation policy.

2.1.1. Geography and climate

Gabon covers an area of 267,668 km2, and is bordered by Equatorial Guinea, Cameroon, the Republic of the Congo and the Gulf of Guinea (Figure 2. 1). Straddling the Equator, 60 – 80% of Gabon is humid or coastal tropical forest (GFW, 2000; percentage cover depends on the method of estimation), with grasslands to the south and southeast across the border with Congo. Gabon has an equatorial climate, with year-round high temperatures and humidity. Rainfall varies from an annual average of 120 inches (3,050 millimetres) at Libreville to 150 inches on the northwest coast, with almost all of it falling between October and May (the wet season), although there is a small (unpredictable) dry season in December/January. In the period from June to September (the dry season) there is little rainfall (Figure 2. 2). Temperature shows little seasonal variation, the daily average being about 81° F (27° C) (Encyclopaedia Britannica, 2007).

Figure 2. 1: Map of Gabon, showing its position in Africa (top left) and borders with Equatorial Guinea, Cameroon and the Republic of Congo (Figure reproduced from University of Texas library: http://www.lib.utexas.edu/maps/gabon.html)

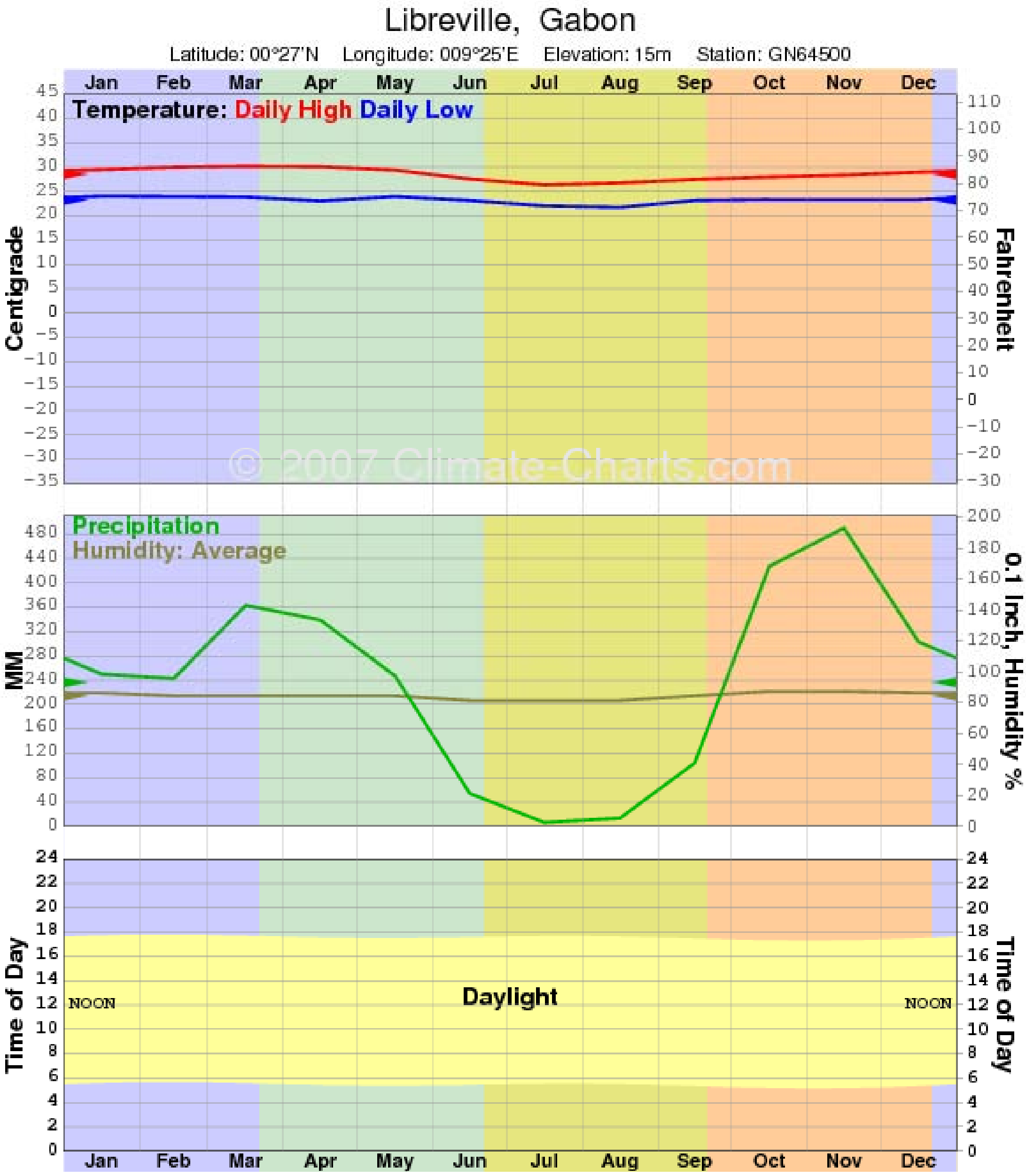


Figure 2. 2: Mean monthly temperature, precipitation and daylight for Libreville, Gabon. Data provided by the National Oceanic and Atmospheric Administration (NOAA). Graph reproduced from the World Climate Index (http://www.climate-charts.com/)

2.1.2. Political History

It is thought that the first people in Gabon were the Babongo Pygmies, before the immigration of other Bantu tribes. Currently Gabon's population stands at 1,384,000 (UN, 2006), with of 41 different ethic groups, of which the Fang and the Bapounou make up 49% of the population (Raymond, 2005). Other large groups include the Ndzebi, Myene, Bakota, Eshira, and Okande. The first European traders to arrive were Portuguese, but the French became protectors of Gabon in 1839 – 1841, by signing agreements with coastal chiefs. The slave trade was active along the Gabonese coast, and freed slaves founded Libreville, the capital, in 1849 after the French abolition of the slave trade. In 1885 France officially occupied Gabon, and began to administrate it in 1903, when it became one of the four territories of French Equatorial Africa. Gabon gained independence from France again on August 17th 1960, when president Leon M'ba was elected president. French has remained as the countries official language, and ties with France are still strong, with French military presence in Gabon. The French have also left the legacy of Christianity, which is the main official religion, but individual tribes retain their own traditional beliefs.

Leon M'ba ruled until his death in 1967, when the then Vice president, El Hadj Omar Bongo, automatically succeeded him. In 1968 Bongo declared a one-party state, inviting all parties to form a new party, the *Parti Démocratique Gabonais* (PDG). Bongo re-introduced a multi-party system in 1993, and there have been elections in 1993, 1998 and 2005, which President Bongo has won, despite two uncovered *coups d'etat,* allegations of election rigging, and riots in 2005, when it was announced that the president had won 79% of the vote (FCO, 2007, BBC 2005). International observers of the 2005 election declared the results to be representative despite irregularities. Having been in office for 39 years, Bongo is Africa's longest serving ruler (FCO, 2007).

2.1.3. Gabon's economy

Due to the discovery of oil in the 1970's, Gabon has the 4th highest GDP per capita in Africa, at $7,200 per person (CIA 2006 estimate), and the Human Development Index for Gabon is one of the highest for West and Central Africa, at 0.633 (UNDP, 2004). However, wealth is very unevenly distributed, and although there are no official statistics on poverty or wealth distribution it has has been suggested that 80% of the rural population live under the povety line of less than $1 a day (Yates, 1996). Gabon does not have a system of taxation, with the government drawing money directly from the economy through oil and logging taxes and permits; this means that there is little public accountability as to how oil revenues are spent (Yates, 1996).

Gabon is a classic ‘rentier’ state, which means that it is a ‘country that receives on a regular basis substantial amounts of external economic rent’ (Mahdavy, 1970). Gabon’s main raw materials are oil and timber. It does not actively contribute to the production process of these materials, yet still shares in the incomes from the products through renting exploitation permits to foreign (mainly French) companies (Yates, 1996).

2.1.3.1. Oil

Significant reserves of oil were found off the coast of Gabon (in the Gamba region) in the late 1970’s, and have influenced the countries economy, population movements, infrastructure and sense of identity; unfortunately not many of these changes have been positive. In the 1980s, Gabon enjoyed high oil revenues and a population of under a million people, earning it optimistic comparisons with Kuwait and Saudi Arabia. Money was ploughed into infrastructure, including the Trans-Gabonaise railway from Libreville to Franceville. However, oil revenues in dollars increased cheap imports of food, which severely depressed the agricultural sector. Higher wages in the oil sector increased this agricultural downturn, as people left rural agricultural in search of employment in the capital (Wunder, 2004).

In 1986 world oil prices plummeted, and this combined with overspending on the railway (which finally cost $3 – 4 billion in 1986 prices (Yates, 1996)), the CFA franc devaluation of 1994 and low oil prices in the 1990’s has put Gabon in significant debt to the Paris club and the IMF. Due to low economic diversification, Gabon’s economy is also vulnerable to changes in oil prices; in 2006 oil revenues comprised 63% of the government of Gabon’s budget, 43% of GDP and 81% of exports (US Bureau of African Affairs, 2006). This is worrying, as at the beginning of 2005 the IEA announced that without the discovery of new fields current production would exhaust

Gabon's oil reserves by 2012 (EIA, 2005). In the meantime, Gabon's agricultural sector has never recovered from the oil boom. Gabon is now dependant on imports, even importing bananas from neighbouring Cameroon, and in the early 1990's over 75% of all the food eaten in Gabon was imported (Yates 1996).

2.1.3.2. Timber

The forestry sector contributes around 7% of Gabon's GDP (BAA, 2006), and one species, Okoume *(Aucoumea klaneana,)* accounts for 71% of the felled wood (FAO, 2007). The number of active logging permits has grown steadily since the 1950's (Figure 2. 33), and in 2000 active logging concessions covered 12 million hectares, or 55% of Gabon's forest area. Logging permits are granted by the government, which is the major landowner; however logging companies are generally foreign-owned (GFW 2000). More than 90% of Gabon's log production is exported (GFW, 2000), and Asia is the primary importer. The industry is therefore vulnerable to market fluctuations, and during the Asian economic crisis of 1997 - 98 Okoume exports dropped by 45%, resulting in a stockpiling of timber, and the loss of may Gabonese jobs (GFW 2000).

Because Okoume is often the only species extracted, studies suggest that logging in Gabon can potentially have a low impact on the forest structure, with an average of 10% canopy loss; however, 50% of the canopy can be damaged or disturbed due to unsustainable logging practices (Wilks, 1990). The FAO has estimated that Gabon has lost 20 – 30% of its original forest cover already, and the current deforestation rate is estimated to be 0.5%, at which rate Gabon will lose 50% of its present forest cover in the next 100 years (FAO, 1999).

Logging in Gabon has direct impacts on hunting; bushmeat is hunting and consumed by workers in logging concessions and a study carried out in a logging concession near the Lope reserve estimated that the 1,200 concession employees consumed 80 tonnes of bushmeat a year (Gabonese Govt., 1999). However, it is the secondary effects of logging that are likely to have the most ecological impact, with logging roads opening up previously inaccessible parts of the forest to hunters. The Global Forest Watch (GFW, 2002) recently completed a study to find out how much contiguous forest still exists in the Congo Basin, defining a 'low-access tract' as a contiguous forest block without roads or forestry tracks, of more than 1000km2 (the area thought to be required to sustain populations of the majority of rainforest mammals, Redford and Robinson, 1991). 73% of Gabon's forest is currently in low-access tracts, but of this, 58% is within logging concessions, and at risk.

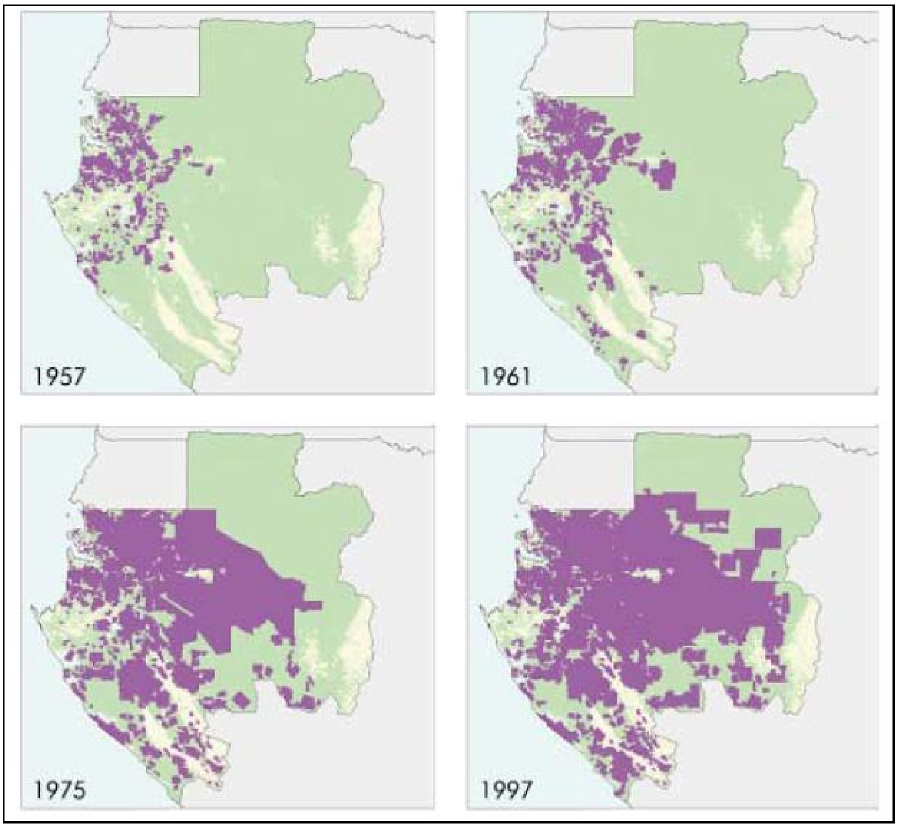


Figure 2. 3: The area of Gabon covered by logging permits. Taken from: GFW, 2002. In 1957 the timber concession coverage was 1.6 million hectares, in 1997 it was 11.8 million hectares and in 2000 it was 12 million hectares (GFW, 2002). In the past not all of the logging permits given out were exploited, but now virtually all are. Figure reproduced from GFW, 2000.

Although laws do exist concerning the extraction practices in logging concessions, the laws have been poorly constructed (three-quarters of the decrees planned for the forestry activities law were never written (GFW 2000)), and are rarely enforced, partly due to a lack of government enforcement agents. Permits are given on short-term contracts (10 – 25 years), and are often illegally bought up by companies who sublet them (a practise known as *fermage*). In this environment, there are few incentives to practice sustainable logging. There are some signs of hope. In 1998 a new forestry law was submitted to the National assembly, written to encourage sustainable practice. One concession owned by the C*ompagnie Equatorial du Bois* has also independently incorporated sustainable practice (including a tag system for individual trees, and closing logging roads with locked gates) into their management plans in order to get timber certifications for the environmentally-conscious European markets (GFW, 2000, pers. comm., Jenmart, CEB).

2.1.3.3. Other extractive industries

Before the discovery of oil, timber and manganese were the main extractive industries in Gabon, and in 2004 Gabon was one of the top five world producers of manganese (Bermudez-Lugo, 2004). Aside from manganese, Gabon is rich in natural resources, and has reserves of gold, platinum, diamonds, iron ore and uranium.

2.1.3.4. Agriculture

Although in Gabon's official statistics, 60% of the workforce is employed in agriculture (CIA, 2007), the commercial agricultural sector is very weak, and there are no official estimates of its contribution to the GPD. The high number of agricultural workers probably reflects that those people not employed in the extractive or services industries (who might otherwise be recorded as unemployed) all have family plantations (agricultural fields). Most rural families own a number of plantations in cleared areas of forest around the village, and many urban dwellers, even in Libreville, own plantations on the outskirts of town. Commercial crops sold in Gabon include cocoa, coffee, sugar, palm oil and rubber.

2.1.3.5. Bushmeat

Although not officially included in estimates of GDP, it has been estimated that the net worth of Gabon's trade in wildlife is roughly equivalent to 2% of GDP (Hammond, 1998).

2.1.4. Population dynamics

Gabon's population density, at 5.2 individuals/km^2 is one of the lowest in the world. This low population probably stems from a historically low population, which was then reduced further by the country's slave trade history, and series of famines in the 1920's (Pourtier, 1999). High levels of infertility also help to keep the population low (Schrijvers et al, 1991). Gabon's population is highly urbanised, and this is due to rural-urban migration and the government policy of *regroupement*.

2.1.4.1. Rural-urban migration

Although the overall population has been steadily increasing (with a current growth rate of 4.2%), since the 1950's the rural population has been in steady decline, falling from 416,000 in 1950 to an estimated 227,000 in 2005 (UN, 2007). In 1950 Gabon's population was approximately 469,000, with the majority (88%) of people living in rural villages. Today an estimated 83% of the population live in urban areas, and almost half of these people live in Libreville (UN, 2007). This dramatic change is due to rural-urban migration, which was greatest during the oil boom, but is still continuing, with a rural growth rate of -2.17 between 2000 and 2005 (UN, 2007). Migrants leaving the villages to go and work in towns tend to be the young and middle aged, leaving rural villages with populations with increasing higher dependant populations (Figure 2. 4).

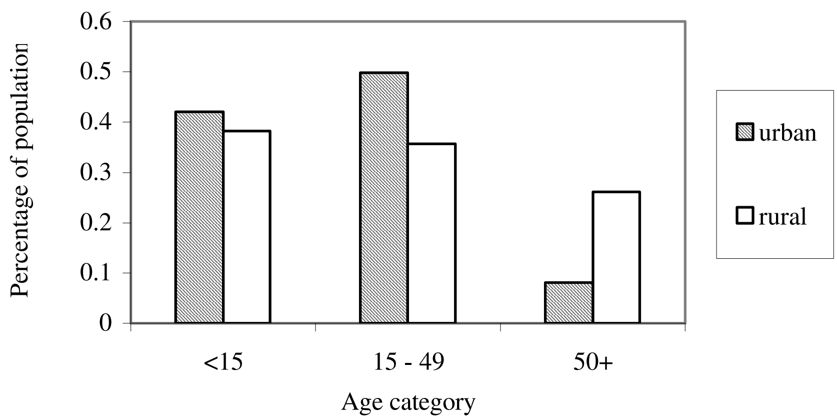


Figure 2. 4: Frequency histogram showing the proportion of inhabitants of each age class, in the rural and urban population of Gabon, 1993. Data taken from the 1993 Gabonese census (Gabonese Government, 1993)

2.1.4.2. Regroupement

Before the First World War, the population of Gabon was mainly nomadic. Temporary villages comprised 1 or 2 'houses', or families of the same clan, and villages were often under 100 people. There were no main roads, and villages tended to be distributed along tributaries and contours, producing a very dispersed, shifting population (Figure 2. 5).

'*Regroupement'* describes the forced movements and consolidation of these nomadic villages, which begin in the early 1900's under French rule, but was only introduced as national policy in 1947. One of the reasons for this movement was because nomadic, dispersed populations made state control very difficult. Larger, fixed villages stopped the fluidity of the previous nomadic system, allowing administrative control, especially with the low population densities in Gabon and also providing an accessible labour-force. Villages were located along roads for ease of access, and men of working age in the new *regroupements* were also used as forced labour, constructing the first main roads in Gabon. Another reason given for the *regroupements* was that larger, fixed villages along main roads allowed for the provision of healthcare, schooling, and sanitation and water facilities (Pourtier, 1998).

Regroupement continued after independence in 1960, and between 1960 and 1970 the number of villages in Gabon fell from 4228 to 2876 (Pourtier, 1998). Figure 2. 5 shows how these *regroupements* radically changed the distribution of the Gabonese population between 1940 and 1970. However, with the discovery of oil, and the subsequent rural-urban migration, the size of villages did not grow as hoped, and in 1993 the mean size of villages was 80 - 100 (Gabonese Government, 1993), well under the 1000 aimed from by the Gabonese government in the 1960's.

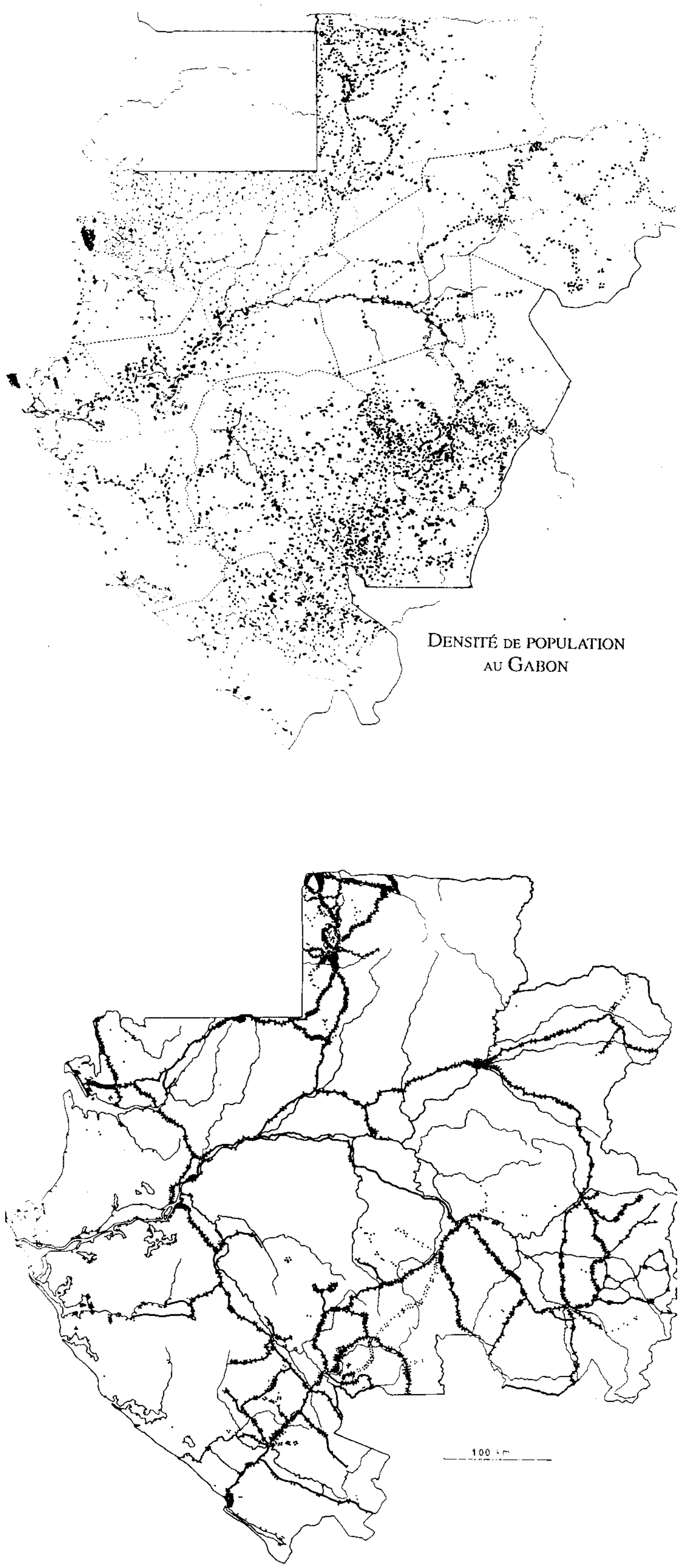


Figure 2. 5: The distribution of Gabonese villages in a) 1944 and b) 1970. During this period, the policy of regroupement forced, or coerced villages to group together along main roads. (Figure reproduced from Pourtier, 1998).

2.1.5. Conservation and Gabon's national parks.

2.1.5.1. Gabon's biodiversity

Gabon's forest is part of the larger Congo Basin forest, the second largest dense humid tropical forest after the Amazon (
Figure 2. 6), covering approximately 2 million km^2, and comprises over 90% of Africa's remaining tropical forest. The Congo Basin forest boasts some of the richest wildlife and plant communities in Africa, and Gabon alone has 190 mammal species (see WCMC, 2007 for full list), including 20 primate species, 676 bird species, and an estimated 6,500 flowering plant species (World Bank, 2004; Christy, 2001), with up to 20% of these species endemic to the country (Laurance et al, 2006). Gabon is also home to an estimated 40% of the lowland gorillas in the world, 61% of the chimpanzees, and 15% of the African elephants (World Bank, 2004). A full list of the protected species in Gabon can be found in Appendix A1.

2.1.5.2. The National Park system

In 1999, six of the nations within the Congo Basin, including Gabon, signed the Yaoundé agreement, creating the Congo Basin Forest Partnership (PFBC, 2007). The aim of this partnership is to strengthen the links between these countries as concerns their conservation policy, and the declaration in 1999 included plans to establish 10% of each nation's forest in protected areas (Kamden-Toham et al, 2003). In 2002 President Bongo delivered on this promise, creating 13 National Parks in Gabon (Figure 2. 7), which are managed by the Gabonese Government in collaboration with the Wildlife Conservation Society, the World Wildlife Fund and Conservation International. These parks encompass about 30,000 km2, or 11% of the country's land areas (Laurance et al, 2006).

At present Gabon's park system is very new. All of the parks have been delimited on the ground, and in the larger national parks (such as Ivindo, Lope, Louango, Mayumba, Minkebe and Plateau Bateke) preliminary monitoring rounds have been completed, and ecoguards have been trained. However, some of the national parks still have no management structure in place, and are only 'parks on paper' (Henschel, pers. comm.). Ecoguards also presently have no official mandate, and so although they can patrol the parks, they have no authority to arrest people, or confiscate arms.

2.1.5.3. The potential for ecotourism

Ecotourism is growing at a world rate of 4.6% (Laurance, 2006). With the oil revenues in Gabon declining it is important for the country to diversify, and the national parks, and the charismatic fauna of Gabon provide a fantastic base for ecotourism. However, tourism in Gabon is currently limited for all but the very adventurous; there is very little access to the parks, which reduces the human impact, but makes ecotourism difficult, and although tourist lodges have been designed, only a few parks (Louango, Lope, Ivindo) have the infrastructure for tourists. More generally, Gabon is a difficult destination for tourists. Very few Gabonese speak English, access visas with a letter of invitation are required for entry into the country and travel around the country is difficult and time-consuming. The forest in Gabon also does not provide the same viewing experiences as East African savannas, with hours of tracking on foot required to see certain species. Some ecotourism ventures (e.g. the Mikongo gorilla project in Lope) have rebranded themselves as ‘forest experiences’ due to this problem.

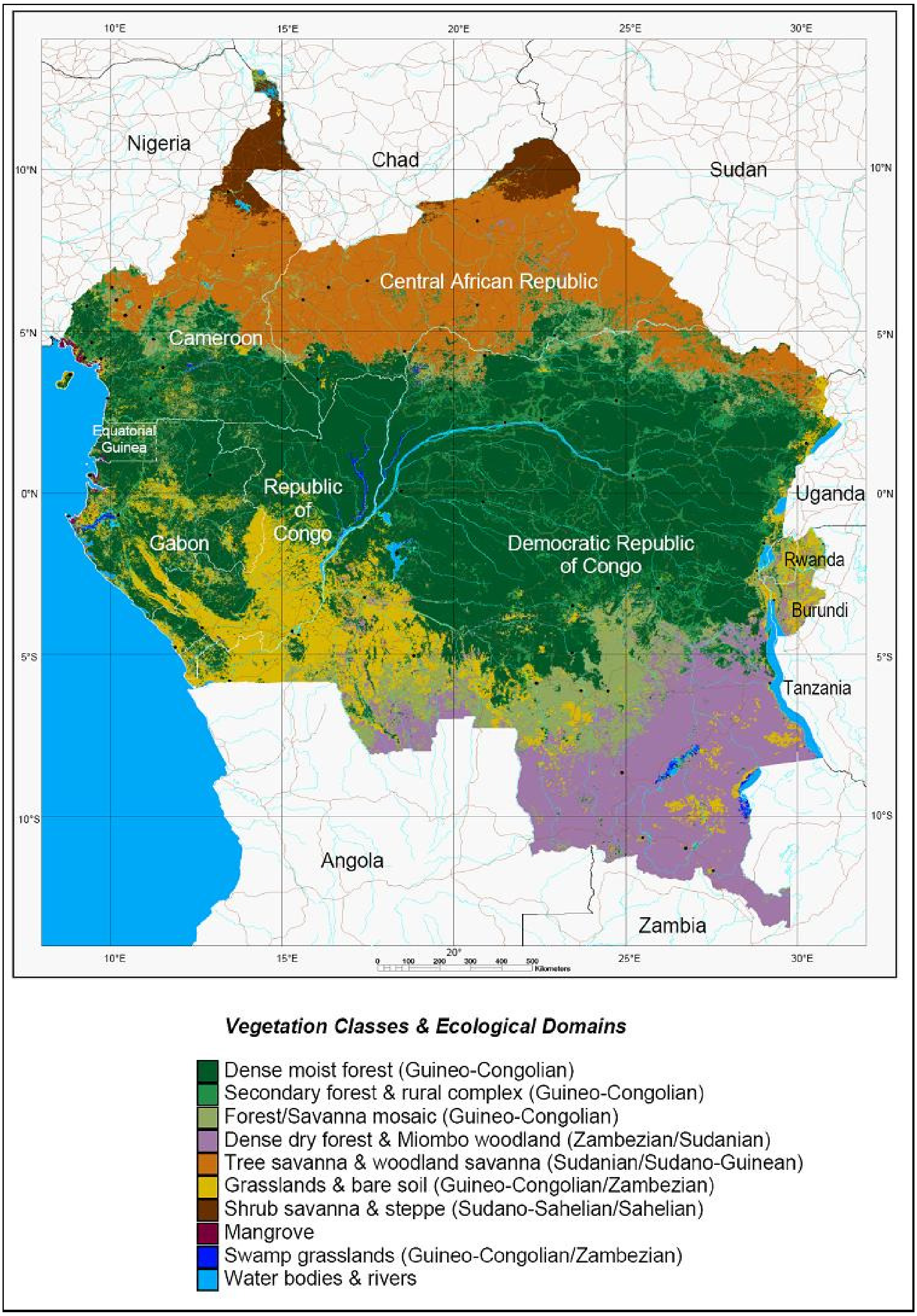


Figure 2. 6: Vegetation classes across the Congo Basin; Gabon is generally covered by Dense moist forest, apart from the grasslands of the Bateke Plateau in the southwest, extending across into Congo and DRC. Figure reproduced from Eerens et al (2000).

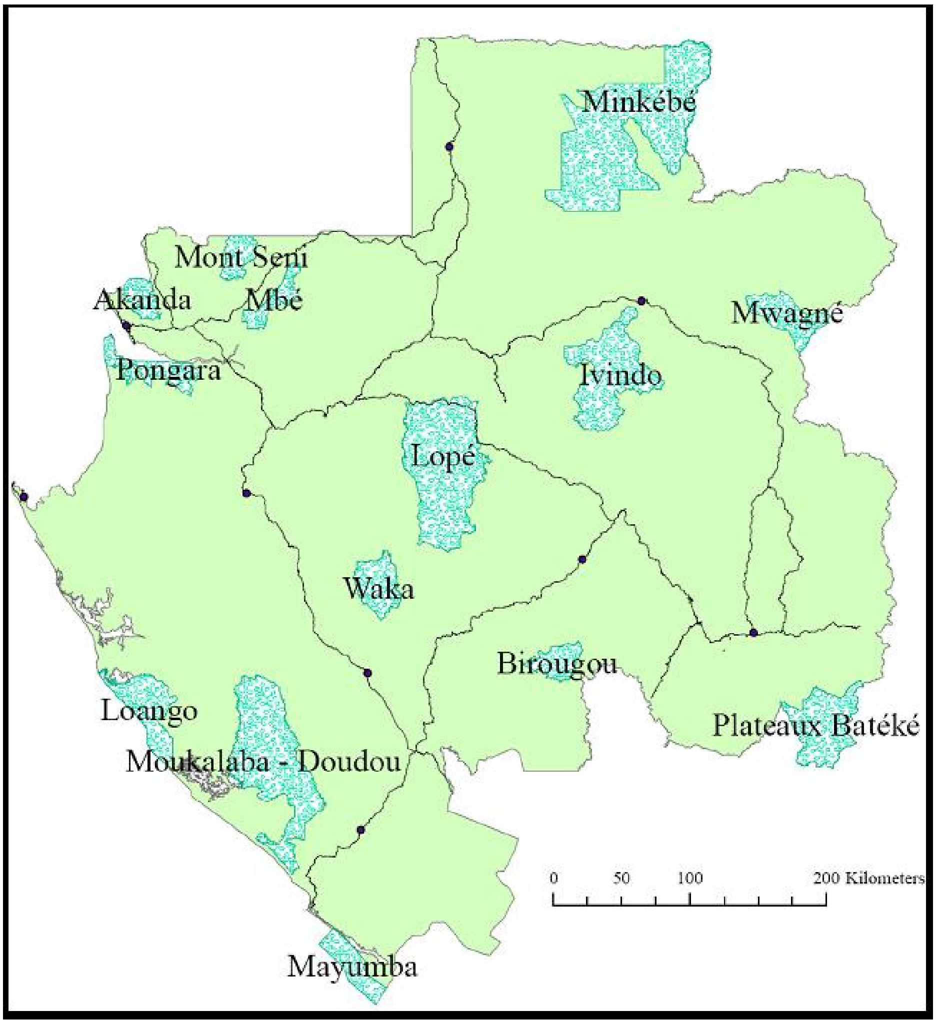


Figure 2. 7: The location of Gabon's 13 national parks. National parks in patterned dark green. 'Mont Seni' and 'Mbe', in the Northwest corner of the county, together make up the Crystal Mountains National Park. Major towns (black circles) and roads (black line) are also shown. Produced using shapefiles provided by WCS Gabon.

2.1.6. Bushmeat hunting in Gabon

2.1.6.1. The extent of the trade

The first countrywide study to try and assess the quantities of bushmeat consumed in Gabon was carried out from 1992 – 1993 by Steel (1993), which suggested that 17,000 tonnes/year of bushmeat were being consumed in Gabon. However, the sample size for Steel's study was small, and did not use standardised methods for rural and urban areas. Wilkie and Carpenter (1999) used rural and urban consumption rates taken from studies in the Congo Basin to provide an estimate of 11,000 tonnes/year for Gabon, but this used a very low population estimate for Gabon of 760,000 people. A more comprehensive countrywide survey of bushmeat consumption rates, in 1221 households in eight villages and four towns (including Libreville) was carried out by WCS in 2002 (Starkey, 2004). They calculated a consumption rate of 0.02 kg/AME/year (where AME is an Adult Male Equivalent, see Starkey, 2004 for methods) for urban areas, and 0.26 kg/AME/year in rural areas (high compared with other areas in the Congo basin; see Wilkie and Carpenter, 1999). Extrapolating up for this suggested a consumption rate of 26,000 to 33,000 tonnes per year for the whole of Gabon given the population size in 2002 (Starkey, 2004). The difference between Steel and Starkey's estimates may be due to changes in per capita consumption of bushmeat between 1993 and 2002, but could also be due to differences in the data collection methods. However, observational data suggests that there has been an increase in the last 20 – 30 years in the consumption of bushmeat in Gabon (Adams and McShane, 1996, Wilks, 1990).

Even though Gabon's population is highly urbanised, the rural population consumes approximately half of the total bushmeat consumed in Gabon, due to higher per capita consumption rates. For instance, although Libreville accounted for 40% of the population in Gabon in 2002, its inhabitants only consumed an estimated 16% of the bushmeat (Starkey, 2004). The recent urbanisation of Gabon is likely therefore to have influenced the overall consumption of bushmeat in the recent past. Starkey (2004) found that, assuming that the per capita consumption of bushmeat in rural and urban areas was the same in 1993 as it was in 2002, and given the 1993 population size and the number of rural and urban dwellers, the total amount of bushmeat consumed in 1993 would have been 24 – 35,000 tonnes a year. This suggests that despite an increase of 36% in the population of Gabon between 1993 and 2002, the total amount of bushmeat consumed per year would have stayed stable if per capita consumption did not change. However, with the urban population already at 83%, it is unlikely that the rural-urban shift will dampen the effects of further population increases on bushmeat demand quite as much. Schenck et al (2006) predict that at the current growth rate, demand for bushmeat is likely to double in the next 25 – 35 years.

2.1.6.2. Urban demand and rural supply

Studies into the urban consumption of bushmeat in Gabon suggest that in Gabon the preference for bushmeat in urban centres is weak, and that education programmes and elevated prices may have a big effect on reducing urban bushmeat consumption. A study by Wilkie et al (in press), using market and consumption data from across Gabon suggests that bushmeat may be an elastic good, with the consumption of bushmeat declining with increases in its absolute price and price relative to substitutes. When presented with alternative type of protein during a taste test (Schenck, 2006), urban consumers in Gabon did not show a strong preference for bushmeat. During interviews with consumers in Libreville, Starkey (2004) found that reasons for eating bushmeat included a preference for the taste, familiarity with the meat and nostalgia for village cuisine, and the perception that bushmeat was more full of 'vitamins', and so healthier than frozen meat. Those who didn't eat bushmeat said that this was due to the high prices, the unhygienic way that the meat was transported and sold, and diseases associated with the meat. Younger participants, who had grown up in the city, were also reported to avoid eating bushmeat.

Despite these promising signs, currently there is a thriving bushmeat trade in Gabon, and household surveys in Libreville have shown that traded meat is being brought into Libreville from across the country, even arriving from neighbouring Congo (Figure 2. 8).

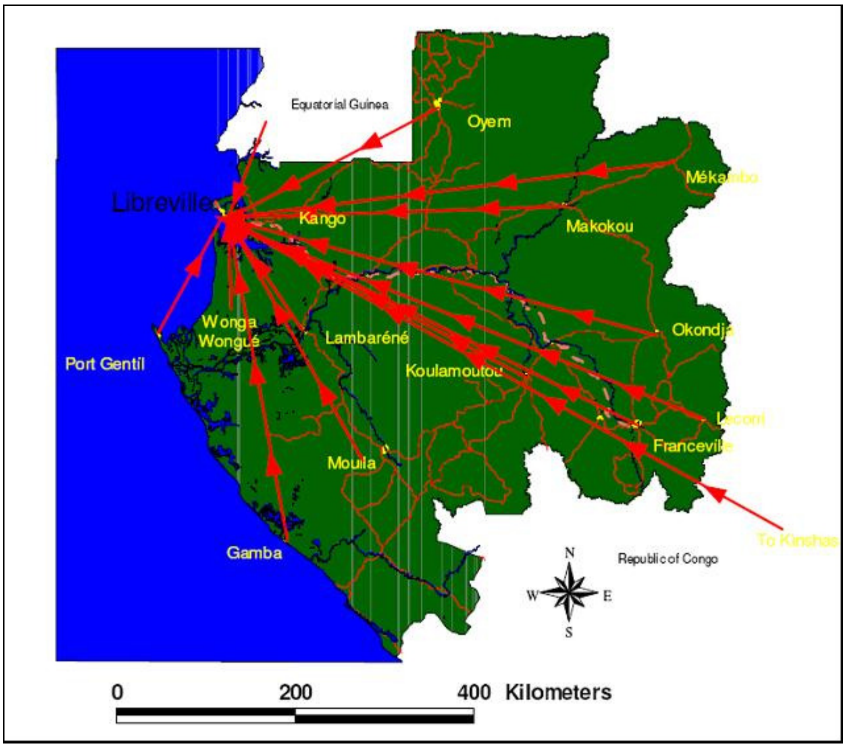


Figure 2. 8: The origin of bushmeat consumed in Libreville that was did not pass through formal markets. Figure reproduced from Starkey, 2004.

There is much less information on role of hunting in rural communities in Gabon, with only two detailed village studies to date. (Lahm, 1993; Starkey, 2004). Both these studies suggest that the trade in bushmeat in rural areas provides an important source of income for village households (Lahm, 1993) used ecological surveys and hunter interviews to look at the impacts of village hunting on prey populations, and investigate the role of hunting in rural communities, and found that 73% of households gained some of their income through bushmeat. Starkey (2004) then investigated the role of hunting for consumption and income at the level of the household in more detail, using quantitative recall surveys of the use of forest products, for 92 households in 6 villages in the Ogooue-Lolo province between September 2001 and May 2002. He found that 58% of the animals captured were sold, and that hunting contributed between 15% and 72% of total household incomes, with the percentage of incomes provided through hunting increasing with the remoteness of the village. Starkey (2004) also collected data on the hunting techniques used, species captured, and which animals were eaten and sold, during these recall surveys, and his results will be discussed in more detail where pertinent to the results of this study.

2.1.6.3. Ecological impacts of hunting in Gabon

A number of studies carried out in Gabon have shown that, as for much of Central Africa, hunting pressure is locally reducing prey populations, especially larger-bodied species and primate populations (Lahm, 1993; Laurance, 2006). From here, the next step is to quantify the effect of hunting in Gabon's landscape. This has been initiated by Walsh et al (2003) who have used data on the abundance of gorillas under different levels of hunting pressure/distance from human populations centres, and the geographical distribution of hunting pressure in Gabon (using a proxy of population size), to produce a landscape model of the effect of hunting and Ebola on gorilla populations in Gabon. By performing a landscape assessment they were able to estimate that there has been a 50% decline of Gabon's gorilla population. It is possible that in the case of Gabon, the *regroupement* of villages, and the low population densities may mean that in large areas of the country prey populations are currently in good shape, even if there is intense local depletion of prey species in hunted areas. However, without data on the distribution of hunting pressure in Gabon this is only speculation.

2.1.6.4. Hunting regulations in Gabon

The current hunting laws in Gabon have been in place since 1956 but were recently updated in 2004 (and are summarised by Christy, 2006). Under these laws, all cable snare hunting, net hunting and dog hunting is illegal, whether for subsistence village use or not. The only legal forms of hunting are 'traditional' village hunting techniques (snares using raffia instead of cable, and bows, spears and pitfall traps), and gun hunting, which is only legal under certain conditions. It requires three permits: a permit to own a gun (which must be a basic shotgun, not an elephant gun), insurance for the gun, and a hunting permit. Gun hunting at night is illegal, and there is also a closed season, from the 1st September until the 1st March (most of the wet season), in which no gun hunting is allowed. All forms of hunting must be carried out within the village territory. This is not clearly defined in the hunting regulations, but in forestry regulations a village territory is defined as the areas within a 5km radius of the village.

No hunting of protected species is allowed and there is a limit to the number of partially protected species that can be hunted per hunter (there are 58 protected species and 18 partially protected; see Appendix A1). For unprotected species there is a bag limit of no more than 9 animals per week, and no more than 3 individuals of the same species per trip. For all species only male animals can be hunted. In addition to this, in response to an Ebola outbreak in the North of the country in 2002, the Ministry of Health banned the consumption, transport and trade of all primates in the country. All sales of bushmeat outside of the village are illegal unless a special permit has been awarded, however, sales of bushmeat within the village that the hunter comes from are allowed, as is the transport of meat for personal consumption.

Penalties for breaking these laws include prison time and fines. For hunters found selling bushmeat, using illegal hunting techniques, or hunting outside their village territory fines can be from 10,000 to 1,000,000 CFA (20 to 200 US dollars), with from 5 days to 3 months in jail, depending on the offence. Penalties are much stricter for hunting in protected areas, and hunting protected species, with fines of 100,000 to 10,000,000 CFA (200 to 20,000 US dollars) and 3 to 6 months in jail.

These are very strict hunting regulations, and when first produced they borrowed heavily from French hunting legislation, and therefore are not very well suited for purpose (Pers. comm. Olivier Hymas, bushmeat coordinator WCS). Although penalties are strict, there is very little enforcement. The Department of Wildlife and Hunting is part of the Ministry of Forestry and the Environment, and the *Eaux et Forets* (water and forests) agents who are employed to make sure that logging companies are acting within the law, are also responsible for hunting law enforcement. In 1999 in the Ogooue-Lolo province (the site of this study) there were 10 agents, with only 4 vehicles, patrolling an area of 25,200 km^2, which is close to the size of Equatorial Guinea (GFW, 2000). During the 15-month village study carried out by Starkey (2004) in this region, there were no arrests or penalties, although all hunters were obviously breaking the law.

2.1.6.5. Current proposals for controlling the bushmeat trade in Gabon

Currently the enforcement of hunting regulations focuses on the trade of wildlife in the larger urban markets. This is mainly because of the bottleneck that markets provide; a few *Eaux et Foret* agents policing an urban market are able to cover more of the commercial trade than they are at the village level, with over 2400 villages in Gabon. Targeting the commercial urban trade also means that subsistence use of bushmeat in rural villages is less likely to be affected (see Chapter 4 for further discussion). In order to reduce to consumption of bushmeat in urban areas the demand for bushmeat needs to be decreased and the demand for substitutes increased. A number of strategies to achieve both of these are currently in use in Gabon:

Increasing the price of bushmeat, through enforcement

Market studies carried out by WCS (Wilkie et al, in press) suggest that a 25% increase in the price of bushmeat would result in a 20% drop in consumption, due to the price elasticity of bushmeat. Increases in the price of bushmeat can be achieved by restricting supply, and by increasing costs for the vendors, through fines and taxation. Currently the *Eaux et Foret* agents in Libreville and other market towns enforce the bushmeat trade laws at the level of the market, where there is perceived to be a bottleneck in the trade. However, currently the number of agents and the number of market raids are so few and far between that they have little impact. Another problem with enforcement at the market level is that in Gabon up to an estimated 95% of bushmeat is consumed outside formal markets, travelling directly from hunter to consumer, with a large amount of trade carried out by individual vendors or hunters (Steel, 1993). Enforcement at the market level can increase this individual trading. Indeed, after a crackdown on bushmeat trading in the Koulamoutou market, the trade was simply forced underground, and was sold from freezers in the back rooms of many stores (pers obs).

Much of the meat destined for Libreville (for the formal *and* informal markets) is transported on the Trans Gabonaise railway. CITRAG, the company in charge of the railway, has agreed this year to police this route and remove any bushmeat found on the trains. Under new laws any bushmeat found must then be burnt to prevent it from reaching the markets through a more circuitous route (pers. comm. Hymas, 2007).

Similar policing has been suggested for the main *route economique* running through Gabon from Franceville to Libreville (Abernethy, pers. comm.).

Livestock and bushmeat rearing

Increasing the supply of substitutes for bushmeat is a harder task. Gabon already imports a great deal of frozen meats, and these are already often cheaper than bushmeat in urban markets. The charity Veterinares Sans Frontiers has set up two bushmeat rearing projects in Franceville, one with cane rats and one with porcupines (Jori et al, 1995, Jori et al, 1998), in order to supply two preferred bushmeat species in a sustainable manner. These programmes are showing signs of promise, but are experiencing the price and production problems outlined in Section 1.7.2. The scale of the programme is not large enough as yet to have any impact on the wild trade.

Working with logging companies

WWF have been working with the *Compangnie Equatorial du Bois* (CEB) since 2000, to provide and implement a strategy to prevent bushmeat hunting in the concession. Up and running strategies include the blocking of old logging roads with barriers, and manned barriers on active roads, with permits required for access into the concession. Workers are banned from hunting, and to provide alternative sources of protein, CEB has a livestock and fish-farming programme (pers comm., Phillipe Jeanmart, WWF).

Education

Biodiversity education programmes are currently being run by WCS, WWF and ECOFAC, in local schools around the national parks, with the premise that children who grow up with positive attitudes towards the forest will be more likely to want to preserve it when they become adults. WCS also help to teach university students in Libreville and Franceville in biodiversity monitoring techniques, and give lectures at the university on the bushmeat trade.

Monitoring

WCS have been monitoring 6 of the larger markets in Gabon (including the Oloumi market in Libreville) since 2000, as a tool to track the urban trade and measure the effects of different policies to reduce urban consumption. Monitoring of wildlife populations and hunting sign in and around 9 of the 13 National Parks has been going on since 2003. This will enable the impact of hunting from surrounding villages on the prey population within the parks to be quantified, and will be used to track changes in hunting intensity and prey densities over time. These monitoring programmes are still in their infancy, and analysis of preliminary results is imminent.

Implementing new bushmeat policy in Gabon

Environmental policy in Gabon is moving at a fast pace since the creation of the National Parks. In 2002 the FAO organised a government and NGO meeting at Lope National park to brainstorm changes to the current bushmeat policy. Some of the changes have been implemented in the new hunting laws (Christy, 2006) and have led to the new enforcement policies on the railway. In 2007 a follow-up meeting was held in Libreville, moving towards the implementation of a National Strategy for hunting, to be implemented through a new department (*Bureau National de coordination de la mise en oeuvre de la stratégie et des plans d'action sur la faune sauvage (BNCMO/SPA-FS))* within the Department of Wildlife and Hunting.

2.2. Study site villages

2.2.1. Choosing a study site

In order to provide the level of detail required for an in-depth analysis of the bushmeat trade at the village level, a case-study approach was used. The two villages chosen for this study were Dibouka and Kouagna, approximately 40km (or 2 hours drive) southwest of the town of Koulamoutou (and the nearest market) in the Ogooue-Lolo province, central Gabon (Figure 2. 9). Malcolm Starkey, who collected data on household incomes from 2000 – 2002, was also based in these villages. Using the same village to collect detailed hunting information means that the data from these two studies, being collected only 1 year apart, can be combined to produce detailed information on most elements of village livelihoods, which is generally not possible during one study, due to time and resource constraints, and responder-fatigue if too many questions are asked simultaneously. There were also advantages to working in a village which had already experienced having been part of a research project, as trust between the researcher had been built, which provided an easy starting point for this study. Unlike most of the previous studies on hunting, Dibouka and Kouagna are not close to any protected area, being 75 km and 45km as the crow flies (no road access) from the borders of Lope and Biroughou national parks (which may act as source populations of prey), and so provide a more representative case study.

2.2.2. Dibouka and Kouagna villages

Dibouka and Kouagna villages lie on the N4 road, which is one of the main roads in Gabon, and one of the oldest, having been opened in the 1950's (Pourtier, 1989). Older members of the village remember being forced to build the road under French rule (pers. comm. Chief of Kouagna). Cars travel from Koulamoutou to Libreville via Dibouka and Kouagna when the *Route Economique* is closed, and it is not unusual to see 3 – 5 cars passing through the village each day.

Dibouka (Figure 2. 10a) is a relatively large village for Gabon, with 301 permanent residents and 45 households; Kouagna (Figure 2. 10b) is smaller with 131 residents and 30 households. As with many rural villages in developing countries, the age structure

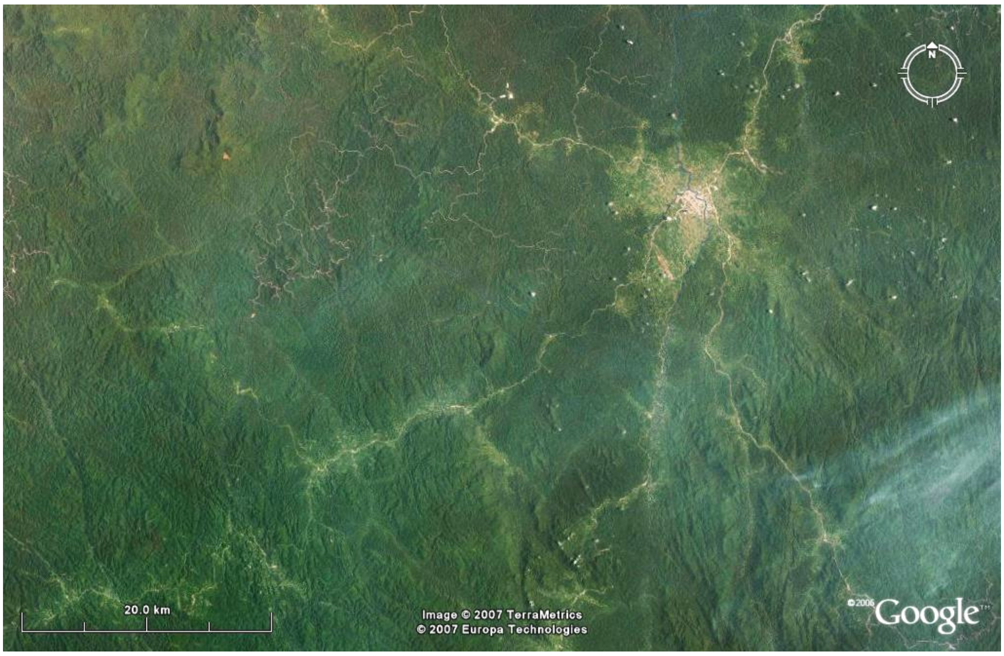


Figure 2. 9: The location of the two study villages, Dibouka and Kouagna, with (a.) an outline map of Gabon, showing the main roads (blue) and towns (red), and the study site in yellow (produced using shapefiles provided by WCS Gabon, and (b.) a satellite map showing the positions of the study villages, and other surrounding villages on the same road, and Koulamoutou, the nearest town and market (reproduced from Goggle Earth, 2007).

Figure 2. 10: The two study villages of (a.) Dibouka and (b.) Kouagna, Ogooue-Lolo province, Gabon
Photos by Lauren Coad

in Dibouka and Kouagna is biased towards the under 20's (Figure 2. 11). Due to the low number of households between the two villages (75 in total), there was no need for sampling, and all households and individuals that were willing to cooperate were included in surveys during the study.

The majority (91%) of residents during the study period were of Pouvi ethnicity (as are most villages from Koulamoutou to Mouila-Pouvi), with a few Massonga, Ndzebi and Pounou (Gabonese ethnic groups), and one Congolese, who have mainly come to live in the villages through marriage. The Pouvi (also known as 'Bapove') are a small ethnic group, with their own language, only existing in the Ogooue-Lolo province, and comprising 5000 people. French and Pouvi were both spoken in everyday use, but the older members of the village (over 70) often only spoke Pouvi.

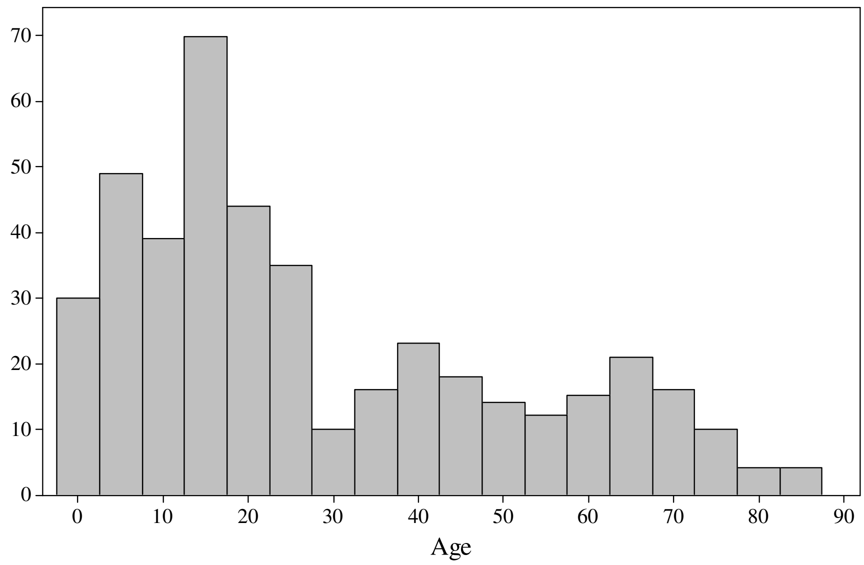


Figure 2. 11: Histogram showing demography of Dibouka and Kouagna (combined). Data taken from this study: see section 3.4.2.1, Chapter 3.

Dibouka and Kouagna are not quite distinct villages, as they are perceived to be part of the same *regroupement*. Kouagna has its own village chief, but the chief of Dibouka is also the chief of the two-village *regroupement*. Each separate village has its own forest territory, and residents describe themselves as either from Dibouka or Kouagna, not from the *regroupement*, but there is a shared history, and migration of residents between the two villages is common. The closeness of the two villages is reflected in the friendly behaviour between residents, whereas relations with the neighbouring village of Mouila Pouvi are frosty, and sometimes end in fistfights. Each village is divided into *quartiers*, which represent the old villages and clans that were brought in from the forest to form the *regroupement* along the road, but the importance of the *quartiers* has been diminishing over time, and will be discussed in chapter six.

Houses are predominantly made of mud or wood, with corrugated iron roofs. Before the regroupement houses were built using lianas, sapling trees and *marantacaea* leaves, but this type of house is now only used in hunting camps. Both villages own deep-water pumps, and Dibouka has a dispensary; a nurse is employed in the village by the government, however he has no supplies. Originally the dispensary had a solar-powered fridge to keep medicines in, but this broke at least 4 years previous to my arrival, and has not been fixed. Similarly both villages have a generator, but the generator in Dibouka was broken throughout the study period. The generator in Kouagna was working, but diesel is too expensive, and so there were only a handful of nights during the two years that I was there when it was run; these were ceremony nights or public holidays, when the village grouped together to buy diesel. Dibouka boasts a large school, which is used by the surrounding three villages, employs three teachers, and teaches up to secondary level, when those children who's families can afford it go to live in Koulamoutou to continue their education. Dibouka also has a cement-built market in the middle of the village, where the community can sell agricultural produce.

Both Dibouka and Kouagna had small shops (one in Kouagna and two in Dibouka), which doubled up as bars, selling basic goods such as tinned fish, pasta, rice, drinks, tobacco, some vegetables and some clothing; a full list of stocked goods can be found in Appendix A2.9. Individual households also sold a small amount of produce, such as beer, tomato paste and tinned fish (imported from France).

Agriculture is the main livelihood activity in both villages; Starkey (2004) reported that 75% of household incomes in Dibouka and Kouagna came from agriculture. Each women of working age owns 2 – 3 plantations (illustrated in Figure 2. 12), and the main crops grown were Manioc (cassava), tarot (another type of tuber), sweet potato, peanuts, cane sugar and plantain, all of which were sold to traders from Koulamoutou, Franceville and Libreville, as well as making up an important part of the local diet.

Livestock, in the form of chickens, goats and sheep, were kept by most households, but are used as savings, rather than a form of protein. Fishing was rare, as the river had been polluted 2 years earlier by some local boys who tried to increase their catch by putting a potent herbicide into the main river. The river has yet to recover. Livestock and fishing are discussed further in Chapter 4.

Another 15% of household incomes came from hunting, and only 10% of incomes came from other livelihood activities. Although the *'Société du bois Lastoursville'* (SBL) owns logging permits for the forest surrounding Dibouka and Kouagna, they have not yet started to exploit the area, and so provide no local employment. A cocoa plantation just outside Ndjole used to employ a large proportion of the men in both villages, until it closed in 1997. Employment opportunities in the two villages will be researched in detail in Chapter 3.

Figure 2. 12: An example of a village plantation. This plantation is less than a year old, with evidence of the burning used to clear it. Young tarot, cane sugar and plantain plants are visible. Photo by Lauren Coad

There are two modern religions in the village: Catholicism and Bahai, and Dibouka has both a church and a Bahai temple (both mud and corrugated iron construction). However, these new religions rest, sometimes uncomfortably, alongside older traditional practices, including *bwiti and nzergho*. *Bwiti,* the major traditional belief system in Gabon, and very much alive; during my time in the village I was able to observe the public aspects of the *ceremonie du diable,* which is the *mwiri* coming of age ceremony for a young Pouvi boy, before he can be initiated into the *bwiti* (Figure 2. 13). The vast majority of men in Dibouka and Kouagna carried the circular brand given to them during this initiation. The *nzergho* (the Pouvi word for leopard) society is made up of the powerful, usually older men in the village. On several occasions during my stay the women in the village had to stay inside during the night with their windows and doors locked, while these men drove the leopard spirits out of the village. The leopard is one of the totem animals for the Pouvi (the only other I heard of being the African grey parrot), and if one is hunted accidentally a ceremony must be performed by the *nzergho.*

Figure 2. 13: Part of a *mwiri* ceremony in Dibouka, 2004. The young men shown will go through a three-week initiation, during which they will branded, which singles them out an initiated Pouvi man. Photo by Lauren Coad

2.2.3. Hunting strategies in Dibouka and Kouagna

Four type of hunting strategies existed in Dibouka and Kouagna: trap, gun dog and net hunting. Most hunting in these villages is either trap or gun hunting, with a very few hunters practising net and dog hunting.

2.2.3.1. Trapping

Trapping was the dominant form of hunting in the two villages. Traps were generally constructed using sapling trees and cable, which was introduced in the 1940's by the French and replaced the traditional raffia ropes. Two types of trap predominated: *tsonde* neck traps and *toule* foot traps (Figure 2. 14). *Toule* traps are laid on established animal paths, are capable of catching a wide range of species, and their mechanism is explained in Figure 2. 15. *Tsonde* neck traps have a similar mechanism (Figure 2. 16), but target smaller animals. Neck traps are generally laid in groups, at intervals along a *barrage* – a wall made of palm leaves. This is laid perpendicular to an animal path, or paths, with the only gaps in the wall filled with traps.

Young boys also laid two types of traps for birds; a cage-trap, called *rghbolie*, made from sticks and baited with banana, and glue traps (*bulembo*) using tree resin. However, these were seldom checked, and only caught very small birds. Because it was a very infrequent activity of young children, and very hard to monitor, the catches of these traps have not been included in this study. Historically, the types of trap that were used in the past were also more diverse. They included pitfall traps *(*named *ébé* in Pouvi*)*, traps that used suspended logs to crush animals (*rghenyenga)*, and overhead traps running between trees for monkeys and civets *(ngambi)*, and a selection are illustrated and described in Figure 2. 17.

Hunters laid their traps along private paths, generally leading from one of the principal village paths, with traps distributed close enough to one another that they could all be visited in one trip. Hunters would then visit these trapping areas a couple of times each week, to check for catches, and would also take the opportunity to add more traps, or remove old traps. The number of traps that each hunter owned varied widely and trapping distributions and strategies will be described in detail in Chapters 6 and 7.

Figure 2. 14: Foot (*Toule)* and Neck (*Tsonde)* traps. Photos by Lauren Coad

a. A dormant foot trap, and a porcupine caught in a foot trap. Foot traps are quite cryptic, and are capable of catching a wide range of species.
b. A dormant neck trap, and a cane rat caught in a neck trap. Palm leaves are used to produce a *barrage*, or wall, along an area of thick vegetation. Animals travelling across the line of the wall are forced to find a gap in the wall in order to cross it, and hunters provide gaps in the wall, which is where the trap is placed.

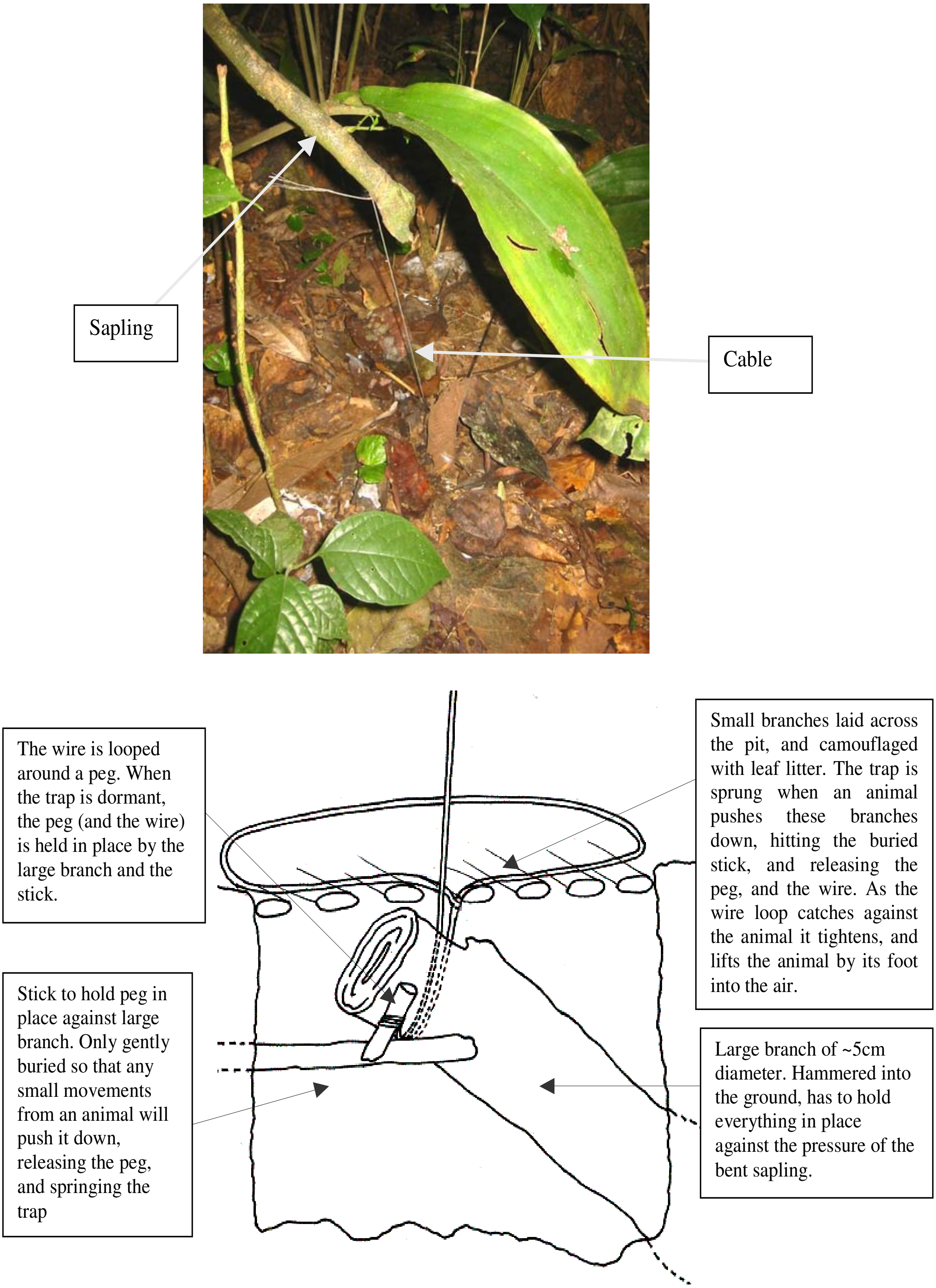


Figure 2. 15: The mechanics of a foot trap. Photo and drawing: Lauren Coad

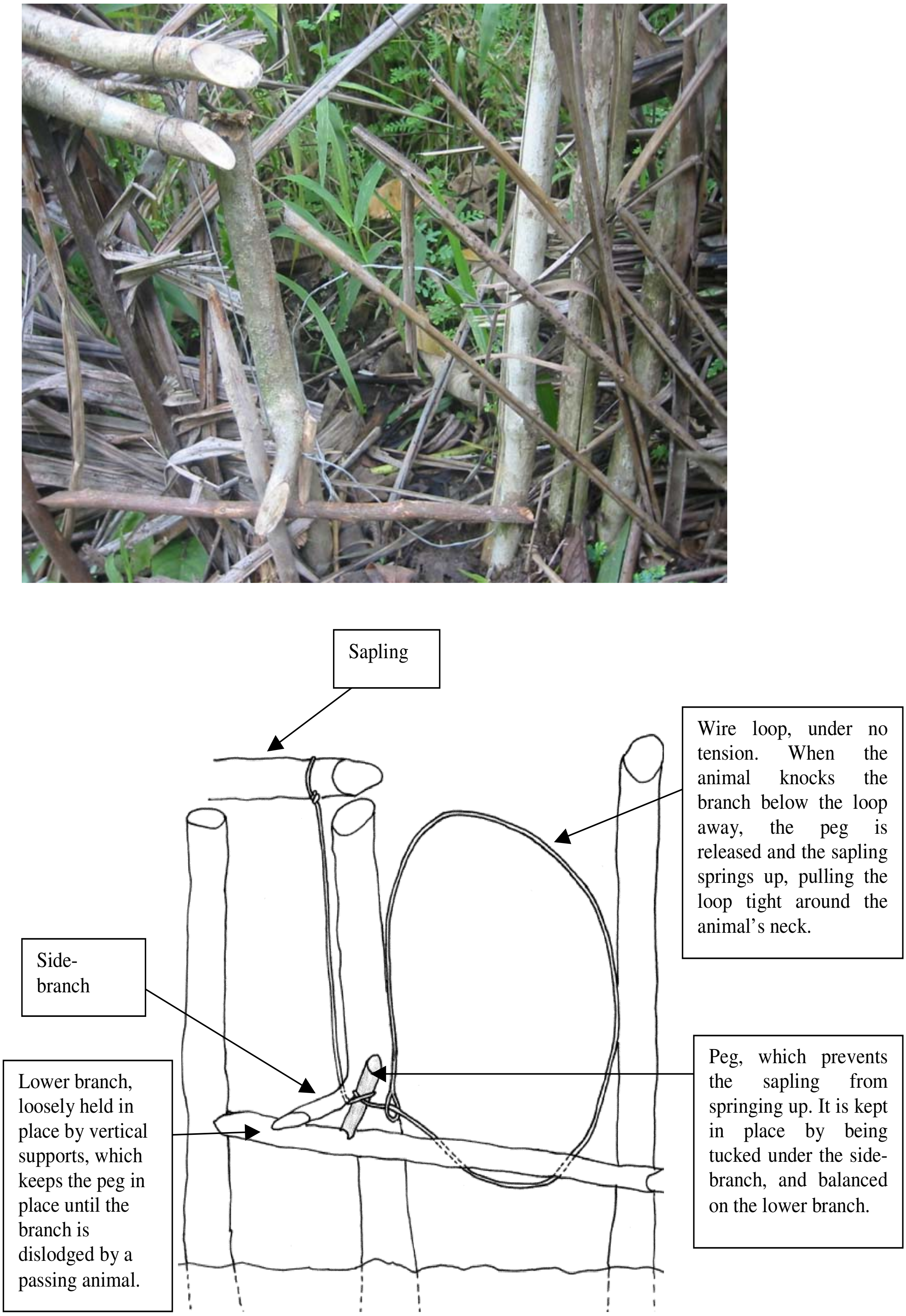


Figure 2. 16: The mechanics of a neck trap. Photo and drawing: Lauren Coad

Clockwise from top left:

a: Pitfall traps (*ébé*). Used in the past before wire snares were introduced. They were still used after the regroupement, but stopped being used around the 1940's – 60's. Approx 4 foot deep, were disguised with a layer of sticks and leaf litter, and were often used to catch duikers and red river hog. Now prove a hazard to gun hunters at night.

b. The modern equivalent of pitfall traps. Shallow pits with a board of wood with exposed nails. Use to deter human and elephant plantation raiders.

c. Glue traps (*bulembo*). A type of tree resin is used as glue, and spread over sticks, which are laid on the forest floor next to bait (often banana). Birds then become stuck while foraging. Used by young children, and often for play rather than food.

d. Overhead *ngambi* traps. Used to catch civets and small monkeys. Two bamboo poles span two trees across a human path, providing an overhead route across the path. A trap similar to a neck trap is positioned in the middle of this overhead route. The trap in the photograph was the only trap in the two villages of this type seen during the study.

Figure 2. 17: Traps used infrequently in Kouagna and Dibouka. Photos by Lauren Coad

2.2.3.2. Gun hunting

Gun hunting was overwhelmingly a night activity. Older hunters told me that in the past they hunted by day, and it was the reduction in prey that had forced them to now hunt at night. Hunters leave the village in the early evening, to walk out from the village to their hunting area, or hunting camp. They then walk at a slow pace, keeping as quiet as possible, and using a powerful head torch to scan for prey. I was not allowed to accompany the hunters on a gun hunting trip because I was a white woman and the hunters were afraid that I might get hurt. However, Starkey (2004) accompanied several gun hunters during his fieldwork in the same villages, and reported that once an animal has been found, the skill in hunting was to keep the torch beam steady on the animal, while raising the gun to shoot. Prey were usually detected at close range (10 – 15m). Gun hunting during the day generally occurred as part of another activity; for instance when hunters went to check their traps they would often bring a gun with them, just in case an animal was spotted. Infrequently the older hunters would go monkey hunting early in the morning, when monkeys were more likely to be found in the trees surrounding the village, and by the larger rivers.

Hunters used a single barrel 12 gauge shotgun, with 00 cartridges, which were often collected and refilled. Thirty-three guns were owned in the two villages, and this high number was probably due to the wages from the cocoa plantation in Ndjole during the 1990's. Many of the old hunters reported an increase in hunting after this plantation shut, partly due to gun purchases from the wages, and partly due to the increase in unemployed men in the villages. Although not every hunter owned a gun, most hunters were able to borrow a gun from a friend or family member in exchange for some of the catch, and so ownership did not necessarily limit hunting.

These guns were capable of killing prey up to the size of a red river hog, but buffalo and elephants required a *chevrotain* rifle, and nobody in either village owned one. When there are crop-raiding problems due to elephants, villagers can appeal to the *Eaux et Foret*, who will, if deemed necessary, send a trained hunter with a *chevrotain* rifle.

2.2.3.3. Dog hunting

Dogs were used during gun hunts during the day, to flush out prey. Dogs were also trained by young hunters, who had not yet learnt how to use a gun, to fetch and retrieve medium-sized game such as cane rats, porcupines and blue duikers.

2.2.3.4. Net hunting

Net hunting occurred very infrequently, and was only performed by the very oldest hunters, as it was a traditional technique used in the old villages before the regroupement and the introduction of cable and guns. Net hunting generally took 2 – 3 days, and sometimes up to 1 week. Hunters would travel to the known location of a porcupine den, and would then encircle the den with nets (generally made from raffia), and flush out porcupines into the nets using fire and/or dogs. Afterwards, hunters either returned to the village, or smoked the catch over a fire to preserve it and moved onto the next den. Net hunting could only be carried out during the dry season, because rain quickly rots the nets. Interestingly, the older hunters told me that they always left some porcupines in the den, and then left it alone for the rest of the dry season, so that the den would have a chance to recover after the harvest.

2.2.3.5. Hunting camps

Hunting camps were used by some of the more active hunters, to allow them to set their traps further into the forest. They were generally a days walk from the village, and were often on the site of old villages, due to the fruit trees found in these sites. Camps were also constructed in the style of old villages, with houses made from saplings and palm and *maratacaea* leaves (Figure 2. 18), rather than wood and corrugated iron. Hunters would bring with them supplies of rice and tobacco, and would then stay in the camp for 2 – 7 days, eating some of their catch and often smoking the rest to preserve it. One hunter based himself in a hunting camp, and would come back to the village with for short visits, to sell smoked bushmeat and re-stock. While in the camp, hunters often checked their traps during the day, and then went gun hunting at night, to capitalize on their time there.

Figure 2. 18: A hunting camp, used regularly by the hunters of Kouagna. Photo by Lauren Coad

Chapter 3:

General Methods

Chapter 3

3.1 Overview of data collected

In Chapter 1, the research questions posed by this thesis were outlined. To address these questions, data was collected from two villages, from September 2003 to March 2005, providing information on:

1. The socio-economic characteristics of the village households and individual community members, including hunters.
2. The livelihood options and activities for men in the village.
3. The hunting effort, hunting methods and characteristics, and offtakes of village hunters, followed over the course of a year.
4. The characteristics of the offtake, including its fate (eaten, sold etc), destination (village, town), and the profits made by hunters.
5. The use of hunting incomes.
6. The past and present hunting practices, and the perceptions of hunters as to the changes in hunting practices and prey availability, over time.

In this general methods section I have provided an introduction to the general field set-up, and have then outlined the main data collection methods. The subsequent use and analysis of this data to answer specific research questions is explained in each data chapter.

3.2 Community participation

Community participation in this project was very important. In order to become accepted by the community, and so that we could learn about each other, I spent the first three months in Gabon (July 2003 – September 2003) in Koulamoutou and Dibouka, learning about the culture, improving my language skills, and being shown the forest and hunting techniques by my first field assistant, Mbombe Wilson. I also spent time helping the women in the plantations, to get to know people and show them that I wasn't just going to observe from a distance. The community were from the start incredibly welcoming, and treated me with immense kindness.

When we began the study, in September 2003, we began by holding a large community meeting, where I introduced myself, and the project, with the help of Mbombe Wilson, who translated it all into Pouvi. We then had a question and answer session, and made sure that everyone was happy with the project before proceeding. Another two of these general meetings were held during the study, partly to keep people updated and iron out any problems, and partly to provide a small thank you with an evening of drinks.

Generally, hunters and the community as a whole were happy to be involved in the study (partly through kindness, and partly because they found a white woman in the forest amusing!). Some of the older hunters (age 70 – 80) were uncertain about the project, mainly because I was a 'moutanganye' (white/stranger) and they were old enough to remember French occupation. Fortunately they often had children or grandchildren who were happy to show me their traps. Ultimately, only four of the total 86 potential hunters were not happy to work with us, and the reason given was generally that animals would be frightened away during the hunter follows and work with the traps. This was not a complaint voiced by any of the other hunters cooperating with the study, and it is more likely that they just did not trust me. For three of these four hunters, several follows were carried out before they decided not to be part of the project. Using this information, and through discussions with my field assistants, I estimate that the traps belonging to the four hunters represented approximately 4 to 5% of the total number of traps laid during the study.

As described in Section 2.1.6.4, Chapter 2, trapping is illegal in Gabon, gun hunting requires permits (which hardly anyone owned in Dibouka and Kouagna) and 40% of the species present in the forest around the villages are protected and partially protected species. However, I am confident that hunters did not withhold information on the species that they caught, or the methods of capture, for three reasons:

1. Hunters were actually excited to show me new species, often coming to my house to tell me if something big or interesting had been caught. During the study I registered the capture of a number of protected species.
2. Another researcher, Malcolm Starkey, had recorded bushmeat captures a year beforehand, and no penalties had arisen from their cooperation. A trust had therefore been built before my arrival.
3. I was observed to be on 'their team', after being picked up by the Gabonese authorities which control bushmeat hunting and taken into town for not filling in my own permits to work in the village, which gained me some very useful street cred!

To thank hunters for their time, they were bought a drink, or something small from the local shop, at the end of a hunter follow, but money was never given for participation. These gifts were small enough that they are highly unlikely to have influenced hunting activity.

3.3 Field assistants

Three men were employed in each village. Because the majority of men in these villages were involved in hunting to some extent, the employment of village men will have reduced the number of hunters active in the village. This could not be avoided, as the community would have distrusted men from outside the village. Each assistant was paid a monthly wage equivalent to that of an agricultural worker in the village, and all assistants were involved in all aspects of fieldwork. Each day a field assistant was based in the village to collect data on the hunting trips, and any animals that were brought back, and the remaining two were employed to carry out hunter follows (which was always done with a minimum of two people due to the amount of data that had to be collected), or when there were no hunters to accompany, household and hunter interviews.

In August/September 2003, field assistants were trained in socio-economic semi-structured interview techniques, use of GPS units, and the data collection techniques required for hunter follows. This was achieved using a number of 'dummy runs' in a neighbouring village, Mouila Pouvi, with a hunter and his family who were willing to take part. At the beginning of the study, I accompanied the two village teams on their first hunter follows and household interviews, to iron out any problems. The definitions for the different categories of hill, river, forest and understorey density were explained and standardised during these first trips, and each time that I went on a hunter follow with each team, we made sure that everyone was still assigning the same categories.

At the beginning of the project, a third village team was employed in the neighbouring village of Mouila Pouvi. However, three villages meant that my time was too thinly spread between the villages. Three months into the study, in December 2003, I decided to focus on the two villages of Kouagna and Dibouka, when I found that the two field assistants in Mouila-Pouvi had been fabricating data, visiting only their own traps and the traps of friends on order to benefit from hunting profits at the same time as receiving a salary. These field assistants were fired and a strict system of data checking was put in place:

1. Monthly checking: Field assistants were paid every month. They were only paid after I had been given all the work for the month, and had checked through it for inconsistencies. GPS work also doubled as a monitoring device, as I checked the tracklogs for each hunter follow (Section 3.4.3.1), which proved that they had been in the correct hunting area, especially once there was enough data to compare subsequent follows.
2. Weekly meetings: every week or fortnight, the six field assistants would meet at my house to discuss the project, including the merits and problems of different fieldwork approaches, and decide on changes or additions to the methods. Through this the field assistants gained some ownership of the project; being involved as a team made the assistants much more proud of their work, and I found that their input was hugely beneficial.
3. Hunter follows: I was able to accompany field assistants on approximately 30% of hunter follows. This allowed me to check that previous data collection had been done precisely. After a few months I also brought the datasheets from previous follows with the same hunter, to check that the characteristics of each trap had been noted down properly. While some field assistants produced

fewer errors than others, there were never any important problems with data collection once monitoring was in place.

In the dry season field assistants were put under pressure to help with the plantation clearing by their families. In this case however, they came to me to ask for extra time off, rather than cutting corners with data collection. We added an extra day off during these months, and there was no reduction in the quality of the data.

3.4 Quantitative data collection

3.4.1 Socio-economic household characteristics

3.4.1.1 Household census

A preliminary household census was completed in the first two weeks of fieldwork (September 2003), in order to establish the community structure and the number of hunters in each village. The data collected for each individual is outlined in Table 3. 1, and data collection sheets can be found in Appendix A2.1.

Census data collected	Description
Age	Over the age of 70, many people did not know their age. In this case it was estimated to the nearest 5 years.
Gender	
Place of Birth	Village or town
Ethnicity	Gabonese tribe, or country of origin
Relation to household head	
Job 1 – 4	Interviewees were asked their principal job, followed by their secondary etc.
Education	Level of education reached, or presently engaged in
Hunting activity	Whether the interviewee participated in trap, gun, dog or net hunting

Table 3. 1: Census information collected for each individual in each village

The census was then updated in June 2004, to make sure those individuals who had been travelling in September, but usually present in the village had not been missed. There was quite a lot of movement in and out of the village by younger men and women attending secondary school or sometimes further education in Koulamoutou and Libreville; these were recorded as temporary residents.

3.4.1.2 Measures of household wealth: Asset-based measures

Two months after the preliminary census, in November 2003, structured household interviews were carried out to assess the comparative wealth of each household, using an asset-based approach (as discussed by Morris et al, 2000). A household representative (generally the head woman) was asked about the ownership of 21 different household items, listed in Table 3. 2, including the number owned and their individual price. The items asked about were the same list of items used by Starkey (2004) to allow comparison between the two studies, and were chosen to cover a wide range of goods, from cheaper, more subsistence goods such as cooking pots and chickens, to more luxury items such as refrigerators and sound systems.

Item	Mean value (CFA) (Equivalent $)	Minimum value	Maximum value
Torch	1972 *(3.9)*	1000	2800
Chicken	2509 *(5.0)*	2500	3000
Machete	3175 *(6.4)*	700	6000
Axe	5679 *(11.4)*	1000	12000
Cooking pot	6022 *(12.0)*	1500	30000
Oil lamp	7526 *(15.1)*	1000	18000
Watch/clock	7628 *(15.3)*	1000	20000
Cane sugar press	11075 *(22.2)*	1000	15000
Gas cooker	16225 *(32.5)*	4500	35000
Electric fan	24938 *(49.9)*	12000	39000
Mattress	25471 *(50.9)*	3000	48000
Wheelbarrow	27200 *(54.4)*	15000	40000
Sheep	37500 *(75.5)*	35000	40000
Goat	43958 *(87.9)*	30000	60000
Mobile phone	47143 *(94.3)*	25000	120000
Television	50667 *(101.3)*	12000	80000
Radio cassette	65845 *(131.7)*	10000	250000
Gun	121917 *(243.8)*	20000	250000
Freezer	155333 *(310.7)*	100000	216000
Chain saw	355200 *(710.4)*	50000	750000
Generator	516300 *(1032.6)*	500000	532600

Table 3. 2: Household items used to produce a measure of household wealth, ordered by mean price

This range was designed so that smaller differences between the poorest households could be distinguished, as well as the larger differences between poor and rich households. As Table 3. 2 shows, for each item there was generally a wide range of values, which could have a big impact on the final score of the household if average values were used for each item. To avoid this problem, the price of each individual item was determined where possible, and average prices for an item assigned only where the actual price could not be determined. As Starkey (2004) found, most households were very willing to provide this information, but even with high participation, 28% of items were not individually valued. The value of all of the items was then summed to provide an overall figure for the household. In total, 62 households of the total 75 participated.

In addition to this proxy of wealth, other indicators were collected at the same time, including the construction of the house, and any individual pensions or incomes coming into the household from the occupants. The household representative was asked the value of presents from family or friends that she had received in an average month, and in the past month, as poorer households can often be highly dependant on aid from their extended family (Masini and Stratigos, 1991; Starkey, 2004). The datasheets used to collect this information can be found in Appendix A2.2

3.4.1.3 Measures of household wealth: Household wealth rankings

To provide an alternative measure of wealth, a Participatory Rural Appraisal (PRA) technique was used, which provides a comparative ranking of the wealth of households, using local people's definitions and indicators of wealth (see Chambers 1992, for a full discussion on the use of PRA). This technique employs a focus group of community members to place each household in their community into a wealth category with the aid of a facilitator. The benefits of this technique is that it uses local knowledge about people's levels of wealth; local people, who live in the same village and can observe their community over long periods of time, are likely to have a better long-term idea of the wealth of a household than other proxies of wealth might be able to provide. Societies also have their own concepts of wealth, which are not only dependent on cash income or possessions (for instance, the earning potential of a household, whether realised or not, their outside connections, such as extended family, or their ability to invest their earnings wisely). Wealth rankings can therefore also shed light on the socio-economic characteristics of a household that are perceived by that society to have important impacts on its wealth.

Four focus groups comprised of six community members (three men and three women), and two facilitators (a local field assistant and myself) completed the ranking exercise in each village. For the purpose of this study the opinion of the general community was required, rather than that of different user groups within the community, and therefore participants of each focus group were chosen to reflect the community as a whole, with men, women, young and old, rich and poor community members all included. However, it was also necessary to choose people who were likely to participate fully in the exercise, and also people who had good knowledge of the village (key informants). Wealth ranking were carried out in November 2004. They were left until towards the end of the study, when I was well acquainted with all members of the community, and so was able to choose the members of each focus group well.

Methods for wealth ranking are flexible; in some situations the definitions and identifiers of wealth are discussed with the participants before the ranking exercise, who then rank the households based on these criteria. I decided not to limit or discuss how the participants measured household wealth, which allowed post-hoc study of the correlations between the wealth ranking and the socio-economic characteristics of the household, including other measures of wealth

As there were not very many households in each village, all households were included in the ranking exercise. Four wealth categories were used for the ranking: very poor, poor, rich and very rich. These wealth categories were chosen by the first focus group, and then used by the next seven groups. The name of each household was written on a piece of card, and the six participants assigned a wealth category to each household in turn (Figure 3. 1); discussion was frequent and encouraged, and if there was a disagreement within the group, the decision went with the majority. Once all households had been placed in a wealth category, each category was re-visited, and the participants asked whether they would like to change the category given to any of the households. This produced the final ranking, which was recorded by the field assistant. As the six members of each focus group all belonged to one of the households within the village, the households represented by the participants were excluded from their group, resulting in some households being ranked three, rather than four times.

80% of households had at least three of the focus groups agreeing on the category to which the household belonged, and a final ranking was produced for each household by taking the median ranking from the four focus groups. A total of 62 households were given a wealth ranking, of the original 67 used in the ranking exercise; five households were not given a wealth ranking, as the focus groups could not agree which category to place them in (2 or more groups disagreeing, and by more than 1 category).

Figure 3. 1: A wealth ranking exercise being carried out in Dibouka. This group is in the process of re-assessing the wealth category that each household has been placed in.

3.4.1.4 Measures of household agricultural returns: Agricultural rankings

Agriculture was the dominant economic activity in the village (Starkey, 2004). Although the focus of this project is hunting activity, it is important to have information on the other main activities of each household, to quantify their impact on hunting activity, and place hunting in the context of other livelihood activities.

Weekly recall surveys to collect detailed data on the agricultural returns and profits of each household were begun in June 2004, but with the hunting recall study continuing consecutively, I found that this meant that too many questions were being asked of each household, and the project was meeting resistance. The recall surveys were therefore dropped, and instead households were ranked by their agricultural profits using the same PRA methods as for the wealth ranking. Four focus groups comprised of six women from the village (not men, as women were the main agricultural producers and so had the most knowledge) were asked to rank households by the amount of money that each household made from their plantations returns, using three categories, as chosen by the first focus group: high, medium and low. This was completed for 69 households. 72% of households had at least 3 of the focus groups agreeing on the ranking. Fourteen households (where answers differed by more than 1 category – i.e. one focus group gave a low' ranking and another gave a 'high' category) were excluded from the analysis, leaving 55 ranked households.

3.4.2 Individual hunting activity and offtakes

3.4.2.1 Hunter follows

A hunter follow involves accompanying a hunter on his hunting trip, recording information on the trip while doing so. In the case of trap hunting, this involves accompanying the hunter during the day, while he checks each trap for possible catches, and on some occasions removes or adds traps. During these follows, information on individual trap positions, characteristics and offtakes can be recorded.

The aim of carrying out hunter follows was to get a complete picture of the hunting behaviour (effort, characteristics, and offtakes) of all of the village hunters over the year. I decided to carry out hunter follows only for the trap hunters, and not the gun hunters, of the village for four reasons:

1. Hunters were reluctant to take me out into the forest with them at night, because I was a white woman and they were afraid of the repercussions if I died. I am also convinced that they would have changed their behaviour during

the gun hunts, possibly travelling further into the forest, or spending less time on the trip, to accommodate me.

2. During early pilot studies, where field assistants took GPS units with them during gun hunts, the GPS signal was quickly lost, due to the speed at which the hunter moved and the dense canopy cover, making a satellite lock difficult. It would have been very hard to get any landscape information using GPS units
3. Gun hunting behaviour has been studied in the past, using hunter follows (Mithen, 1989; Alvard, 1993 and 1995), whereas there is little information on trapping behaviour.
4. Focussing on trap hunting allowed hunters to be followed a number of times over the year, which produced a detailed picture of trap movements and catches over time. If fieldwork effort had been split between gun and trap hunting, a lot of important detail would have been lost.

Despite not following gun hunters, useful information on the duration, rough location and offtakes of all gun hunts (and all forms of hunting) was recorded by the field assistant based in the village.

In total 393 hunter follows were achieved (mean of 5 follows/hunter, range: 1 – 23), for 64 hunters between October 2003 and February 2005. A summary of the number of follows per hunter, together with information on the number of traps and catches for the hunter, can be found in Appendix A3.4. Hunter follows were always carried out by two or more field assistants, due to the quantity of data that was collected. One operated the GPS unit, while the other recorded trap information, using the data collection sheets in Appendix A2.3. When I accompanied the field assistants, we were able to collect added information on the forest type and trap catches, and this is described presently.

The number of follows per hunter was dependant on trapping activity, so that the more active hunters, who added more traps per month, were followed more often than hunters who had a barrage outside the village and were not likely to add traps. This was to make sure that trapping data on the more active hunters was kept up to date. Hunter follows were reduced during the dry season as hunters were more reluctant to be accompanied - they had more work to do in the plantations before the wet season, and wanted to get round their traps quickly.

In order to record information on each trap, and re-identify each trap on each consecutive follow, traps were assigned a number. Trapping territories did not generally overlap between hunters, and so trap numbers for each hunter began at 1. Where there were two hunters or more trapping in the same area, a letter was also assigned for each hunter. Numbers were written on a piece of dark green tape, which was stuck to a tree close to each trap at head height, and also written directly into the tree with black marker pen. Where this was not possible (which was quite often), the tape was stuck to the bough of the trap, at the point furthest from the wire (Figure 3. 2):

Figure 3. 2: Individual trap labelling. This example shows a neck trap, as part of a barrage, which has been labelled with green tape directly on the bough of the trap, indicated with the red arrow.

These marks generally lasted for longer than the traps (on long-lived traps of a year old, numbers were often still visible) and on very few occasions did we need to re-identify the trap through past trap follows because a number was unreadable. On each subsequent follow, any traps that had been laid after the previous follow were labelled, and their characteristics recorded. During the collection of data on hunting returns in the village after a hunting trip, hunters were asked whether they had made any big changes to their traps. If they had then we knew to schedule another trap follow with that hunter. Hunters were very happy to keep me up to date, and often came to my house to tell me that I needed to go on another follow with them.

3.4.2.2 Individual trap characteristics

For each trap, the following information was collected, and the datasheets used to record this information can be found in Appendix A2.3:

Type of trap

Traps were overwhelmingly either neck or foot traps, with only five traps of another type recorded. The children in the village set bird traps behind their houses, but these were not included in the study.

Month when the trap was laid

The hunters were asked what month the trap was laid in. At the start of the study there would have been more error in the estimate, as traps were laid longer ago, which make it much harder for the hunter to remember the right month. However, within a few months these estimates were quite good, as new traps must have been laid since the last hunter follow, which in the case of the more active hunters was about 2 months previously. Where hunters seemed unsure, the month was not recorded. Specific events were often used to establish the month (i.e. "Was it before or after the ceremony for Ngadi?") An estimate of the month laid was recorded for 97% of the traps. Unfortunately, it was not possible to ask in which month each trap was removed, or went out of action, as there were generally too many traps to notice when one was missing. However, hunter follows were often carried out frequently enough that it was possible to estimate trap life to the nearest 2 months by looking at when the trap in question no longer appeared in the hunter follow. With smaller, less active hunters this was often also possible, as they tended to have 'barrages' of traps, which are put up in one go, and then left in place for a long period of time, until they are all removed together, and we were able to find out when they had removed all their traps.

Forest type

For each trap, the Pouvi forest classification was recorded, and this classification is described in Table 3. 3. However, this classification meant that a lot of the secondary and primary forest was pooled into the ‘ngoma’ group. A more detailed classification of forest type was therefore implemented halfway though the study when I had gained some training in how to distinguish between the types of forest. My field assistants could record the Pouvi classification, but the detailed classification was only recorded while I was on the hunter follow, to control for variation between observers. Because of this, the more detailed classification was only recorded for 68% of the traps.

Understorey density

Four levels of understorey density were used, and are described in Table 3. 3. Density estimates were collected at the same time at the scientific classification of forest type, and so have the same sample size.

River

Traps were described as ‘on a river bank’ or ‘next to a river’ (within 20m); and otherwise were described as not being next to a river.

Cable

Two types of cable were used: general thickness (approx. 1mm diameter) and a ‘grand cable’ (approx. 3mm) often used for buffalo or sitatunga traps. General cable was either used with just one strand, or strands of cable were wound together to provide thicker cable, in order to hold larger animals. The type and number of strands of cable were recorded (1 – 4).

Animal track

For each trap the hunter was asked which type of animal track he had placed his trap on. Once I had determined the range of responses, these were divided into six categories:

Small animal/Cane rat

Porcupine

Blue duiker

Red duiker

Red river hog

Sitatunga

Human path

Paths were divided into 3 categories:

Plantation: paths going through, or alongside plantations.

Principal: used by all hunters, and by women going to the plantations.

Private: made and used by one hunter.

Hill

The slope of the terrain that the trap was placed on was divided into four categories:

1: Flat. ~ 0 - 10^0

2: Medium ~10 - 30^0

3: Steep ~30 - 50^0

4: Very Steep ~ $50^{0\,+}$

Geographical position

Positions were recorded for each trap using a handheld GPS (Garmin 12 XL, or handspring visor with Magellan attachment) with an external antenna; antennas were stuck to baseball caps, or on the end of sticks in order to try and get better satellite capture. Positions were recorded for 83% of the traps. Where the position was not recorded, it was often because the trap placement was in a steep river valley, or under dense canopy cover, and acquiring a satellite lock would have taken too much time, delaying the hunter. The positions of hunting camps and old villages were also recorded when we came across them during a follow.

During these hunter follows, the GPS unit was programmed to record the position of the observer every minute (tracklogging). This function did not always work, as we were often moving through the forest too fast for the GPS unit to trap the satellite positions, but the same paths were used enough times that these tracklogs built up a very good map of the principal and private hunting paths around the village that were used by trap hunters. There is no doubt that more hunting paths existed than the ones mapped during this study; such as the private paths used for gun hunting. However, I am confident that the paths mapped represent the majority of the paths used during the study for trap hunting.

Current trap status:

The status of each trap still in use by the hunter (old and new traps) was recorded during each hunter follow, using the following five categories:

Dormant:	A correctly set, functioning trap, which has not been sprung or broken (see Figure 2. 15, Chapter 2 for an example).
Broken:	A trap where the wooden branch of the trap has been broken, and the trap can no longer function
Sprung:	The trap has been sprung, through an animal or the weather
Escaped:	An animal has sprung the trap and escaped (this can be determined through track, animal sign such a feathers or hair, and through limbs which have been left in the trap by the animal, after freeing itself).
Caught:	A trap with an animal caught in it.

Forest classification		Description
Pouvi:	Plantation	Traps set within active plantations
	Kange	Fallow forest: regenerating young secondary forest than was recently cleared (<5 years ago). Dense understorey and few trees.
	Evosso	Regenerating young secondary forest; young trees, dense understorey with lots of *Marantacea*, large gaps in canopy cover.
	Ngoma	Young secondary, old secondary, primary forest. Covers quite a large range of secondary/primary forest types.
Detailed:	Plantation	Traps set within active plantations
	Old plantation/ young secondary (Pouvi class. 'kange' and 'evosso')	Fallow forest: regenerating young secondary forest than was recently cleared (<5 years ago); young spindly, thickety trees, dense understorey with lots of *Marantacea sp.*, large gaps in canopy cover. Many African corkwood trees (*Musanga cecropioides*, colonisers). Often impossible to walk through without a machete.
	Young secondary (Pouvi: 'Evosso' and 'Ngoma')	Young trees, but larger diameter. Less thickety areas. Dense understorey, less gaps in canopy, small lianas. *M. cecropioides* still present.
	Old secondary (Pouvi: 'Ngoma')	Established trees, large diameter. Thicker lianas, little *Marantacea sp.* in understorey, and understorey less dense. No *M. cecropioides*
	Young primary (Pouvi: 'Ngoma')	Many large, thick trees, spread out, and very thick lianas (20cm diameter). Very bare understorey cover. No *Marantacea sp.* Dense canopy, and little light.
Understorey Density:	1	Low: Very little vegetation, more than 80% of forest floor clear.
	2	Moderate: ~ 40 - 80% forest floor visible
	3	Dense: ~10 - 40% forest floor visible. Still a large amount of understorey vegetation
	4	Very dense. No visibility of the floor, can see less than 1m through the vegetation

Table 3. 3: 'Pouvi' and 'Detailed' classification of forest type, with notes on how each classification was given.

Catch information per trap

Catch data for each trap were collected in two ways: using information on each hunter's offtake, as he brought it into the village, and by following the hunters on their trap visits.

In order to link the trap offtakes recorded in the village with the trap that they were caught in, hunters were asked to write down the number of the trap that they had found the animal in, or to bring back with them the piece of green tape with the trap number on it. This was not a method that worked with all the hunters; many of the older hunters, who tended to be those who had a small number of traps close to the village, were not willing to cooperate to such a level. However, this method worked very well for the medium and large hunters. There were two main reasons for this. Firstly each hunter who was willing to cooperate was given a notebook and pencil in order to write the trap numbers down. This conferred a level of book learning to the participant, and I often had hunters stopping round to show me how well they had kept records of their catches. I was also seen as a novelty in the village, and for a long time hunters wanted to collaborate with the study simply to be part of it. Secondly, hunters received the non-monetary incentive described earlier. Overall, trap numbers were recovered for 64% of animals brought into the village.

While following hunters to label traps, it became clear that hunters could recall the animals that they had caught in each trap, and were volunteering this information to us during the follow. In order to see how good their recall was, I tested some of the hunters by taking the trap numbers that they had returned for kills over the previous months and seeing whether the hunter would tell me the same information when we reached the trap. Two active hunters that were tested in this way (both with over 200 traps) demonstrated over 98% and 97% correct recall for over 53 catches, and 100 catches respectively.

By collecting trap numbers from hunters on return to the village, and again collecting information on the catches a trap has made in the forest, this method also acts as a check on whether the trap numbers being brought back by hunters are correct or not, and so the two methods helped to validate each other. Catches per trap during hunter follow therefore were recorded for each follow, from February 2004 onwards. At each trap we asked what animals the trap had previously caught, if any. To check the validity of the claims, field assistants (who were also hunters) looked for evidence of a previous catch on the ground around the trap (animals will often kick up the ground, leave traces around the trap, and trap cable will often fray), but this caution did not seem to be required for most hunters. In only one case, a hunter seemed to be exaggerating his catch, and his data were not used in the analysis. The datasheet used to collect this information can be found in Appendix A2.4.

The trap recall data is useful both for validation and to allow the incorporation of previous catches from traps set before the village returns data collection started, and inclusion of hunters for which the trap number method did not work. This also reduces the bias in the sample: older hunters were not able/ willing to return trap numbers, but were able and more willing to tell us which animals had been found in each trap. It also allows catch/month to be investigated: for each trap, the month that it was laid is known, and the date of the hunter follow is known, which provides an estimate of the number of months for which the trap had been active at the time of the follow. The disadvantage of this data is that it does not link to the information on each animal brought into the village (weight/state/destination), and does not provide the date the animal was caught (hunter estimates of when animals were caught were unreliable), which is possible for village hunting returns. If traps were very old (i.e. 12 months) when the follow was carried out, it is also more likely that the hunter had forgotten the trap history of the catch, and so there may be some bias, deflating the catch of older traps.

3.4.2.3 Daily surveys of hunting trips and hunting returns

Information on hunting trips and hunting returns, for all hunters who agreed to cooperate (82 of 86), and all hunting types, was collected for 12 months between February 2004 and February 2005. Surveys were carried out seven days a week, by rotating field assistants between village data collection and hunter follows. Exceptions to this were general holidays, and village ceremonies, when no one in the village worked or hunted.

A checklist of village men was used every morning, to quickly note which men were leaving on a hunting trip that morning. This was achieved by walking around the village and observing the men that were getting ready to go on a hunting trip. Where men had already left and gone into the forest, their wives were asked whether they had gone on a hunting trip, and what time they had left.

For each hunting trip, information on the trip, and any catch, was recorded on a trap-hunting or gun-hunting form. These two forms (translated from French), showing all of the questions asked of each hunter, can be found in Appendix A2.5 and A2.6. Other types of hunting, such as hunting with dogs and nets, were infrequent, and trap-hunting sheets were used to record them. No information was asked of the hunter as he left to go hunting, to prevent delaying him, which may have compromised the good relationship between the field assistants and hunters. Instead questions were asked on the hunter's return, while he was sorting out his catch (if any) and relaxing after the trip.

Hunting trip information

For both trap and gun hunting trips, the time and date for the start and finish of each trip, the reason for the trip, and whether there were any accompanying hunters/porters was noted. For trap hunting trips, hunters were also asked:

- If they had brought a gun on the trip with them, and if any of their catch had been shot (in which case a separate gun-hunting sheet was completed)
- The last time they had visited their traps, and whether they had made any changes to their traps (additions, movements or removals).
- Which area of traps they had visited, if they had more than one trapping area.

For gun hunting trips, hunters were asked:

- How many cartridges they had brought with them, and how many they had used (in order to quantify the cost of the trip, and the skill of the hunter).
- Which areas of the forest they had walked through during their trip, to determine their hunting area and maximum distance from the village.

Later in the study (in the last four months) an additional question was added, designed to look at prey choice by hunters, asking whether the hunter had seen any other animals apart from those he had brought back to the village, and whether he had attempted to shoot them.

It was possible to roughly estimate the number of trapping trips missed by the field assistants by using information provided by the hunter on the last time he visited his traps, and counting how many of these visits had been recorded. Only 3% of trapping trips were estimated as being missed using this method.

Catch information

For all forms of hunting, the catch data collected was the same. The species was identified in Pouvi. This was done because hunters had a word for each species in Pouvi, but did not in French. For example, in Pouvi a white-bellied duiker (*Cephalophus leucogaster*) and Ogilby's duiker (*Cephalophus ogilbyi*) were identified as *Ghessibo Moukebe* and *Ghessibo Sabe*, whereas in French they were both *Antelope*, which was used for all red duiker irrespective of species. Older hunters were generally good at identifying to species, but younger hunters had problems, especially within duikers. When a field assistant did not know the exact species, he either asked an older hunter for help or noted on the form that the exact species identification was not known. Field assistants were trained in how to record species identifications at the beginning of the study, and were provided with a species guide in French. However, I found that the species guide was really only a useful tool for me, to check Pouvi identifications against scientific classifications. Village field assistants and hunters had trouble making sense of western methods of identification, as they could not easily compare the 2D drawings with an 3D animal, and did not use colour as a tool for identification. I thoroughly checked the identification of species during the study, and am confident of accuracy of the Pouvi identifications.

Each animal was weighed using 4 Pesola balances: 5kg (animals under 5kg weighed to the nearest 0.1kg), 10kg (0.1kg), 35kg (0.5kg) and 50kg (1kg). Animals were weighed with the smallest balance possible, to increase precision. When animals had already been cut into pieces (gigots) before the hunter had returned to the village, each gigot was weighed. 73% of the animals caught during the study period were weighed.

If the animal had been caught in a trap, the field assistant or hunter assessed the state of the meat when the animal was found. Five categories were assigned, and are shown in Table 3. 4.

State of meat	Description
Alive	The animal had been found alive in the trap, or was brought back to the village alive.
Fresh	An animal where the flesh had not yet started to decompose (usually an animal that had been caught that day, or during the previous night), and had flys eggs rather than maggots on it. Very little smell of decomposition.
Decomposed	Meat with a large amount of maggots and flies eggs on it, but still edible. Often had a smell of decomposition, and often eggs and maggots were burnt off the meat before it was eaten. Generally 1 – 2 days old.
Rotten	Inedible meat. Generally more than 2 days in the trap, covered in maggots, and putrefied.
Smoked	Hunters often smoked their meat when they spent more than 1 day in the forest, to prevent decomposition. Gun hunted meat was obviously all found alive before being shot, but some was smoked to prevent decomposition during long trips, and this was also recorded

Table 3. 4: Categories for the state of meat brought back to the village.

Information on the sex, age (adult or juvenile), and area of the forest in which the animal was found were also recorded. If the animal was found in a trap, the trap number was asked for hunters cooperating in this part of the study. Trap numbers were returned for 64% of animals brought back to the village.

The destination of the catch was then observed and recorded; possible destinations included the catch being eaten by the household, sold to someone in the village or to the town, given to a relative, used in a ceremony etc. Animals were generally put up for sale outside houses, or in the market. When this occurred, the animal was monitored by the field assistant up until the point of sale, or until the hunter withdrew it from sale, in order to verify the final use of the catch, and its final price if sold. The destination of the catch was known for 88% of animals, and where they were sold, the price was recorded for 92% of animals.

3.4.3 Male livelihood activities

To place hunting in the context of other male livelihood activities, data on the main daily activities of 30 men from Kouagna were collected every day from June 2004 – February 2005, by the field assistant who was based in the village to collect hunter information. Kouagna was chosen over Dibouka because Kouagna is a smaller village, with all the houses based along the road; it was therefore much easier to track the activities of each participant. Participants were chosen mainly for their willingness to cooperate; but effort was made to include a range of hunting levels and ages. Hunters were more willing to collaborate, as they had already invested time into the study and so felt more ownership of the project. Men from the sample had a lower median age (29) than the total sample of adult men (34), but this was not a significant difference (Mann Whitney U test w = 5428, p= 0.30, n = 23, 91). They also had a higher median hunting offtake (76.9kg) than the total sample of adult men (24.8kg), also non significant (w = 1610, p = 0.11). The sample, although slightly biased in favour of hunters, is therefore still representative of adult males for the two villages.

Each day the main activity of each man was recorded. This was achieved as far as possible by simply watching the participants, but was also done by asking participants what they were going to do that day and then watching their movements in and out of the forest/village. Although it would have been preferable to have all the activities for the day, it would have been difficult to find willing participants for such a detailed study, and in order to get any information on daily activities data collection had to be as unobtrusive as possible. Along with the main daily activity, any items brought back to the village, whether they were sold, and how much they were sold for was also recorded. An example of a data collection sheet can be found in Appendix A2.7.

3.4.4 Individual local spending habits

In order to look at the purchasing habits of different groups within the village (such as hunters) data were collected on purchases from the local shop and bar in Dibouka. The shop owner was paid 10,000CFA per month to record all purchases in the shop. She was quite happy to do this, as it also provided her with a record of takings. An example of a record sheet can be found in Appendix A.2.8. For each purchase, the name of the purchaser was recorded, along with the date, the product bought, the quantity and the price. This record was kept over a period of 10 months, from June 2004 until March 2005.

During the study period this was the main shop in Dibouka, and the vast majority of purchases in the village were made here. Alternatives were on a very small scale: One other shop existed in theory, but rarely had any stock, was used infrequently by the villagers. Certain households also sold a small amount of produce; generally beer, stock cubes and tomato paste. At the beginning of 2005 two new shops were set up in the village, and this may have started to influence purchases in the main store. For this reason, data for February and March 2005 were not analysed. This dataset does not provide us with total information on an individual's cash purchases, as it does not contain information on the sale of bushmeat or other forest products between households and does not take into account individuals travelling (very infrequently; see Section 4.3.1.1, Chapter 4) to Koulamoutou in order to buy cheaper goods in town. However, it does provide us with one area of purchases; shop bought goods within the village.

There were a total of 63 different items, which for analysis were divided into three categories (A list of the items in each category, and item prices can be found in Appendix A2.9):

1. Food.
2. Cigarettes and Alcohol.
3. Household Goods.

3.5 Qualitative data collection

3.5.1 Hunting territories: Participatory Rural Mapping (PRM):

The majority of information on hunting trails, camps and hunting areas was collected during hunter follows. In addition to this, to make sure that a complete picture of landscape use by hunters was formed, a participatory approach was used. In

September 2004, the data already collected were inputted into ArcGIS, and a map of the hunting paths, trap positions, forest names, hunting camps and old villages produced, over a basemap proved by SBL, the logging company in the area, which showed the river network, main roads and village positions. Hunters were asked about the positions of major hunting trails that might not have been used that year, old village and hunting camps, and important ceremonial sites, and was also used to during hunter interviews to learn about the history of forest use in Dibouka and Kouagna.

Maps are not used in Dibouka or Kouagna, and therefore are not really understood by hunters as a tool for communicating positions, and so this map was essentially a tool for my communication. For instance, hunters might communicate a position by saying that an old village site was in the forest zone of Ghediaki, past the yahoo river, then over the next small river, and then on a private hunting path to the right. I could then find which path I thought they meant from these directions, and then ask questions on it from the map 'is that the path just after X's traps?' until I was sure of where they meant. The map was put on the wall of my house, and on occasions when there were a group of hunters in my house I would ask them (with the help of some palm wine) to help me fill in any missing information.

3.5.2 Past and present land use and village laws: Semi structured interviews

To investigate the extent to which village law dictates where a hunter will place his traps, and to what extent he can make free choices, based on prey populations, 28 semi-structured hunter interviews were recorded. During these interviews hunters were asked four questions about village hunting laws; whether there were any restrictions or laws influencing where he hunts today, whether any such laws existed in the past, what the penalties for breaking these laws were and, if there have been any changes in land-use laws, why these changes have taken place. Hunters of a range of ages (14 – 75) were interviewed. Each interview was translated from the original French

3.5.3 Unstructured hunter interviews

General hunter interviews were recorded throughout the study, where there was any free time. In these interviews I asked hunters to tell me about their lives, including where they were born, their family, their education, previous jobs, and their lifestyle in town and in the village. I encouraged an informal structure to these interviews, to make sure that I didn't restrict the information that they might provide. These interviews were hugely informative, and helped guide other data collection within the study. Information from them has also helped to make corroborate and make sense of some of the results from the more structured, quantitative research, and have been quoted where relevant.

Chapter 4 :

Hunting and rural livelihoods

Chapter 4

4.1 Introduction

Hunting is on both the conservation and development agenda. With the unsustainability of hunting at the broad scale in little doubt, it is important to identify how a reduction in animal densities, or policies aiming to reduce hunting, will affect the food security and incomes of rural communities (de Merode et al, 2004). As Brown and Williams (2003) note:

'*Any attempt to resolve the bushmeat crisis must be judged against its ability to satisfy the livelihood needs of the rural population, particularly the poor. The strategies on offer often fail precisely because of their deficiencies in this regard*'

Brown (2003) suggests that bushmeat may also be an important tool for poverty eradication, which has generally been disagreed with by the conservation lobby, who argue that the unsustainable use of a natural resource is unlikely to provide sustained poverty reduction (Davies, 2002). There have been few studies, within the bushmeat literature, that have looked at the drivers of hunting, and the relationship between hunting and poverty in rural communities; a recent review of the literature by Bowen-Jones et al (2002) found that only 5.4% of the bushmeat literature addresses livelihood and food security issues. However, there has been a fair amount of research carried out by the development and forestry sectors studying the use of NTFP's (of which bushmeat is a part) by rural households, which has been widely overlooked within the conservation literature.

4.1.1 Non Timber Forest Products, and their benefit to the poor:

NTFP's are an especially important resource for the poor around the world (Sunderlin et al. 2005), with forest resources directly contributing to the livelihoods of 90% of the 1.2 billion people living on under 1$ a day (World Bank 2002). This is because of the open-access nature of the products, which can be used with little processing, using low cost (often traditional) techniques.

NTFP's are used by the rural poor in two ways: as a 'daily net' and a 'safety net'. 'Daily net' describes their everyday use, where they help households to meet current consumption needs, and can be relied on as a source of cash to, for instance, purchase agricultural inputs (Shackleton & Shackleton 2004). They are used as a 'safety net' when other sources of household income fail (for instance when plantations are destroyed by elephants, or floods), or when a quick cash option is required; for example to fund emergency medical care (McSweeney 2005). Although NTFP's are often used by the poor to supplement incomes, it is unlikely, due to the same open-access characteristics that make them available to poor households, they could help to bring households out of poverty (Arnold & Perez 2001).

Fischer (2004) and Reddy and Chakravarty (1999) have both found that the inclusion of NTFP incomes into the total household income can reduce income inequality with a community. They point out that although all resources separately may be poorly distributed, the way that these resources interact may smooth inequalities. For example, if poor households are the main NTFP collectors, then this will lower the overall income inequality. However, the extent to which NTFP's can 'smooth out' the differences in income between rich and poor households may depend on the type of NTFP. NTFP's are not always a resource of the poor. As Dove (1993) observed, in those cases where NTFP's have a high value, they tend to be used by people with more power, more assets and better connections – that is the non poor. Commercialisation and increased market access therefore does not necessarily provide opportunities for the poor, and may shift access and use towards the richer sections of a community (Arnold & Perez 2001). So what type of NTFP is bushmeat hunting?

4.1.2 Hunting as an 'inequality smoother'?

Coomes et al (2004) found that of 25 surveyed hunters in rural Amazonian communities, the top hunter caught 16% of the total hunting offtake, and the top 5 caught 53% of the total. Household participation rate in hunting in the surveyed villages was 25%, increasing the inequality in the distribution of these hunting returns. Basset (2005) discovered that of 44 hunters in Cote d'Ivoire, the top 10 were responsible for 73% of the hunting offtake. Other papers hint at similar distributions, with large variation in hunting offtakes among hunters. For example, Fa and Yuste (2001) report that within a group of 42 hunters there was significant variation in catch size, with the largest hunter catching 276 animals during the study period, and the smallest hunter catching 1. These studies suggest that hunting in these communities is unequally distributed within rural communities. Therefore it is important that we study hunting in conjunction with the other livelihood activities available within a community, and look at which sections of the community are benefiting from the resource, in order to judge the its potential as a 'daily net', and smoother of inequalities.

4.1.3 Who benefits from hunting?

Hunting is often described as a resource used by the poorest of the poor (e.g. Brown & Williams 2003), and this is certainly true on a macro-scale. Many rural forest people live below the dollar-a-day poverty line (data for countries in West Africa (World Bank 2003), suggest that between 32 – 76% of rural inhabitants live on under 1$ a day) and so regardless of relative wealth within the community, hunting can generally be described as a poor man's resource. However, within these rural communities, the limited research to date has suggested that it is the middle or even high-income groups, and not the 'poorest of the poor', who use the resource the most.

De Merode et al. (2004) studied the consumption and sale of all goods in 121 rural households in the Democratic Republic of Congo. Using a 4-level wealth ranking, they found that bushmeat and fish were consumed and sold much more by the higher wealth category households. Similarly, Starkey (2004), in villages around Koulamoutou, Gabon, and Godoy et al (1995) in Nicaragua, both found an increase in hunting returns with household income. Coomes (2004) in the Amazon also found that hunting and fishing returns were higher for land-rich households. This association is not confined to wildlife use; Pattanayak and Sills (2001) used data from the Amazon to create models of all NTFP use and predicted higher use from middle-aged households with more possessions. McSweeney (2004), in Cameroon, and Cavendish (2000), in Zimbabwe's Communal Areas, both found that extraction of NTFP's was higher for higher income households, and Ambrose-Odj (2003) in

Cameroon found that middle-and upper-middle income households extracted the most resources from the forest.

De Merode et al (2004) suggest that the poor use wildlife as a resource less than richer members of the community due to the ‘lumpy investments’ (such as guns, nets and snare wire) required. These start-up restrictions have been demonstrated previously by Dercon (1998), who found that poor households in Tanzania were more likely to participate in low risk, low return activities, whereas richer households would put an initial lump sum into livestock, which have a higher risk but higher return. In Ambrose-Odj’s 2003 study, participants from low-income households reported economic and social barriers to access of NTFP’s, saying that NTFP’s represented an insecure source of income that remained difficult to access under the control of richer groups and secret societies.

Differences in use between different NTFP’s were also investigated by de Merode et al (2004); wild plants were consumed and sold mainly by households with the lowest wealth rankings. This recalls the ideas of McSweeney (2005) and Dove (1993), with wild plants fulfilling the open-access daily and safety use of NTFP’s, whereas bushmeat and fish both have high market values, and so are a resource used by the ‘non-poor’. Godoy et al (1995) also found that plant products were collected predominantly by the poor, and Coomes (2004) found that terrestrial gathering activities were negatively correlated with land ownership. Jones (2004) found that crayfish harvesting in rural southeast Madagascar was predominantly a resource of poor female households. Although crayfish are a wildlife resource, their harvesting requires negligible start-up costs, and so, like plant products, could be available to all households.

There is also some evidence to suggest that while the richer household extract more forest products, NTFP’s may be of higher importance to poorer households. Godoy et al (1995), Coomes (2004) and Ambrose-Odj (2003) all found declines in the economic importance of forest goods with household incomes; rich households extracted more, but forest products represented a larger proportion of the household income for poor households. McSweeney (2004), looking at NTFP’s as a safety net, found that those who sold NTFP’s during a crisis tended to be young – land insecure households; however she also found that bushmeat was not often used as a safety net product; dugout canoes were the preferred way of making quick profit.

These studies generally describe bushmeat as a forest resource that is not as open access as many other NTFP's; some level of lumpy investments is required, which are not possible for the poorest sections of the community. Households with high hunting returns are generally the middle to high-income brackets, however in some cases the poor may still gain a larger percentage of their income and consumption needs from bushmeat.

There are a number of general lessons from these examples. Firstly, although at a macro scale the rural poor are the largest users of, and often reliant on forest products, it is vital to look on a finer scale at whom, *within* rural communities, are the main users of forest resources. Secondly, it is important that we discriminate between different types of NTFP, as different products will have different levels of access, and therefore will be exploited by different sections of the community. Finally we must distinguish between the main users and those who are most dependent on the resource.

4.1.4 How does hunting contribute to household economies?

The two studies from the bushmeat literature that have looked at the influence of hunting on household livelihoods (de Merode, 2002, Starkey, 2004) have both done so by looking at the total and proportional contribution of hunting to the household incomes. They both found that hunting incomes contribute a significant proportion of household incomes, especially in more remote villages. This however, only gives us the potential contribution of hunting to household wealth and livelihoods. In order to fully understand the role of hunting, we must measure how these incomes are used, and how they contribute to the various facets of household wealth.

Research by the FAO (1996) has found that improvements in household food security and nutrition are associated with women's access to incomes, and their role in household decisions on expenditure. A 1999 IFAD study in the Upper East region of Ghana found that women spend the largest proportion of their income on food for the household, followed by health expenditures and other household items (IFAD, 1999). Through development and gender studies, the role of women in rural economies has been studied in some detail. However, there has been little research into how men spend their incomes.

Solly (2004) investigated female and male spending patterns as part of a study into bushmeat hunting in Cameroon. Although she did not look directly at the relationship between spend and hunting offtakes, she found large gender differences in spend, with men spending 69% of their incomes on alcohol and tobacco, compared to 13% by women. Similarly, Katz (1995) found that in Guatemalan households increased male agricultural income was largely spent on male goods, affecting women's ability to purchase food and domestic technology for the family.

If hunting incomes contribute little to the household economy, then as Starkey (2004) suggests, a reduction in the commercial bushmeat trade might not have a large effect on household wealth. However, if hunting incomes are an important provider of incomes, which contribute to poor rural household economies and are used, as de Merode (2003) suggests, to *'…help households purchase important commodities such as medical supplies, and enhance their livelihood strategies with equipment such as fishing nets…'* then declining hunting incomes could severely impact rural livelihoods.

This study aims to fill some of these large gaps in our knowledge. Specifically it will use data collected from Dibouka and Kouagna to:

1. Place hunting in the context of other male livelihood activities. Daily activity data for men in the two study villages has been used to investigate the main livelihood activities practiced by men in the study villages, and how the time spent on these activities interacts with hunting.

2. Study the distribution of hunting within these communities, the characteristics of the user group, and the relationship between hunting and poverty. Data on household and individual male characteristics, including hunting offtakes,

demography, livelihoods, and wealth data, has been used to describe the characteristics of hunters and hunting households.

3. Examine the use of hunting incomes, and how they benefit household economies. Data collected from the village shop on spending by the village inhabitants has been used to describe the spending patterns of men and women, investigate how hunting incomes are spent, and consider the difference in the use of incomes from different livelihood activites.

4. Look at how hunting and other livelihood activities interact to influence household wealth; and consider the contribution of hunting in the context of other livelihood activities. This will revisit the livelihood and wealth data collected for aim 2.

4.2 Methods

4.2.1 Male livelihood activities and their interaction with hunting

Six months of data on the main daily activities of 30 men from Kouagna (see Section 3.4.3, Chapter 3) were used to answer two questions designed to place hunting in a meaningful context within village livelihood activities:

1. What are the main male activities, and how does the time allocated to each activity vary with season? What do these activities involve, and what do they offer?
2. Are there trade-offs between the time allocated to each activity, specifically hunting and other livelihood activities?

In order to look at seasonal differences in activity, data from six months spanning the dry to wet season from August 2004 to January 2005 were analysed. In total 2200 days were used in the analysis, and 23 of the original 30 men, who were all monitored for the same number of days. Seven men had moved out of the village during the study, or spent a large proportion of their time out of the village, and were not used in this analysis.

The activities recorded were divided into 9 categories:

1. Agriculture. Including agricultural labour, or the processing of agricultural products in the village.
2. Hunting. All types of hunting, or travelling to hunting camps.
3. Village time. This describes days where the participant spent all of his time in the village. Often there was no reason given for staying in the village; the collection of activity budget data was reliant on not irritating the participants, and so when staying in the village, men were not pressed to explain their motivation.
4. NTFP collection. The collection of forest products, not including hunting. NTFP's were also collected during time spent in the forest due to other

activities; this category refers to days where the main activity was to specifically collect NTFP's.

5. Travel.
6. Ceremonies.
7. Employment. Any type of paid labour within the village.
8. Building. Construction of houses, shelters etc.
9. Illness.

This dataset was used to compare the proportion of days spent on each category, and how this varied with season. Looking at the activities contained within each category, the characteristics of each category were then described in more detail (for instance, how time spent in the plantation was divided into different plantation tasks), along with the possible returns from each category and how this compared with hunting incomes.

Finally, the interactions between the proportions of time spent by each man on the three main livelihood activities were analysed. This was possible because no activity took up a majority of the time budget, and so the risk of spurious correlations between the time spent on one activity compared to another, due to the use of percentage data, was minimised.

4.2.2 Who hunts?

The socio-economic characteristics of hunters and hunting households were investigated using demographic, wealth and livelihood data collected during socio-economic surveys (Section 3.4.1, Chapter 3), and hunting data for individual hunters and households, calculated from village hunting returns of each hunter during the study period (section 3.4.2, Chapter 3). All of the variables used in these analyses are listed and described in Table 4. 1. As with any dataset there were missing data, and these were quantified and addressed (Table 4. 1). Two men were excluded from the analysis, as they did not want to disclose their hunting offtakes. The households that these men came from were also therefore excluded from the analysis.

Household variables	Description
Demography:	
Household size	Number of people in household
Adults	Number of people >=16 and <65 in household
Women	Number of females >=16 and <65 in household
Men	Number of males >=16 and <65 in household
Dependants	Number of people <16 and >=65 in household
Dependency ratio	Ratio of adults : dependants
Wealth:	
Possessions	Total value of possessions in Central African Francs (CFA)
Wealth Ranking	Ranking (ordinal/factor: 1 (poor) – 4 (rich))
Livelihood:	
Commerce	Ranking, level of commercial activity. Ordinal/factor: 0 (none) – 2 (high)
Agriculture	Ranking, agricultural returns. Ordinal/factor: 1 (low) –3 (high)
Livestock	Value of livestock in CFA
Income	Income, in CFA, from pensions and employment
No. Employed	Number of household members with cash employment

Individual variables	Description
Age	Age of individual
Place of Birth	Binary. 1 = born in village, 0 = born elsewhere
Education Level	Factor: Primary, secondary, tertiary
Individual Income	Individual income from pensions and employment, in CFA

Hunting variables	Description
Adult male hunters	All men from 16 to 65 years old, who caught at least 1 animal during the study period. (n = 57)
Total hunting offtake	The biomass, in kg, of all the animals that each hunter caught during the study period. Of 2647 animals caught, 73% were weighed. Where there was no weight, the animal was given the mean weight of the species, calculated from occasions when that species had been weighed. The only exceptions to this occurred with Chimpanzees, Red river Hog, and Sitatunga, where there were insufficient entire animals weighed to produce a mean weight for the species. In this case, weights from Kingdon (1997) were used, taking into account the sex of the animal where possible.
Eaten biomass/ Sold biomass	The biomass, in kg, of all the animals that each hunter caught, which were then consumed by his household, rather than sold, during the study period. For 11.8% of animals, the destination of the animal was unknown. In this case, the total biomass for each hunter where the destination was unknown was multiplied by the proportion of the rest of his catch that was eaten or sold, to give a calculated estimate of his total eaten and sold biomass.
Hunting income	The total amount of money (CFA) that was made by each hunter during the study period. Where the destination (eaten or sold) of the animal was unknown, a price was given to the animal by multiplying the proportion of the rest of the hunter's catch that was sold by the average price for that species. Sold animals that had no price information (8%) were given the mean price for their species.
Bought bushmeat	The total amount of money (CFA) spent on bushmeat by a household during the study period. (Individual purchase data not collected). 263 animals were sold to households in Dibouka or Kouagna; of these, the identity of the buyer was known in 103 cases. The amount spent on bushmeat per household (in CFA) was calculated from this sample.

Table 4. 1: The names and descriptions of the household, individual and hunting variables used to investigate predictors of hunting activity.

Five hunting variables were used as response variables: total hunting offtake, eaten biomass, sold biomass, hunting income, and bushmeat purchases (Table 4. 1). All of these were calculated for each individual hunter, and for each household, with the exception of bushmeat purchases, which were quantified at the level of the household, and not for each individual village resident, due to the low frequency of purchases (263 purchases within the village).

Univariate correlations between individual and household characteristics and their hunting offtakes and incomes were then examined, and general linear models used to find the best predictors of hunting offtakes and incomes. The distributions of hunting offtakes and incomes among individuals and households in the two villages were measured using a Gini index. Gini indices are the most commonly used measure of inequality, and are used by the World Bank (e.g. Coudouel et al, 2002) to look at inequality at a country level. A score of 0 describes a situation where all households/individuals receive the same benefits from hunting, whereas a score of 1 would mean that a single household/individual is receiving all the benefits from hunting.

4.2.3 What do hunters spend their money on?

In order to study how hunting incomes and offtakes influence hunter and household spending, data were collected on purchases from the local shop and bar in Dibouka (section 3.4.4, Chapter 3). Six months of this data have been analysed; 63 days were analysed for the dry season, between June and August, and 65 for the wet season, between November and January. A total of 4750 purchases were recorded, of which 3324 were by a resident of Dibouka. The remaining purchases were due to passengers travelling through the village, or purchasers for other villages, and have not been used in this analysis. Items bought were divided into 3 categories:

1. Food.
2. Cigarettes and Alcohol.
3. Household Goods.

The differences between men and women in the total and proportional amount that they spent on different categories were investigated, using only data from adult men and women (over 15 and under 65). To explore the influence of hunting incomes on the spending patterns of hunters, correlations between individual hunting incomes, and the total and proportional spend by individual hunters on different categories were examined using a subset of hunters who had been permanently based in the village; seasonal or travelling hunters would have biased the data by having low purchases and low offtakes, due to the small amount of time they spent in the village.

Hunting is the only livelihood activity for which detailed information was collected at the individual level, and so data were analysed at the household level in order to investigate how other household characteristics and livelihood activities influenced spending patterns. Households contain different actors, with different spending characteristics; in order to more fully understand the drivers of household spending, household spending was divided into three different categories:

1. Total hunter spend. Money spent by of all hunters within the household.
2. Spending by non-hunting males, to examine how hunting offtakes and incomes influence the spending habits of non-hunters in the same household, and whether hunters have different spending patterns to non-hunters.
3. Female spend, to examine how spend by women in the household was influenced by hunting offtakes and incomes, and other livelihood activities.

The way in which the spending of the household, and these groups, was correlated with household hunting returns, and with other household livelihood activities (Table 4. 1) was then explored using simple regressions and general linear models.

The proportion of money that hunters spent on different items was compared between the dry and wet season. Absolute spend on different items between the two seasons could not be compared, due to a bias in the collection effort between the seasons. At the beginning of the dry season the bar data was collected less frequently, as the regular bar owner, who was competent at writing, started travelling into Koulamoutou more often, leaving her mother, who was illiterate, in charge of the bar. This will have resulted in lower total spends per hunter being recorded per day, compared to when the main owner was present.

4.2.4 What defines a wealthy household?

The same household and hunting variables described in Table 4. 1 were used to determine how the demography and livelihood activities of a household contribute to the overall wealth of a household, using univariate correlations and general linear models. Two measures of wealth were used as the response variable: the total possessions per household, and the wealth ranking of the household. Possessions per household are a very specific measure of one type of wealth, whereas a Wealth Index is a multi-faceted approach, incorporating all the elements of wealth that the community perceive to be important.

4.3 Results

4.3.1 Male livelihood activities, and their interaction with hunting.

4.3.1.1 Male activity budgets: Main activities

Men spent most of their time on three activities: agriculture, hunting and time spent in the village, and very little of their time was spent collecting forest products and in cash employment. There were quite pronounced seasonal differences in activities. Figure 4. 1 describes the time spent at different activities within each season, and these five activities described above are now described in more detail.

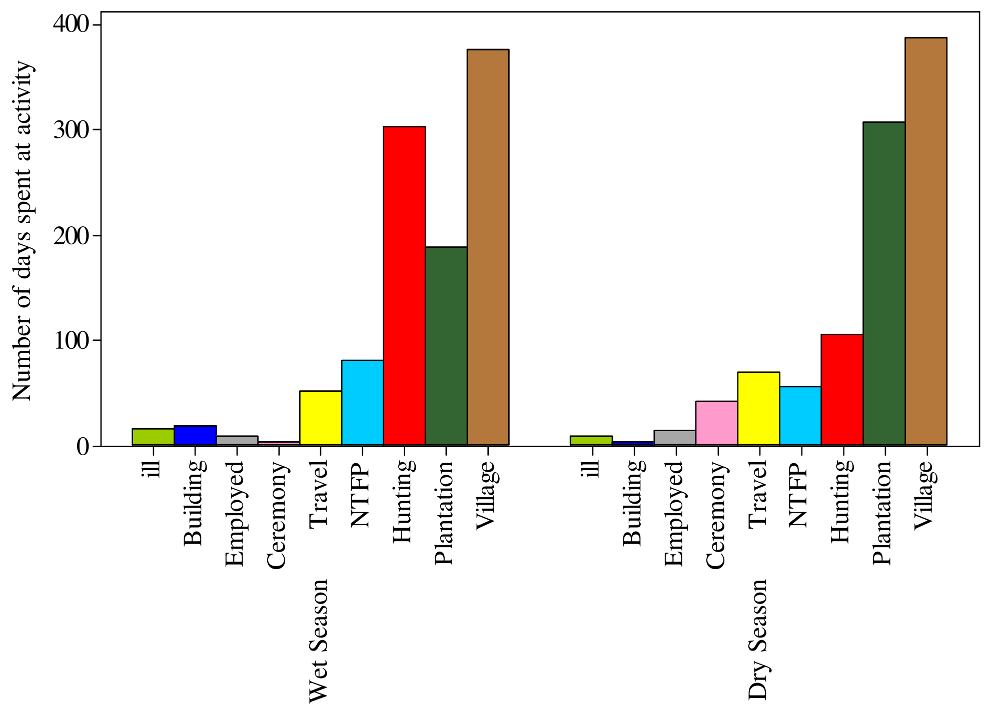
Agriculture

Men spent an estimated 20% of their time working in the family plantations, over the year. Plantation work was highly seasonal, and accounted for on 30% (+/- 4.5) of days during the dry season months (when new plantations are created from old fallow land, and young secondary forest growth is removed) compared to 15.7% (+/- 2.6) during the wet season months. Men are usually charged with any physically demanding work, and of all the time they spent in the plantations, 15% was spent clearing, 40% planting, and 24% harvesting and transporting produce. The maintenance of the plantation during the year is the responsibility of the women and children, and only 9% of men's plantation time was given over to weeding and maintaining. The few exceptions to this occur in 'bachelor' households, where these single men do all their own plantation work (n = 3/72).

Hunting

Overall, hunting also accounted for an estimated 20% of men's time over the year. As with plantation work, there are large seasonal differences in hunting activity, with hunting accounting for 9.5 (+/- 1.7) days in the dry season months, but increasing to 24.5 (+/- 3.85) days in the wet season months (Figure 4. 2). When asked about this, hunters replied that animals were harder to catch during the dry season, as they moved closer to the rivers and reduced their ranges, and in order to maintain a

4.1



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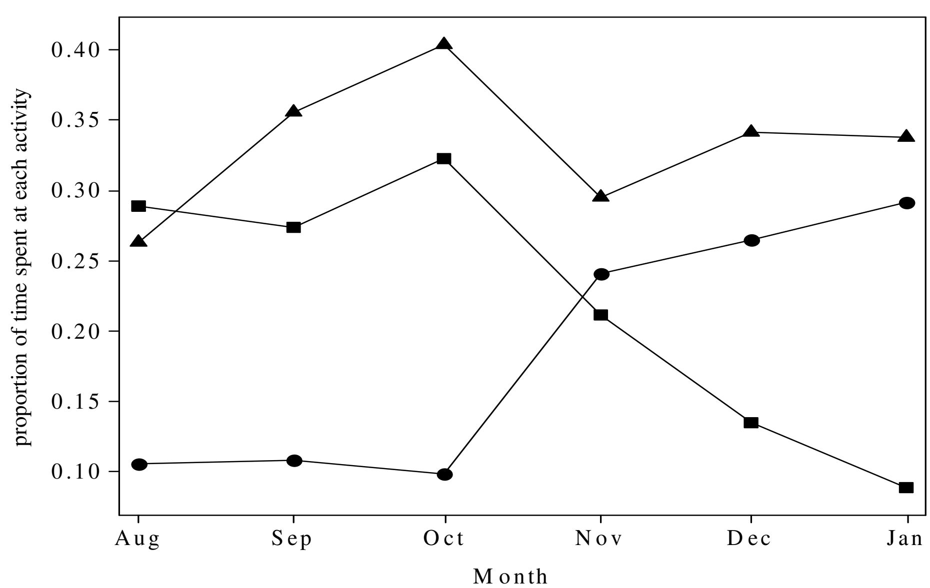


Figure 4. 1: The proportion of time that men spend at different activities (28 men's main daily activity, sample of 2200 days.)

Figure 4. 2: How the mean proportion of time spent at each activity, for all men in the sample, varies over time. Circles = Hunting, Squares = Agriculture, Triangles = Village time.

reasonable catch rate they would therefore have to move their traps. These issues are explored further in Chapter 7. Another reason for the reduction in hunting effort could be the increase in physically demanding plantation work during the dry season.

Village time

Time spent in the village accounted for an estimated 37% of surveyed days (33% when potential school attendees were excluded from the dataset), which does not vary between seasons (dry season: 38.5% +/- 4.0; wet season: 33.3% +/-4.8). Although some of this time may be due to observer error (The field assistant not realising when the participant left for the forest) the size of the village, and the visibility of all the houses leads me to believe that this data represents the real situation accurately. Where reasons were given for staying in the village, they included: waiting for banana buyers to arrive from town, waiting for medical aid, looking after members of the family, fatigue after hunting trips and ceremonies, and, among the younger men, playing card games.

NTFP collection

The main male forest activity outside hunting and agriculture is palm wine production (which comprises less than 3% of survey days), where a local wine is produced from the sap of felled palm trees. Of the 65 palm wine trips recorded, the average amount brought back to the village was 2.3 litres (+/- 0.41), and 1.3 (+/-0.31) litres were sold, at 500 CFA per litre. Information on the destination of the sold wine was not collected, but it is probable that most palm wine was sold within the village, due to its short shelf life, and high demand within the village.

Fewer than 4% of survey days were spent collecting other forest products (including fruits, plants, firewood and traditional medicine) and the majority are regularly sold in Koulamoutou market, and so have a market value. Using approximate values for each item brought back, an average of around 1000 CFA potential profit can be suggested for each NTFP trip. (This is a guide rather than an exact price, as some returns data did not specify exact amounts for each product).

Forest products were also harvested while men were out hunting, to a small extent. Forest and agricultural products were brought back on 20.0% of hunting trips. Palm wine was the most likely to be brought back (8.8% of products brought back), followed by bananas (8.0%), cane sugar (7.6%), and edible leaves (7.2%). An approximate market value was used to estimate the value of products brought back from a hunting trip. The average value was just under 1000 CFA, giving an estimated value of 200 CFA per trip.

Employment opportunities

There were very few employment opportunities within the village, reflected by the number of days that were spent employed in the sample (26/2200, or a mean of 1% (+/- 0.46) of survey days). All of the employment in this sample was temporary, daily employment offered by other village members, and included building work (barriers and shelters in plantations, houses in the village), and plantation clearing during the dry season, with a fixed-rate of 3000 CFA per day. In comparison, the median income from a one-day hunting trip was 89 CFA (interquartile range = 0 - 4500), and the maximum earned from hunting in one day was 54,500 CFA.

Other types of employment did exist within the two villages during the study period, which were not represented in this sample, and these case studies are described in Table 4. 2. These case studies highlight the paucity of steady employment available within the village, and they also illustrate that even the most productive hunters are willing to leave their traps for more formal employment, if it is available. Most formal employment has a monthly salary higher than the median monthly hunting return for a hunter (median 7300 CFA, IQR 0 – 14,800 CFA, max. 74,500 CFA).

Job (number of men employed)	CFA per month	Description	Hunting Activity
Aquaculture (1)	< 1000	Pond dug and stocked by the American Peace Corps 2 years previously. Jackson harvested fish every 6 months, but poor knowledge meant that all sizes and sexes were harvested, and returns were low. Out competed by traders from the town bringing frozen fish for the same price.	None
Woodcutting (1)	~ 10,000	Hunter 4 cut planks using a chainsaw, and sold them to traders in town. Access to wood limited by family forest areas, and permission required from the chief of the village. In May 2005, he left to work for a logging company.	Hunter 4 had a small barrage next to the area of the forest he cut wood from. He caught 4 animals from Jan – May 2005, and had no hunting income.
Vegetable gardens (3)	60,000 Unknown	Hunter 25 and John were employed by a Dibouka-born politician to run a vegetable garden of about 2 acres, supplying the Koulamoutou market. The garden seemed to do well financially, and the men were committed to their work, but the garden closed after the politician failed to pay salaries for a number of months. John left the village and Honore started hunting, and then left hunting to open a bar in the village. Beken and his wife ran his own, smaller garden, supplying Koulamoutou.	Hunter 25 caught 7 animals between working in the garden and beginning to run his bar (Apr- Jun). John was not from Dibouka, and left the village when the garden folded. Beken had a few traps around his plantations. No animals were recorded.
Goat husbandry (1)	60,000	Hunter 13 was employed by the same politician to run a goat rearing business, supplying live meat to the large muslin population in Koulamoutou. The politician again stopped paying wages, and Hunter 13 left to look for logging work.	During the study period, Hunter 13 caught 125 animals and had a mean hunting income of over 20,000 CFA per month. During goat rearing he left his traps for the whole month of September. He left his traps with his uncle when he left the village to look for work.
Teaching (1)	85,000	When one of the qualified teachers left the village, Hunter 19 was employed to take his place. He was still working when the study finished.	Before working as a teacher, Hunter 19 had caught 11 animals and had a mean hunting income of 700 CFA a month. He told me that he was intending to start trapping again, while teaching.
Forestry/ Town employment (3)	100,000 to 120,000	Hunter 13 and Hunter 4 both found employment as a woodcutter and a driver in logging companies during the study. Hunter 45 had the highest hunting offtakes in Kouagna until April 2004, when he decided to travel to one of the large towns, Mouila, to look for work. He stayed there until May 2005, when he returned to the village due to lack of opportunities.	Hunter 45 had caught 107 animals and had a mean hunting income of 60,700 per month before leaving for Mouila. I do not know whether on his return he then intended to stay in the village and hunt, or search further for employment.

Table 4. 2: Employment opportunities in Dibouka and Kouagna over the study period.

4.3.1.2 Interactions between time spent at the three main activities

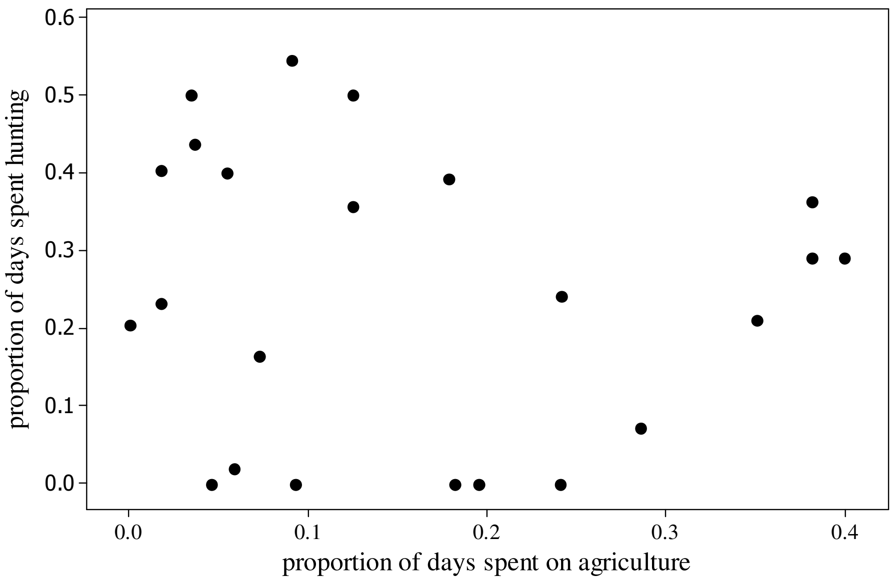
Hunting and agriculture

Although there is an obvious seasonal propensity towards hunting in the wet season and plantation work during the dry season, the amount of time that individual men spend hunting within a season does not seem to covary with the time they spend on agriculture (Figure 4. 3). This may be because men have a large amount of time in the village to be drawn from, which means that the time spent on one livelihood activity does not reduce the time available to spend on another.

Village time and livelihood activities

In the dry season, there is a negative correlation between the amount of time spent in the village and time spent on agriculture (Figure 4. 3). This may be an example of 'slack time' in the village being reduced in order to increase the amount of time spent in the plantations. The same correlation cannot be seen in either season between time spent hunting and time spent in the village.

a.



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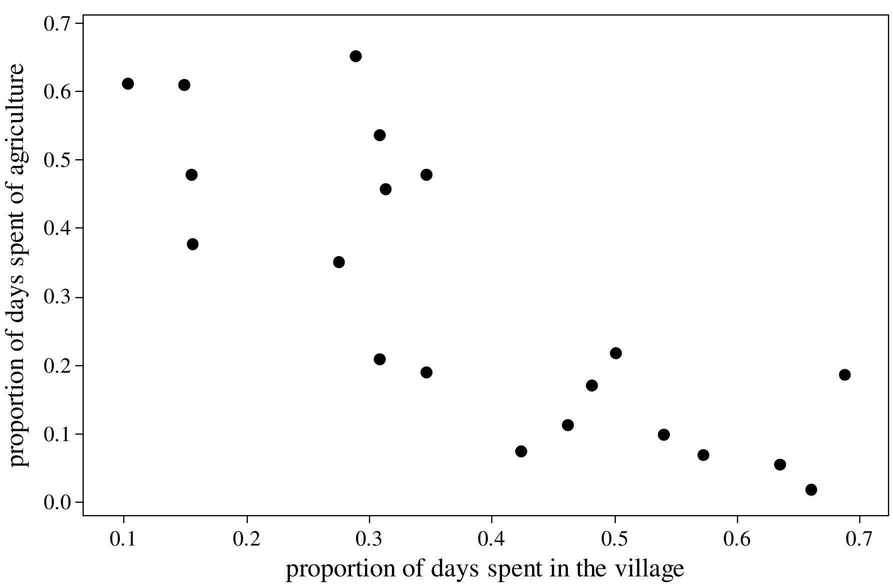


Figure 4. 3: Interactions between the proportions of time each man spent at the 3 main activities (n = 21 men).

a. The proportion of time working on agriculture compared with the amount of time spent hunting.
b. The proportion of time that each individual man spent on agriculture, compared to the time he spent in the village, during the dry season.

4.3.2 Who hunts?

4.3.2.1 How many individuals and households are involved in hunting?

The majority of men in Dibouka and Kouagna (72%, or 64/90) engaged in some level of hunting activity during the study period, Similarly, 65% (49/75) households surveyed contained men who did some level of hunting. Households that did not hunt were often those that lacked an active male; these included households containing only dependants (men under 16, or over 65, n = 7/27), only women (9/27) or households with ill or injured men who were physically unable to hunt (2/27). Ninety-one percent of households that contained an active male carried out some level of hunting during the study period. The majority of men and households that hunted also sold a proportion of their catch; 74% of hunters, and 77% of households that engaged in hunting, sold some proportion of their hunting offtake.

52% of men who hunted engaged in some level of gun hunting (38% of all men), whereas 89% of men who hunted did some trap hunting (64% of all men). 55% of men who hunted only used trap hunting, whereas few men were solely gun hunters (8%). 36% of households contained an active gun hunter.

Despite the relatively widespread use of hunting, hunting offtakes and incomes are very unevenly distributed, with a small proportion of households or individuals catching most of the animals and making most of the money. Gini index scores for the distribution of individual and household hunting offtakes and incomes were all between 0.75 and 0.90 (Table 4. 3), where a score of 0 depicts evenly distributed hunting returns and a score of 1 depicts a situation where only one hunter or household is benefiting from the resource. The ten households with the largest offtakes caught 69% of the total biomass for the two villages (Figure 4. 4). Hunting incomes and gun hunting incomes and offtakes were the most unevenly distributed.

Hunting variable	Household All households	Household Hunting hh's	Individual All men	Individual Hunters
Total offtake	0.76	0.62	0.77	0.63
Total hunting income	0.81	0.69	0.81	0.71
Gun hunted offtake	0.87	0.79	0.88	0.80
Gun hunter income	0.90	0.84	0.90	0.85
Hunting offtake eaten by household	0.76	0.60	0.75	0.62

Table 4. 3: Gini index results for different measures of household (n= 75 households) and individual (n = 95) hunting returns.

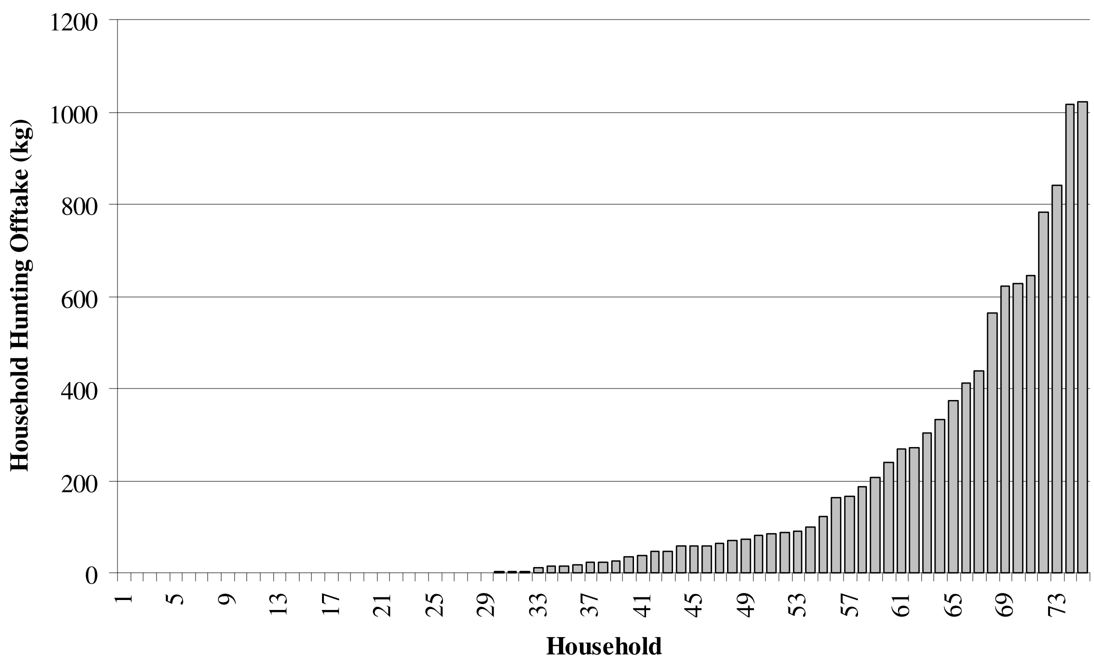


Figure 4. 4: The distribution of total hunting offtakes among households.

4.3.2.2 Who catches the most bushmeat?

Demography

Hunting is a male activity, and the household hunting offtakes increase with the number of males in the household ($r_s = 0.631$, $p > 0.000$, $n = 75$). Men of middle-age bring back higher individual offtakes (Figure 4. 5) with men of 30 to 50 (representing 33% of men between the ages of 16 – 65) bringing back 61% of the male adult (16 – 65) catch.

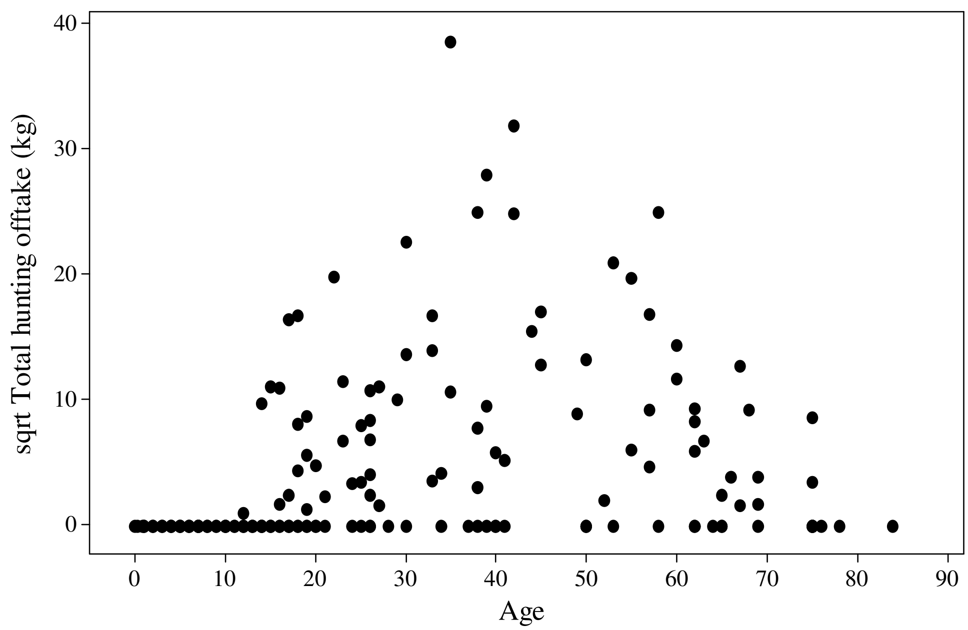


Figure 4. 5: Men of middle age bring back the most bushmeat. Sqrt total individual hunting offtake (kg) = - 10.4 + 0.983 age - 0.0114 age^2 ($F_{2, 87} = 4.85$, $p = 0.01$) for men between 16 and 65.

Biomass caught per individual was divided into two groups; trap caught and gun caught. Both have the same correlation with age as total biomass, but the correlation is stronger for gun-caught biomass (Sqrt gun caught biomass = - 9.69 + 0.819 Age - 0.0108 Age^2. $F_{2, 87} = 5.83$, $p = 0.004$. Sqrt trap caught biomass = - 4.99 + 0.516 Age - 0.00514 Age^2. $F_{2, 87} = 4.21$, $p = 0.018$).

This relationship with age could be due to a number of factors: Hunting is a highly physical activity, and so young and old men may not have the strength to do a lot of hunting. Skill may also increase with age, allowing a higher catch per unit effort (see Chapter 7 for further analysis and discussion). Another hypothesis is that middle-aged men are more likely to have young families, therefore holding more responsibilities, and so have a higher need to produce good offtakes than young or old men. However, there is no correlation between a household's hunting offtake and its dependency ratio, or number of dependants. Middle-aged men may also be wealthier, and more able to invest in hunting gear.

Wealth and livelihood activities

The total hunting offtake for a household also increased with the wealth of the household (Figure 4. 6), although the direction of causation was unclear; the observed correlation could be due to hunting offtakes increasing a household's wealth, through its contribution to food and/or income. However, it could also be that wealthier households are more likely to hunt because they can afford the bulky investments required for hunting (shotguns, cartridges, snare wire). When the total biomass is divided by hunting type, trap-caught biomass is correlated with wealth ($r_s = 0.324$, $p = 0.01$, $n = 62$), but gun-caught is not.

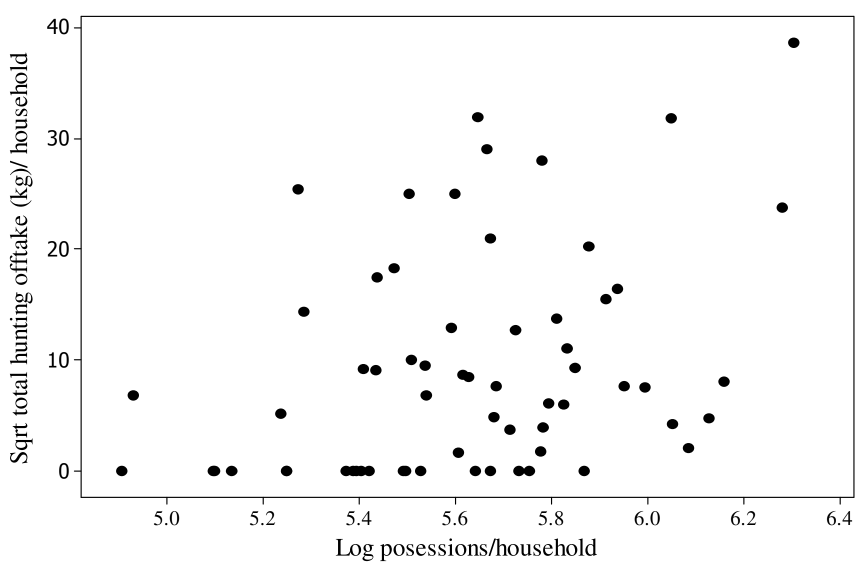


Figure 4. 6: The total hunting offtake per household increases with possessions per household ($r_s = 0.343$ $p = 0.003$, $n = 62$).

Both the amount of hunting and the wealth of a household increase with the number of adult males in a household. I therefore also considered how hunting offtakes vary with possessions/adult/household, and in this case there is no significant correlation.

Household hunting offtakes were not significantly correlated with any of the other household livelihood activities. This suggests that the amount of hunting that a household engages in may be independent from its other main income sources. This was also true at the individual level, as there was no correlation between individual incomes from other sources and hunting offtakes.

Hunting Type

Hunters with higher offtakes were more likely to do some gun hunting than hunters with lower offtakes, and gun-hunting offtakes increased in line with total offtakes ($r_s = 0.562$ $p < 0.001$, $n = 92$). However, hunters with higher offtakes did not have a higher proportion of that offtake coming from gun hunting (tested using a GLM with a binomial error structure, $p > 0.05$). These data suggest that larger hunters are more likely to employ both trapping and gun hunting techniques, but that the gun hunting per se is not the reason for higher offtakes.

Best predictors of hunting offtakes

Regression analysis, using a GLM found that of all the household predictors (listed in Table 4.1) the number of men in the household was the only significant predictor of household hunting offtakes ($F_{1, 59} = 39.49$, $p = 0.001$). The only significant predictor of individual hunting offtakes for men, and for hunters, was age (within hunters: $F_{2, 58} = 4.37$, $p = 0.017$).

To examine how the characteristics of the household might influence the hunting offtakes of an individual hunter from that household, the hunter with the highest total offtake per household was taken into a sub-sample, to avoid the problem of non-independence between hunters belonging to the same household. In this case, age and the number of males in the household were the best predictors, reflecting the increased probability of having a productive hunter in a household with a larger number of adult males (Table 4. 4).

General Model	**d.f. (change, residual)**	**F**	**P**
Age	1, 36	5.29	0.027
Age 2	1, 36	5.07	0.031
Number of males/household	1, 36	5.02	0.031
Possessions/household	1, 33	0.18	0.671
Commerce index/household	3, 33	1.18	0.332
Agricultural index/household	2, 28	1.63	0.216
Income/household	1, 35	0.29	0.591
Minimal Model:	**Estimate**	**s.e.**	
Constant	-15.5	11.0	
Age	1.356	0.589	
Age2	-0.016	0.0073	
Number of males/ household	2.44	1.09	

Table 4. 4: Results for a General Linear Model using a normal distribution, showing the terms associated with hunting offtakes (square-root transformed) for the hunter with the highest offtakes in each household.

4.3.2.3 Who sells the most bushmeat?

Commercial hunting was correlated with the same household and individual characteristics as the total hunting offtake; household hunting incomes increased with the number of male adults in the household (r_s = 0.60, p <0.001, n = 75), and individual hunting incomes were higher for middle-aged men (individual hunting income = - 243 + 22.0 Age - 0.273 Age^2, $F_{2, 87}$ = 4.26 p = 0.017). Unlike with the total household offtake, there was only a trend towards wealthier households selling more bushmeat (correlation of hunting income and possessions/household: r_s = 0.24 p = 0.054, n = 62).

As household and individual hunting offtakes increase, so does the proportion of the offtake that is sold (Figure 4. 7 a and b). One interpretation of this correlation is that as offtake increases, to a certain degree the protein requirements of a household/ individual will stay the same, which leaves a larger proportion of the offtake that can be sold. The proportion of a household's offtake that was sold was not correlated with measures of household demography or wealth. The proportion of an individual hunter's catch that is sold is also correlated with the proportion of the catch that was gun hunted (Figure 4. 7 c), suggesting that gun hunted offtakes may be more likely to be sold that trap-caught offtakes. The same correlation cannot be seen at the household level.

With regression analysis, using a GLM, the best predictors of total hunting incomes were investigated, using the same individual variables as when investigating total offtakes, and adding the proportion of offtake that was gun hunted as an extra predictor. As with total hunting offtakes, the best predictor of an individual hunter's hunting income was age ($F_{1, 56} = 4.67$, $p = 0.013$), and the best predictor of household hunting offtakes was the number of males ($F_{1, 74} = 60.43$ p 0.001).

4.3.2.4 Who buys the most bushmeat?

Wealthier households (using possessions/household or wealth ranking) purchased more bushmeat than poor households (Figure 4. 8), and none of the 12 households with a wealth ranking of 1 (very poor) bought bushmeat. Whether examining all households, or just those that bought bushmeat, households with high hunting offtakes did not buy any less bushmeat than households with low hunting offtakes.

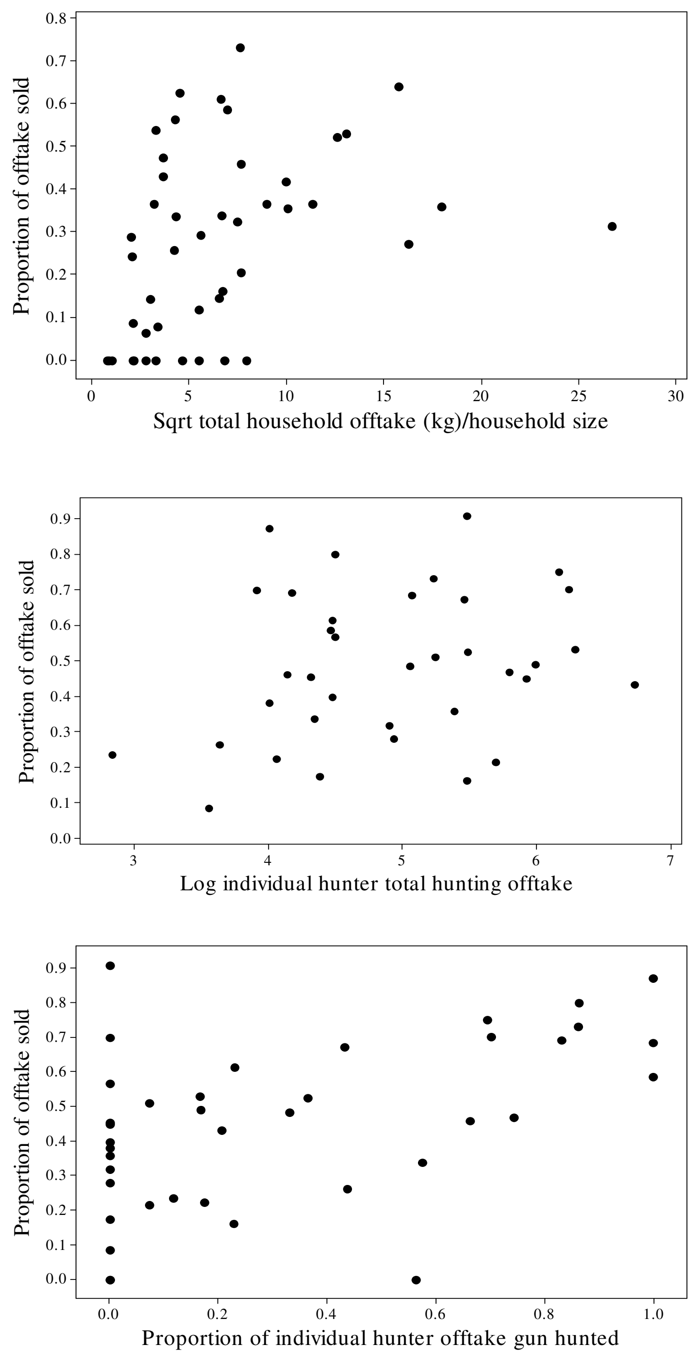


Figure 4. 7: Correlates of the proportion of hunting offtake sold.

a. How the proportion of household offtake sold/household increases with total hunting offtake/person/household ($r = 0.47$, $p = 0.002$, $n = 75$).
b. How the proportion of an individual hunter's offtake sold increases with his total offtake ($r = 0.419$, $p = 0.008$, $n = 37$).
c. How the proportion of an individual hunter's offtake sold increases with the proportion gun hunted ($r = 0.439$, $p = 0.005$, $n = 37$).

(For individual hunter correlations, hunters catching under 10 animals were not used, due to the biases that small sample sizes produce when calculating proportions.)

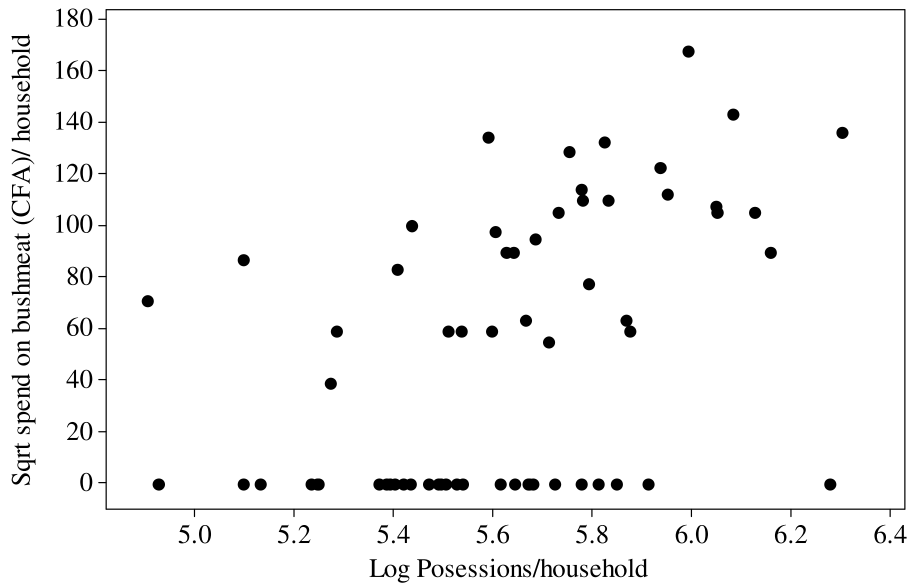


Figure 4. 8: The amount that a household spends on bushmeat increases with household wealth. $r_s = 0.496$ $p < 0.001$ $n = 62$.

4.3.3 Purchasing luxuries and necessities

4.3.3.1 Differences in spending between men and women

Figure 4. 9 describes how men and women allocate their spending. An average of 56.1% of a man's total spend goes on alcohol and cigarettes, and the mean amount of money spent on alcohol and cigarettes by a hunter was equivalent to 54% (s.e. +/- 18.2) of his hunting income during the same study period. In contrast, an average of 53% of a woman's spend is allocated to food, with 30.4% spent on alcohol and cigarettes.

The differences in the amount and proportion of money spent on alcohol and cigarettes and food by men and women were tested using Mann-Whitney U tests (Table 4. 5). Overall, men spent more money in the shop than women. However, although the total alcohol and cigarette spend for men was significantly higher than for women, the amount that they spent on food was not significantly different, indicating that the increase in total spend for men is driven mainly by an increase in spending on alcohol and cigarettes.

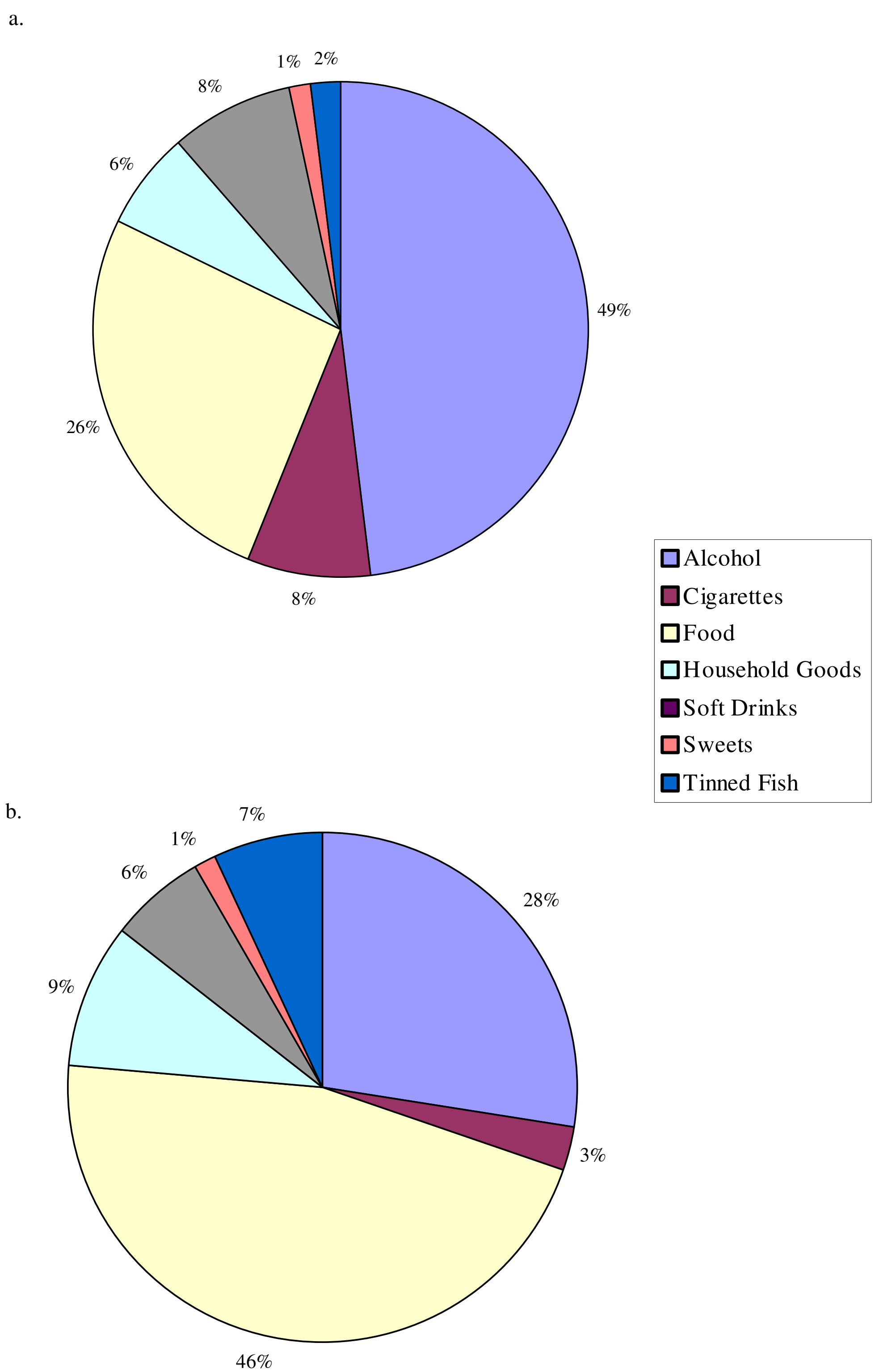


Figure 4. 9: The mean proportion of the total spend on different categories, for (a) men and (b) women.

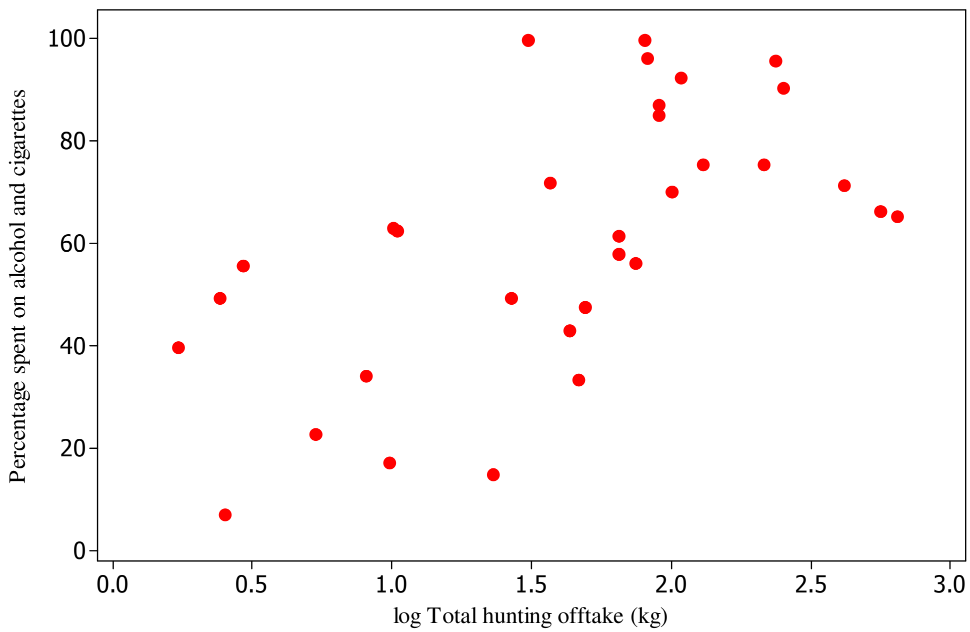
	Median Spend Men (IQ range)	Median Spend Women (IQ range)	Mann Whitney U test W	p
Total Spend All Items (CFA)	5200 1025 – 14,043	1330 100 – 4694	7316.5	<0.001
Total Spend Alcohol (CFA)	2425 150 - 7125	0 0 – 1500	7912.0	<0.001
Total spend Food (CFA)	900 50 - 2250	450 0 – 2331	6558.5	0.417
Proportion spent on Alcohol	0.57 29.9 – 77.1	0.27 0.00 – 51.8	5364.0	<0.001
Proportion spent on Food	0.20 7.5 – 42.9	0.49 25.2 – 88.12	3258.0	<0.001

Table 4. 5: Spending differences between men and women. Significant values are in bold. Italics display the interquartile ranges. Total spend indicates the total amount spent over the study period (June – Feb)

	TOTAL SPEND			PROPORTION OF SPEND		
Hunting Variable	Alcohol and Cigarettes	Food	Household	Alcohol and Cigarettes	Food	Household
Total Biomass (kg)	**0.472** **0.006**	**-0.428** **0.015**	**-0.037** **0.037**	**0.685** **<0.001**	**-0.535** **0.002**	**-0.538** **0.002**
Total Hunting Income (CFA)	**0.333** **0.063**	-0.313 0.081	-0.270 0.129	**0.500** **0.004**	-0.277 0.125	-0.269 0.136

Table 4. 6: Spearman's rank correlations showing how the total and proportion of a hunter's spend in the bar correlates with his hunting offtakes and incomes, by category. Upper values are r_s values, and lower values are p values. Values in bold are significant. N = 32 hunters.

a.



b.

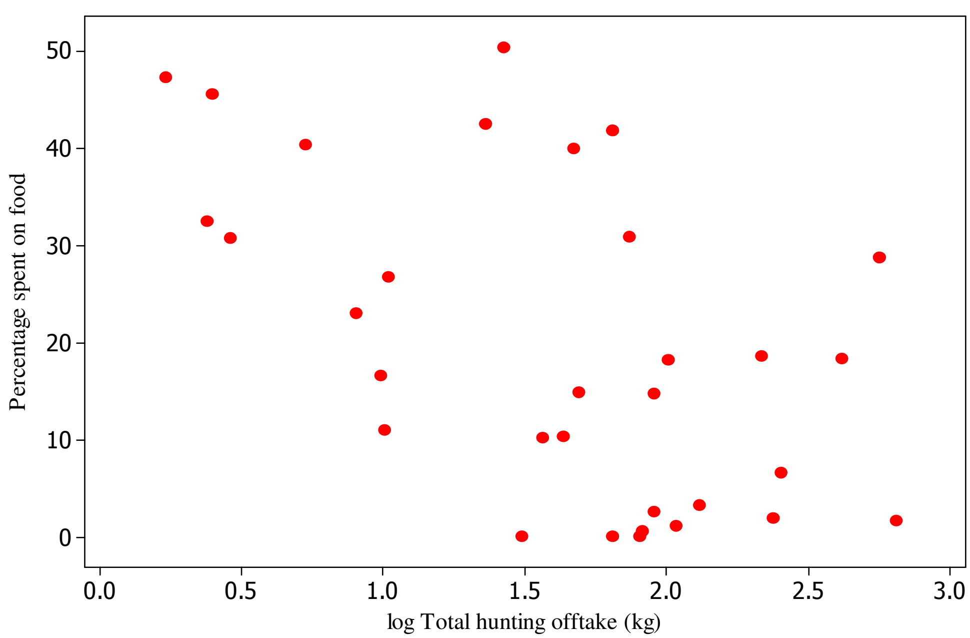


Figure 4. 10: The proportion of the total spend in the village shop that a hunter spends on alcohol and cigarettes (a), and food (b), and its correlation with a hunter's total offtake over the study period (log10 transformed).

4.3.3.2 Hunting offtakes and incomes, and their impact on hunter and household spending

Hunter purchases

Spending by individual hunters was analysed, to examine how individual hunters spent their own hunting returns. Correlations between individual hunting variables and spending suggested that hunters are using their hunting offtakes for the purchase of luxury goods. Hunters who achieved higher hunting offtakes, spent significantly more money on alcohol and cigarettes, and hunters with higher offtakes and hunting incomes also spent a larger proportion of their total spend on alcohol and cigarettes (Figure 4. 10, Table 4. 6). In contrast, the total and proportional spend on food, and household items, significantly decreased with larger hunting offtakes (Figure 4. 10, Table 4. 6).

Household purchases

Further analysis moved from looking at individual hunter spending habits, to those of the entire household, and for different groups (i.e. all of the women, or all of the hunters) within the household. While the amount of luxury goods bought by an individual increase with his hunting offtakes, purchases for the rest of the household did not increase with household hunting offtakes, suggesting that hunters do not use their hunting returns to purchase items for the household. However, food purchase was reduced for households with higher hunting offtakes, which suggests that hunting may contribute to livelihoods at a household level by providing meat.

Purchases by all household members

Univariate correlations between household spending and household wealth and livelihood activity variables, including hunting, were investigated. The total amount that a household spent on cigarettes and alcohol increased with the household's hunting offtakes, as measured by number of animals ($r = 0.482$, $p = 0.013$, $df = 31$), and showed a strong trend with biomass ($r = 0.511$, $p = 0.051$, $df = 31$). Wealthier households (as measured by wealth ranking, and possessions) also bought more alcohol and cigarettes (possessions: $r = 0.482$, $p=0.013$, $df = 31$), and spent more money in the shop in total (possessions: r = 0.422, p = 0.032, df = 31). Spend on food by a household was not correlated with household wealth, nor with any household livelihood activities, including hunting.

Regression analysis, using a GLM, was used to distinguish between the influence of household wealth, demography, and livelihood activities. Household size was forced into the model, to account for increases in spending simply due to an increased number of people in the household. Neither household wealth, nor any of the household livelihood activities (including hunting), were found to be significant predictors of household spending.

Purchases by hunters

This household analysis looked at the purchasing habits of the hunters (as a group) of each household. Hunter spending on alcohol and cigarettes was correlated solely with hunting offtakes (r = 0.521 p = 0.006, df = 31). Food and total spend showed no significant correlations. The results of a GLM (constructed in the same way as with total household spend) found the biomass of the household hunting returns to be the best predictor of hunter alcohol and cigarette purchases (Table 4. 7). There were no significant predictors of food or total spend.

Purchases by non-hunting men

This household analysis looked at the purchasing habits of the non-hunting men (as a group) of each household. Spending by men who did not hunt was not correlated with household wealth or and of the household livelihood activities, including hunting. This was confirmed by the results of a GLM, which gave no significant predictors of spending, suggesting that the non-hunting men in a household do not benefit from the increased luxury purchasing power of hunters in the same household.

Purchases by women

This household analysis looked at the purchasing habits of the women (as a group) of each household. Female spend on alcohol and cigarettes was not significantly correlated with household wealth, or any of the livelihood activities of the household. Money spent on food, however, increased significantly with both the household's agricultural index (r_s = 0.529 p = 0.014, df = 26) and the wealth index of the household (r_s = 0.452 p = 0.035, df = 26), which is highly correlated with the agricultural index). Total spend also increased with plantation returns (r_s = 0.527 p = 0.014, df = 26).

There were no significant univariate correlations between female spending and household hunting offtakes. However, hunting offtakes predicted female spending when incorporated into a regression analysis, using a GLM (Table 4. 7). As hunting offtakes increased, the amount that a household spent on food decreased, which suggests that as the amount of meat coming into a household increases, women of the household have to spend less of their income on food. As previously discussed, women gain most of their income from agriculture, and women's total spend, and spend on food were also predicted positively by household agricultural returns in the model.

4.3.3.3 Seasonal differences in spending habits

Hunting offtakes vary significantly between the wet and dry season. However, there are no significant differences in the percentage spend by individual hunters, on any of the items between the two seasons (e.g. total spend: paired t-test, t_{32}= 0.18, p = 0.859).

a.

General Model	d.f. (change, residual)	F	P
Hunting offtake (kg)	**1, 24**	**5.69**	**0.026**
Size of household	**1, 24**	**5.02**	**0.035**
Household commerce index	2, 15	0.24	0.787
Household agriculture index	2, 17	0.62	0.550
Household possessions (CFA)	1, 18	0.02	0.884

Minimal Model:	Estimate	s.e.
Constant	28.4	16.4
Hunting Offtake	2.58	1.08
Size of household	4.58	2.05

b.

General Model	d.f. (change, residual)	F	P
Hunting offtake (kg)	**1, 18**	**15.87**	**> 0.000**
Household agricultural index	**2, 17**	**6.65**	**0.007**
Household wealth index	3, 13	1.1	0.394
Size of household	1, 17	0.52	0.48
Household commerce index	2, 17	0.01	0.99

Minimal Model:	Estimate	s.e.
Constant	82.0	21.9
Hunting offtake (kg)	-18.84	4.73
Household agricultural index 2 (medium)	53.4	20.5
Household agricultural index 3 (high)	69.8	19.3
Household agricultural index reference level: 1 (low)		

Table 4. 7: Results for a General Linear Model using a normal distribution, showing the terms associated with:

a. Money spent on alcohol and cigarettes by the hunters in a household.
b. Money spent on food by the women in a household.

4.3.4 What are the characteristics of a wealthy household?

The four main livelihood options available to households are Agriculture, Commerce, paid Employment and Hunting. Table 4. 8 shows the correlations of these livelihood activities, with the two wealth indicators and measures of household demography.

Livelihood Activity	Possessions (CFA)	Possessions/ Adult	Wealth Index	Number of Adult Men	Number of Adult Women
Agricultural index (1 – 3)	**0.365** **0.008**	0.119 0.420	**0.646** **<0.001**	0.059 0.666	**0.340** **0.011**
Commerce index (0 – 2)	**0.352** **0.005**	**0.301** **0.023**	0.251 0.065	0.068 0.600	0.200 0.120
Paid Employment (CFA/ month	0.151 0.240	-0.066 0.625	-0.052 0.706	**0.289** **0.023**	0.067 0.605
Hunting (total offtake, kg)	**0.343** **0.006**	-0.161 0.231	0.053 0.681	**0.652** **0.000**	0.213 0.068
Number of women in Household	**0.431** **>0.001**	N/A	**0.444** **>0.001**	N/A	N/A
Number of men in Household	**0.314** **0.013**	N/A	0.246 0.053	N/A	N/A

Table 4. 8: Spearman's rank correlations between the returns from household livelihood activities and household demography and wealth variables. Upper values are r_s values, and lower values are p values.

All households take part in some level of agriculture, and wealthier households have higher agricultural returns. Agriculture is almost exclusively a female activity, with agricultural returns increasing with the number of females in a household, not with the number of males.

Household wealth also increases with involvement in village commerce. The level of commerce is not associated with the number of adults in the household, suggesting that commerce is not labour-dependent; even old men and women can sell goods from their house (often while the more active adults are employed in more labour-intensive work such as agriculture) and the amount of goods sold can increase without increasing the number of people employed.

The collective income from individuals in the household who are employed or receiving a pension does not seem to influence the wealth of the household. This could be because the number of employed individuals in these villages was very low, and the dataset not large enough for any trends to be visible. It could also be because paid employment in these villages is generally short-term, and therefore does not significantly influence long-term wealth indices, such as household possessions.

Men and women contribute to household wealth in different ways. Both the number of men and women in a household are correlated with the wealth of a household, as measured by possessions/household. However, the wealth index, which reflects how village participants perceive wealth, is correlated strongly with the number of women and not with the number of men. This suggests that the participants of the wealth ranking exercise considered women, or the livelihood activities with which women are associated, to be allied with household wealth, rather than the number of men. Agriculture (correlated with the number of women) is also highly correlated with the wealth index, whereas hunting (a male livelihood activity) is not. The best predictors of Possessions per household (regression analysis using a GLM with a normal distribution, Table 4. 9) were the total hunting offtake that was eaten by the household, the commerce index and the agricultural index. Neither any of the other hunting variables nor household income were found to be significant predictors of possessions in the model. It is possible that the wealth of a household might dictate the amount of bushmeat eaten by the household, and therefore the direction of the relationship between the amount of bushmeat eaten and the household wealth is uncertain.

The number of adults per household was then forced into the model, to account for increased livelihood activity that was just due to an increase in the number of adults. In this case, the number of adults, commerce and the agricultural index were found to be the best predictors of Possessions per household (Table 4. 9).

The wealth index of a household could not be used as a response variable, due to low sample sizes for each index level.

a.

General Model	d.f. (Change, residual)	F	P
Sqrt Household incomes (CFA)	1, 47	3.64	0.063
Agricultural index	2, 49	4.42	0.017
Commerce index	2, 49	4.43	0.017
Sqrt Hunting offtake (total biomass)	1, 48	6.02	0.018

Minimal model:	Estimate	s.e.
Constant	5.2828	0.0864
Agriculture 2	0.1852	0.0977
Agriculture 3	0.2779	0.0935
Commerce 1	0.0471	0.0875
Commerce 2	0.2711	0.0919
Sqrt Hunting offtake (total biomass)	0.00844	0.00344

Household agricultural index reference level: 1 (low)
Household commerce index reference level: 0 (none)

b.

General Model	d.f. (Change, residual)	F	P
Adults/ household	1, 48	5.81	0.020
Agricultural index	2, 49	4.01	0.025
Commerce index	2, 49	4.40	0.018
Sqrt Hunting offtake (total biomass)	1, 47	2.00	0.164
Household incomes (CFA)	1, 47	2.13	0.151

Minimal Model:	Estimate	s.e.
Constant	5.3445	0.0869
Adults/ household	0.0505	0.0210
Commerce 1	0.0356	0.0918
Commerce 2	0.2571	0.0964
Agriculture 2	0.2260	0.1010
Agriculture 3	0.3059	0.0975

Household agricultural index reference level: 1 (low)
Household commerce index reference level: 0 (none)

Table 4. 9: Results for General linear models, using a normal distribution, showing the terms associated with: a. Possessions (CFA) per household and b. Possessions per household when the number of adults in the household is forced into the model.

4.4 Discussion

Traditionally, despite NTFP literature to the contrary, bushmeat has been seen as an open-access resource, used as a ‘daily net’ and/or ‘safety net’, and providing important food and incomes for subsistence use (e.g. Bennett, 2002). This case study has provided further evidence that the distribution of hunting revenues, and their use, do not fit this model.

To best describe the use of bushmeat in Dibouka, I have begun by discussing who hunts, what they use their hunting incomes and offtakes for, and how hunting fits within the context of village livelihood activities, and its relative contribution to household wealth. I have then gone on to discuss how this scenario will influence conservation policy, and some of the possible alternative livelihood activities available to village men.

4.4.1 Hunting: Who benefits?

In Dibouka and Kouagna, a few hunters and households account for the majority of hunting offtakes and incomes, despite widespread participation in hunting within the community. Hunting incomes were also highest for wealthy households, and this agrees with studies from the NTFP literature (e.g. Coomes, 2004; Pattanayak and Sills 2001), and with de Merode et al’s hunting study in the DRC (2004). In this study we found that the low hunting offtakes seen in poor households can be explained partly by the lack of adult males within them.

A number of studies (Godoy et al, 1995; Cavendish, 2000, de Merode et al, 2004) that found higher forest resource use among wealthier households also found that although poorer households use a forest resource less, the use of the resource accounts for a higher proportion of household production than for wealthier households. However, Starkey (2004), working in the same villages as this study, found that the proportion of household incomes attributable to hunting were highest for middle-income households, and lowest for the poorest households.

Purchases of bushmeat in the two villages were made by richer households. Socio-economic surveys by Eves and Ruggiero (2000) in villages surrounding the Nouable

Ndoki National Park, Northern Congo also found that wealthier households purchased more bushmeat, and Bassett (2000) hints at the same trend in his Cote d'Ivoire village study, with one of his participants exclaiming 'if you want to eat bushmeat [in the village], you have to be rich!" Bushmeat purchases by wealthier households have also been demonstrated in urban markets (East et al, 2005),

Taken together these results start to provide a picture of resource use which is very different to the poor man's 'open access' resource often described in the bushmeat literature (e.g. Brown and Williams 2003). It suggests that there are barriers to producing high offtakes to hunting (active male labour, and possibly lumpy investments, as suggested by de Merode et al, 2004), which result in resource use by a wealthier minority. In these villages bushmeat may be one of the forest products described by Dove (1993), where commercialisation and market access has shifted resource users to wealthier, members of the village with the assets required to commercially exploit the resource.

4.4.2 How does bushmeat contribute to household economies?

Previous hunting studies (e.g. de Merode, 2004; Starkey, 2004) have looked at the influence of hunting on household incomes. However this is only half the story; we must know what use these hunting incomes are put to before we can understand how they influence household economies.

This study found striking gender differences in the use of incomes, with women spending the majority of their money on food, in contrast to men who spent it on alcohol and cigarettes. This agrees strongly with Solly's (2004) findings in Cameroon.

These gender differences are already well known (but not often published) by development agencies (e.g. FAO, 1996; IFAD, 1999), and although it there has been little published on the impact of men's incomes on household wealth, it seems that the policies of development organisations are already influenced by a perceived gender difference in spending. In Latin American cash transfer schemes, such as those in Brazil and Mexico, subsidies are handed out directly to female heads of households in order to enhance the women's roles in the household, and to reduce the risk of deviation of the resources towards ends other than improving children's nutrition and quality of life (Nigenda and Gonzalez-Robledo 2005). It has been calculated that 70% of the money received is used to increase the availability of food in the household (Hoddinott and Skoufias, 2000).

But are the incomes spent by men and women obtained from different livelihood activities? This study is novel in that it has enabled the use of incomes from different livelihood activities to be assessed, and has shown that as hunting offtakes increase, hunters spend more of their money on alcohol and cigarettes, and less of their money on food. This implies that bushmeat incomes may, to a certain extent, provide disposable incomes for individual men rather than contributing significantly to household wealth. Solly (2001) suggests that in Cameroon the Dja Bulu hunters generally perceive the income earned from hunting as money that you can do little with, and it has a reputation for being frittered away. Kumpel (2006) also reported that in her study village of Sendje, Equatorial Guinea there was a high level of alcoholism for men, and that people tend to live hand-to-mouth, spending whatever money they earn on costly luxuries in the bars, mainly cigarettes and alcohol.

Regardless of their use of hunting incomes, men are making a vital contribution to household food security in Dibouka and Kouagna through the bushmeat that is consumed by the household; total and consumed biomass are the two measures that were both correlated with the wealth of the household. Women's spending on food – best predicted by plantation returns – is also negatively correlated with hunting offtakes. This could be because as hunters bring back more meat for the household to eat, there is less need to buy 'bulking' foods such as rice, bread or pasta. Similarly, the proportion of a hunter's spending that went on food, decreased as his hunting offtake increased. This may be because he has reduced the amount of money that is required for household food by providing meat, and can therefore spend this money on other items. Interestingly as hunting offtakes for a household increased, the percentage of the offtake that was sold also increased. This might reflect a household's requirement for a certain level of bushmeat, after which hunters can sell the remaining meat, and spend the proceeds as described.

That hunting provides an essential source of protein has been well documented in previous studies (Anstey, 1998, Fa et al 2003, Bennett et al, 2000b). It has also been hypothesised that incomes from hunting can be just as important for rural livelihoods, as they represent a large proportion of total household incomes in many areas (Infield, 1998; Brown and Williams, 2003). Results from this study suggest that incomes from hunting, and the savings which men make on food spending due to hunting, are not directed into the household to pay for subsistence goods, but rather provide cash for individual hunters, to spend on luxury goods. If this is the case, then the argument for maintaining the bushmeat trade as poverty alleviation tool has little ground. In fact, reduction in commercial hunting may benefit rural livelihoods by reducing the pressure on an important food security resource.

In Dibouka and Kouagna hunting incomes represent on average 15% of household incomes (Starkey 2004). It would be interesting to test whether in communities where hunting incomes represent a higher proportion of total household incomes (e.g. De Merode, 2004 (25% of incomes); Infield, 1998 (33% of incomes), Starkey, 2004 (villages further from Koulamoutou than Dibouka, 61% of incomes) these patterns of hunter and household spending remain the same, or whether hunting incomes are used increasingly to buy subsistence goods.

4.4.3 Which livelihood activities contribute to household wealth?

In this study, possessions per household were correlated with the number of adults in a household, plantation returns, hunting offtakes (though not incomes) and commercial activity. Interestingly, the wealth index for each household, created by village participants, was not correlated with hunting returns or the number of men per household, suggesting that the community perceive women, agriculture and commerce to be more beneficial to household wealth.

These correlations cannot tell us about the relative contributions of different livelihood activities to these households. For an idea of this we can refer to Starkey (2004), who studied household incomes from different livelihood activities in the same area, and found that from a pooled sample of villages 75% of the village's incomes were from agriculture, and 24% from bushmeat.

Women almost exclusively controlled agricultural work in these villages, and strong correlations between household agricultural rankings and the number of women in a household confirms this. An assessment of rural poverty by IFAD (1999b) found that in Gabon, women are responsible for 95% of the labour in the plantations, usually working around 15 hours a day, whereas men generally spend 2 to 3 hours a day on agriculture. It is now commonly recognised that in poor African households women farmers usually work longer hours than men, and are responsible for the bulk of the agricultural labour (Gelb, 1997).

Despite being the backbone of agricultural production, women do not have complete control of agricultural incomes. From talking informally with the women in Dibouka, I was told that where a woman had a husband she would generally give him 50% of agricultural incomes. Men kept control of all their hunting incomes; he could spend some on his family, but there was no general rules concerning how they were allocated. This also applied to his plantation share – when asked about how their husbands would spend the agricultural incomes, women replied that it was his choice. Limited access to resources, including incomes, is the norm for women in sub-Saharan Africa (FAO 1996).

In this study, hunting is therefore a resource with access limitations, used by the wealthier sections of the community. Hunting offtakes used for consumption benefit the household economy directly by providing a valuable source of protein, and indirectly by reducing the amount of money that women, the main food providers, need to spend on food. Incomes from hunting, however, are used to a much greater extent to buy luxury goods for individual hunters. If this is the case, then commercial hunting pressure might be eased by providing alternative sources of income for village men. So what are the options?

4.4.4 Men's livelihood activities: Alternative income opportunities?

Looking at male activity budgets for Kouagna, it is immediately apparent that apart from agriculture and hunting, there are very few livelihood opportunities for men in the village. This is supported by the work done by Starkey (2004), which showed that livelihood activities other than agriculture and hunting accounted for only 4.7% of the household economy. Employment or commercial opportunities are either transient (as with the market garden, goat rearing or planks) or there are a finite number of people who can engage in the activity (such as bars or shops).

Where employment opportunities existed in the village, the case studies outlined in Table 4.2 suggest that hunters may be willing to leave their traps for more formal employment. Informal discussions I had with hunters regarding employment opportunities support these case studies. All but the oldest hunters (some who had retired from formal employment in town and come back to their village for their retirement) expressed a wish to find formal employment, whether in town or in the village:

'*At the moment, because I still have work to do, I cant spent my life in the village yet. I need to go and work, but unfortunately I have my family! I have to make sure that my parents are provided for when I leave the village. So, if I have that [organised], then I can leave the village. I would like to go into commerce, that is what I would like to do'*

Interview# 41, Hunter 34, aged 30

If there was work I would leave my trap and my gun hunting as well, to go and work. But there is none. We wait, but we find nothing. We go into town to look for work but there is nothing. You need to know someone to get you a job, but with no-one you are forced to stay in the village, and trap and gun hunt.

Interview # 55, Hunter 24, aged 26

Often young men were frustrated with their village life, and said that employed town life was much preferable. One of the barriers to finding employment in town was that in order to look for work, one had to be based in the town. However, without an income, town living is too expensive for most villagers, and so they find themselves in a catch-22 situation.

Informal interviews with hunters also suggested that few of the hunters had been based in the village for large amounts of their adult life. Men tended to move out of the village when paid employment became available, generally with transport or extraction industries. These jobs however, were often short-term and contracts could be terminated abruptly. When work was unavailable, men tended to return to the village, because life in town without employment was too expensive, and would then leave when another job became available. In this intervening village time, they resumed hunting.

'I was in Lastourville to look for work. My uncle, who worked for SBL (a logging company) could not find me work, and could only find 10,000 CFA for me. With 10,000 CFA you can't live. I was obliged to return here, to press cane sugar and to go hunting.'
Interview #39, Hunter 32, aged 21

'I returned from the village [after leaving employment as a driver] because you must find employment! I tried to work at Comilog [a mining company], but I didn't find anything. At the moment in Gabon its politics that finds you work! You need to know someone [in the company]. There are lots of companies but…I was obliged to return to the village.'
Interview #49, Hunter 25, aged 38

This is not a new phenomenon – many of the old men had spent their lives in different towns/ logging concessions in Gabon, returning to the village between jobs and now hunting in their retirement. Hunting is an activity which can be put down and picked up whenever other commercial activities appear and disappear, and can be used to supplement other incomes; in this way it is a classic 'daily/safety net' NTFP.

Similar observations were made by Noss (1998b) in CAR, who found that most snare hunters shifted between formal and informal occupations that included hunting, fishing, raffia wine tapping, diamond mining, farming and logging, and moved to and from their village in pursuit of these occupations.

Apart from hunting, agriculture is the other main male livelihood activity in Dibouka and Kouagna. However agriculture is not traditionally a male activity, and agricultural returns for a household correlate with the number of women in a household, not the number of men. Men are needed to clear the plantation for the next agricultural season, and during the dry season, men switch from hunting to plantation clearing; this seasonal switch has also been described by Delvingt (1997) in Diba, Congo, Jeanmart (1998) in Ekom, Cameroon, and Kumpel (2006) in Equatorial Guinea. However, despite this seasonal effect, men who spend more time on agriculture do not spend less time on hunting, and vice versa. It would also be unwise for a household to invest all of its effort in agriculture, rather than diversifying as much as possible; if agricultural returns fail, it is important to have alternative incomes in place.

If commercial hunting was reduced through declining animal abundance, or conservation action, there would be a need for other cash opportunities in the village that are not as transient as those I observed over the study period. Most employment is to be found in town, or in logging concessions, not in the village. The migration of active men towards employment opportunities can lead the current situation in Gabon: a dwindling village population comprised of the very old and the very young. Those men who do stay in the village generally hunt, possibly due to lack of any other opportunities.

Cocoa production used to be an alternative male livelihood strategy in Dibouka and Kouagna. Cocoa plantations in Gabon are being revived by the International Cocoa Organisation (ICCO), with a new 5 year project to "recreate a viable and productive cocoa sector in Gabon based on private smallhold farming and characterised by relatively high yields, thus enabling farmers to earn comparatively high incomes, resulting in a cocoa sector no longer dependent on government support and services" (ICCO, 2001). If there were other cash-providing opportunities then this might reduce the amount of commercial hunting done by men. When asked about the amount of hunting that went on over the years in Kouagna, the chief of the village (Hunter 62) said that the amount of hunting was lower in 1987 – 1990 because of the cocoa plantation that was based in the neighbouring village, Ndjole (Interview #31). Many of the men worked for the cocoa plantation, and did not have time to hunt as much, suggesting that cash alternatives might reduce hunting pressure. Basset (2005) found in Cote d'Ivoire that with the collapse of the cotton industry in the 80's and early 90's, hunting pressure increased. Rural communities were responding to the reduced incomes from cotton by diversifying their activities, and commercial hunting was one of the ways that they did this.

However, alternative incomes sources for men may not result in a decrease in hunting. As we have discovered, bushmeat purchases are generally by the wealthier sections of the community. Therefore increasing the cash incomes of a household may increase demand for bushmeat within the village. Removing a hunter from the system may just increase the amount of hunting that the remaining hunters carry out, or result in a switch in techniques. Damania et al (2005) created a multispecies simulation model of hunter behaviour parameterised with data from Ashanti, Ghana. They found that although an increase in agricultural prices resulted in a smaller amount of time that was allocated to hunting, the amount of gun hunting carried out increased, wildlife populations declined, and the two most vulnerable species became extinct.

Chapter 5 :

The characteristics of the commodity chain from forest to town

Chapter 5

5.1 Introduction

Village hunting offtakes provide hunters and hunting households with a source of income and food, and as the previous chapter has illustrated, these two uses have different impacts on the household economy. This chapter will now describe the characteristics of the catch by use: the catch that is eaten compared to that which is sold within the village, and the catch that is sold and sent to the nearest market.

Why is this analysis of catch characteristics by use important? Firstly, if we understand the proportions, and the characteristics, of animals used for the commercial trade, we can determine whether there is a difference in the way that commercial use and use of wildlife for food targets local animal populations, taking in account the level of hunting selectivity. Analysis of the characteristics of sold animals, combined with information on prices gained for each animal, can also provide us with valuable information on the bottom-rung of the bushmeat commodity chain, including information on the demand for different animals from urban markets onto rural sellers. With this information, we can begin to understand how changes in prices and market demand will influence what is sold from the village.

As Cowlishaw et al. (2005) observe, because most work on the bushmeat trade has focussed on the biological implications, rather then the socio-economic aspects of the trade, very little is known about the structure of the bushmeat commodity chain, and the way in which species and incomes flow from the point of extraction to consumer purchase. This is especially true of the bottom-rung of the commodity chain, from forest to first sale, as the few studies published on the bushmeat commodity chain (Mendelson et al, 2003; Cowlishaw et al, 2004; Cowlishaw et al, 2005; Cowlishaw et al, 2005b) have concentrated on the market end of the chain, and on the actors involved in selling the meat in urban areas. To date, the majority of village studies that describe overall catch characteristics have only followed the fate of the catch as far as quantifying the percentage of meat that is sold (Table 5. 1).

Site	Percentage of catch sold	Source
Kiliwa, DRC	90%	De Merode et al (2003)
Bayanga, CAR	73%	Noss (2005)
Monte Mitra, Equatorial Guinea	68% (50% village, 50% town)	Fa and Yuste (2003)
Diba, DRC	68%	Delvingt (1997)
6 villages near Koulamoutou (includes Dibouka and Kouagna)	59%	Starkey (2004)
Dja Reserve, Cameroon	56% (90% sold in village)	Solly (2004)
Oleme, DRC	54%	Delvingt (1997)
South-west Congo	50%	Wilson and Wilson (1989)
Ekom, Cameroon	40%	Delvingt (1997)
Kanare, CAR	35%	Delvingt (1997)
Northeast Gabon	30 – 60%	Lahm (1993)
Tabora district, Tanzania	14%	Carpaneto and Fusari (2000)

Table 5. 1: The percentage of the total catch that is sold, from different study sites.

Where the characteristics of sold bushmeat have been described, a bias towards larger-bodied, gun hunted species being sold has been suggested. Noss (1998) in the Central African Republic, compared village offtakes to what was on offer at the nearest market, and found that of the 18 species caught in the village, only seven were represented in the market during the same study period. Species present in the market were four species of red duiker, red river hog, and two species of monkey. Those missing from the markets were smaller-bodied, including civets, mongoose, pangolin, brush-tailed porcupine, giant pouched rat, several bird species and one species of snake. Fa and Yuste (2001), studying village hunting in Equatorial Guinea, reported that across species, the proportion of animals that were sold to market were positively correlated with the body mass. Re-analysis of data presented in Delvingt (1997) on the proportion of each species sold in Diba, DRC, also shows that the proportion of a species that was sold was significantly correlated with its mean mass (linear regression: percentage sold = 32.4 + 1.70/ kg, $p = 0.016$, $r^2 = 40.1$ $n = 12$ species).

Gun hunting is thought to be more commercial than snaring, due to its selectivity and increased efficiency. Through hunter follows in Nouabale-Ndoki, Northern Congo, Wilkie and Carpenter (1999) calculated the estimated rate of return for shotgun hunting at 7 to 25 times higher than with traditional weapons such as bows and nets, and Alvard (1993) has shown that gun hunters will selectively kill the most profitable prey, leaving smaller, more unprofitable species. Solly (2004) found that gun hunters in the Dja reserve, Cameroon, often had a strong commercial motivation to hunt, and had the highest earnings per hunter of all hunting types, even though they had lower total offtakes than other hunters. We might expect therefore to see a higher proportion of gun-hunted animals sold than those from other hunting techniques.

Finally, village hunting studies have also been able to study the level of trap wastage, which tells us about the proportion of meat that never even makes it onto the commodity chain (Table 5. 2). Estimates, using hunter record and hunter follows, range from 4 to 27%, although the figure from Noss (1998) is the most widely used in the literature.

Area	**Wastage**	**Source**
Dja reserve, Cameroon		Muchaal and Ngandjui (1999). Hunter follows
	5.7%	<=1.5 km from village
	18.8%	>1.5km, <= 15km from village
	28.5%	>15 km <=30 km from village
Diba, DRC	4%	Delvingt (1997). Recorded by hunters in notebooks.
Oleme, DRC	4%	Delvingt (1997). Recorded by hunters in notebooks.
Udzungwa mountains, Tanzania	17%	Nielsen (2006). Hunter questionnaires.
Kanare, CAR	20%	Delvingt (1997). Recorded by hunters in notebooks.
Ekom, Cameroon	26%	Delvingt (1997). Recorded by hunters in notebooks.
Bayanga, CAR	27%	Noss (1998). Hunter follows.

Table 5. 2: Estimates of trap wastage.

Although these studies provide us with some clues as to the characteristics of the bottom rung of the commodity chain, there have been no studies to date that have comprehensively analysed which catch characteristics influence whether an animal is sold or eaten, and the movement of meat from forest to market. Similarly, information on demand for bushmeat has focussed on consumers at the market level (Wilkie et al, 2005; East et al, 2005; Wilkie and Godoy, 2001), and little is known about demand at the village level, and how prices are affected by catch characteristics. The first aim of this chapter is therefore to provide information on supply and demand at the bottom-rung of the commodity chain for this site, including a thorough analysis of which catch characteristics are the best predictors of whether an animal is eaten or sold, and of price.

Knowledge of the biases in the characteristics of the catch that is sold to town is also required to evaluate the use of markets as a monitoring tool for the bushmeat trade. In order to directly assess whether hunting is sustainable, information on village offtake rates, and animal densities within the hunting catchment, is required (e.g. Muchaal and Ngandjui, 1999; Fitzgibbon et al., 1995; Peres, 2000b; Hart, 2000). However, village studies of this nature require substantial time and effort, and do not lend themselves to long-term data collection, or monitoring of large areas. Markets on the other hand are well suited to longer-term data collection, as they provide a bottleneck of easily accessible information on the bushmeat trade. Market studies have provided a first look at the bushmeat trade (e.g. Wilson and Wilson, 1989; Steel, 1994; Juste et al 1995), are used to assess the country-level magnitude of the trade (Fa et al, 2006), and have more recently been suggested as a tool for long-term monitoring and assessment of hunting sustainability.

Rowcliffe et al (2003) and Jerozolimski and Perez (2003) suggest that market data can provide an index of sustainability, from the proportion of large-bodied to small-bodied species over time, with a decline in the ratio suggesting depletion of the wildlife resource. This idea has been taken from the fisheries literature, where the decline in the mean trophic level of species groups of fish over time has been described as ‘fishing down the food chain’, and has been demonstrated by Pauly using global fisheries catch data from 1950 – 1954 (Pauly, 1998). Wilkie and Carpenter (1999) used this trend as a rough tool for comparison of levels of depletion between sites in Central Africa, producing an index of rodents to duikers from the catch data of the different sites, where a high proportion of duikers would imply a less depleted area. Fa et al (2000) found similar trends from market data in Equatorial Guinea with smaller-bodied species making up a higher proportion of the number of animals found in the market during a 1996 survey, compared to an earlier survey in 1991. Cowlishaw et al (2005b) looking within one time frame found that large-bodied species were not present in Takori market, Ghana, suggesting that the level of hunting was unsustainable for these species. However, small-bodied species seemed to be persisting, and Cowlishaw suggests that this may be evidence of post-depletion sustainability for small-bodied species with high reproductive rates. Recently Crookes et al (2005) were able to test for an increase in the proportion of small-bodied species over time, using a 15-year dataset from 1987 – 2002 from the Kumasi bushmeat market, Ghana. No increase was evident, possibly due to the post-depletion nature of the market.

Market data have also been used to compare the number and prices of certain species present in markets over time. Milner-Gulland and Clayton (2002) looked at the change in the number and price of wild pigs in a North Sulawesi market over a ten-year period, and found that numbers of pigs bought by individual dealers were decreasing and prices were increasing. Crookes et al (2005) also found an increase in real bushmeat prices in the Kumasi market.

In rare cases, market data has even been used to directly assess the sustainability of hunting offtake for an individual species. Refisch (2005) assessed the consumption per capita per year of a number of monkey species in the Tai region, Cote d'Ivoire from market surveys, and compared these figures with the maximum sustainable yield of these species, in order to assess the sustainability of monkey hunting in the region.

Longer-term use of markets, as a practical tool to track changes in bushmeat consumption and sustainability has also been established. In 2000, WCS Gabon began a countrywide bushmeat monitoring programme, encompassing 6 of the major markets, to keep track of bushmeat use and sustainability, with a view to informing and testing policy (WCS 2006)

However, in order to be confident in our use of markets as a reflection of hunting sustainability at the source (villages, or the forest) we need to know how well the market data reflect original offtakes. Crookes et al (2005) used their study of Kumasi market, Ghana, to look at some of the potential biases of market data. They suggest that due to hunter selectivity in the animals that they sell, the animals appearing in market represent a biased proportion of the animals killed, with smaller-bodied species being eaten while the more profitable, larger-bodied species are sent to market. This could result in an inaccurate reflection of hunting pressure and hunting sustainability. Crookes et al (2005) also hypothesize that markets might not show a decrease in large-bodied species or prices, even when species are becoming locally extinct, due to changes in the market catchment area. They found that over time, animals were coming from villages that were further and further away from the market, possibly due to local depletion. This same trend was shown by Milner-Gulland and Clayton (2002). In this case, information on purchases of wild pigs, by dealers, showed that between 1988 and 1999 the time that dealers needed to drive from the market in order to purchase pigs had increased by 30%.

Aside from Crookes et al (2005), there has been little research into market biases. Currently, WCS is carrying out a study designed to test and compare indirect monitoring methods, including the use of market data, at Nouable Ndoki national park, DRC (Eaton, 2004). Information on direct species counts, hunting offtakes, and market data are being compiled to test the effectiveness of markets as monitoring tools, but as yet there have been no published outputs. Although on a smaller scale, this study allows a first look at how the composition of the catch changes from forest to the first level of town vendors, and so can provide some preliminary hypotheses as to how market data may be biased, and how this may affect the best use of market data as a monitoring tool.

In order to study the bottom-rung of the commodity chain, and to evaluate biases in market data, this chapter will examine which catch characteristics are associated with whether an animal is eaten or sold, providing information on the changes the composition of the catch from forest to market, and which characteristics influence price, providing information on village and market demand. Specifically it will look at associations between species, mass, hunting type, state and season on the probability of an animal being sold, and the price gained for an animal.

5.2 Methods

5.2.1 Data

As described previously (Section 3.4.2.3, Chapter 3), information on catches from hunting trips was recorded from the beginning of February 2004 until the end of January 2005. For each hunting trip, data were collected on the following characteristics of each animal:

Mass (kg)
Species (in 16 categories, described in Section 5.3, results)
State (alive, fresh, decomposed, rotten and smoked)
Hunting type (gun, trap, dog, net)
Season (dry and wet)

The general collection methods and categorisation of these characteristics are described in Section 3.4.2.3, Chapter 3. During the study, most animals were caught through trap (67.9%) or gun (30.6%) hunting. Due to the low numbers of animals caught using dogs (1%) or nets (0.5%), only gun hunting and trapping were considered within hunting type for these analyses.

I also recorded the destination of each animal, in ten categories:

1. Discarded – rotten trap meat is left in the forest.
2. Eaten by the hunter/ the hunter's household.
3. Sold by the hunter in the village.
4. Sold by the hunter to a nearby village.
5. Sold by the hunter to a buyer travelling through the village to the nearest town, Koulamoutou.
6. Sold by the hunter in Koulamoutou.
7. Given to someone else in the village.
8. Used in a ceremony.

9. Commanded – when a hunter is paid, generally in gun cartridges, to go gun hunting. The hunter will then keep a proportion of the catch, and has no hunting costs, but receives no money for the meat that is given to the person who commanded the meat.
10. Kept – animals are sometimes kept alive until they reach maturity.

The animals given or kept represented very small proportions of the catch (six and five animals respectively), and these sample sizes were too small for individual analysis. Animals that were commanded (21 animals, less than 1% of the catch) or hunted due to a ceremony (58 animals) already had a predetermined fate, and so were not used in this analysis. Therefore, due to sample size, ease of analysis, and relevance to the questions being asked by these analyses, the destination of the catch was firstly classified as ‘eaten’ (eaten by the household, given or kept – categories 1,7, and 10) or ‘sold’. ‘Sold’ was then divided into two categories; sold within the village (Dibouka or Kouagna – category 3) and sold to town (animals sold to Koulamoutou – category 5 and 6). The 2% of animals that were sold to villages other than Kouagna or Dibouka (category 4) were not included in the analysis.

Whether an animal was eaten or sold was known for 88% (2333) of the animals, and only these animals were used in the eaten/ sold analyses. Within sold animals, whether an animal was sold to town or sold within the village was known for 74% (617) of animals. For those animals that were sold, the price gained for the animals, in CFA, was known for 90% of animals. A summary of the mean weights and prices recorded for each species can be found in Appendix 3.2.

5.2.2 Analyses

Using these data the proportion of animals that were eaten, sold and sold to town was described in terms of individual animals, total biomass, and number of species. When looking at the number of species present for each destination, a bootstrapping technique, with replacement, was used to control for the effect of sample size. The original catch was sampled 10,000 times, with the original number of animals eaten, sold, sold to the village and sold to the town providing the sample size. For example, 347 animals were sold to town, therefore a sample of 347 animals was randomly selected from the original catch 10,000 times, to calculate the mean number of species one would expect to find in a subset of 347 animals drawn randomly from the original catch. This provided an expected number of species for each sample size, with respective confidence intervals, which could be compared with the observed species eaten, sold and sold to town.

To understand which of the catch characteristics were associated with whether an animal was eaten or sold, and whether it was sold in the village or sold to town, univariate analyses of the characteristics of the catch by destination were carried out using the whole dataset (for example, the mass of eaten animals compared with sold animals). Univariate analyses were also used to investigate how different catch characteristics covaried (for example, whether there was a correlation between hunting type and weight, or the species caught with the season). This showed that catch characteristics are not independent from one another and so General Linear Models, with a binomial error structure, were used to find the best predictors of whether an animal was eaten or sold, allowing the interactions between catch characteristics to be tested. There were too many species with low sample sizes to include species as a factor in the analyses, so the GLM was carried out twice using data for two species where sample sizes were adequate - brush-tailed porcupines and blue duikers - to allow for exploration of patterns independent of species. Sample sizes were too small to conduct these analyses looking at whether an animal was sold within the village or sold to town.

In the same way as with the destination of the catch, univariate analyses were also used to look at how price varied with catch characteristics, and two GLMS were carried out in order to find the best predictors of price, using data for brush-tailed porcupine and duikers. Finally, the characteristics, destinations and prices of animals that were cut into pieces, known as gigots, were analysed, and the use of certain species for ceremonies described.

5.3 Results

5.3.1 The overall proportions of animals sold:

In total, 2647 animals were caught by hunters from Dibouka and Kouagna in the 12 months from February 2004. Of these, 51% were eaten, 17% were sold within the village, and 22% were sold to town. A higher proportion of the total biomass was sold; 40% of the total biomass was eaten in the village, 19% sold within the village, and 31% sold to town.

Of the 50 known species that were caught over the study period, 47 were eaten in the village, whereas only 28 species were represented in the animals sold in the village and town. Within those animals that were sold, 19 species were present in the catch sold within the village and 17 in the catch sold to town. Bootstrapping reveals that the numbers of species sold, sold in the village and sold to town are considerably lower than what one would expect through sampling effects alone: fewer species are sold than would be expected by chance (Table 5. 3).

	Observed number of Species	Expected number of species (mean number from bootstrapping)	95% Confidence Interval
Total catch	50	-	-
Eaten	47	43.46	39 - 47
Sold	28	41.17	37 - 45
Sold to Village	19	33.41	29 - 38
Sold to town	17	30.71	26 - 36

Table 5. 3: Observed and expected species numbers at each point in the commodity chain

5.3.2 Relationship between the characteristics of animals caught and their fate.

5.3.2.1 Mass

The mean mass of animals caught in Dibouka and Kouagna was 3.9 kg. Overall, sold animals are heavier than those eaten (mean mass of eaten animals = 2.6 kg; sold animals = 4.7 kg; Mann Whitney U test: $W_{987, 622} = 651828$ p <0.0001). Animals sold to town weighed significantly more than those sold in the village (mean mass of animals sold in village = 3.9 kg, sold to town = 5.8 kg; Mann Whitney U test: $W_{200, 266} = 40583$, p <0.0001). The proportion of animals sold increased significantly with the mean mass of species (Figure 5. 1), and therefore the ratios of the number of small: medium: large-bodied species varied with the fate of the catch (Figure 5. 2).

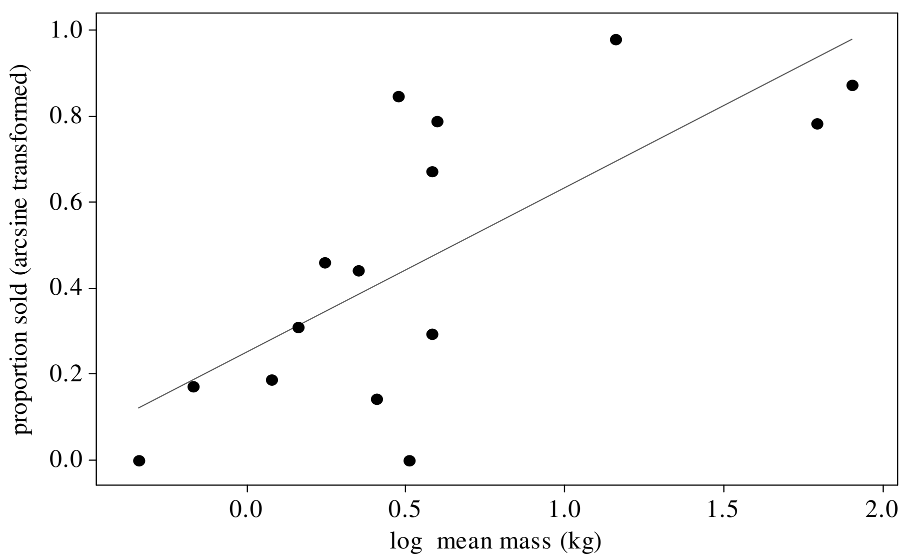
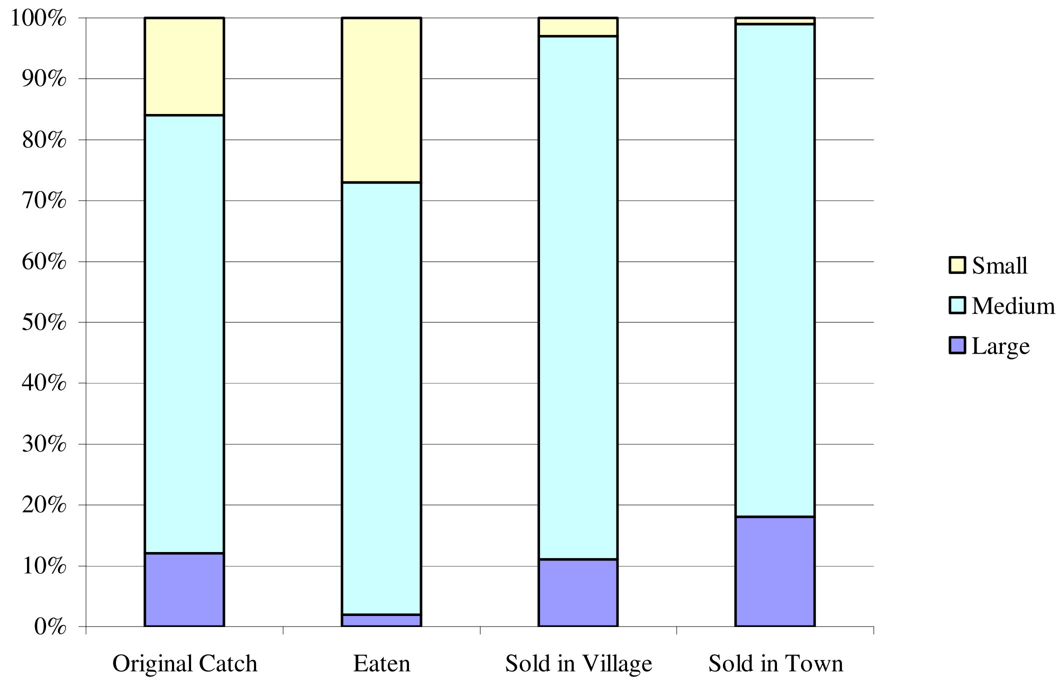


Figure 5. 1: The proportion of the catch sold increases with the mean mass of a species. Pearson's correlation: r = 0.72, p= 0.002.

a.



b.

	Original Catch	Eaten	Sold within village	Sold to town
Small: Large	1:1	11:1	1:3	1:21

Figure 5. 2:

a. The proportion of small: medium: large species varies with the fate of the catch. a. Bar chart, showing the percentage of the catch made up of small (0 – 2.0 kg), medium (2.1 – 8.0 kg) and large (8.1 – 35kg) species for each catch fate.

b. b. Ratio of small: large species at each point in the commodity chain.

5.3.2.2 Species

Table 5. 4 describes the species composition of eaten animals compared with sold animals. Chi squared analysis, comparing numbers of individuals, showed that there were significant differences in the proportions that were eaten and sold among species. A larger proportion of blue duikers (50% sold), porcupines (56%), red duikers (69%) and red river hog (71%) were sold than expected. Monkeys (39% sold) were sold in the expected ratio. Smaller-bodies animals, including pangolins, birds, civets and mongooses, rodents and reptiles, were sold infrequently.

Within the animals that were sold, more red duikers (70% sold) and African palm civets (85%), and fewer pangolins (17%) were sold to town than expected ($\chi^2 = 21.95$, df = 6, p = 0.001). These biases in the species that are sold, and sold to town resulted in large differences in species composition between the original catch and the catch sent to town. Red and blue duikers, and brush-tailed porcupines together represented 90% of the biomass of the catch that was sold to town. In comparison, these three species comprised 65% of the biomass of the original catch, with a range of other species categories making up the remaining 35%. Appendix A3.1 describes the species composition of the original catch compared with the catch sold to town.

A bias towards certain species being sold was also apparent when looking within hunting type (gun hunting: $\chi^2 = 113.2$, df = 6, $p < 0.001$, trap hunting: $\chi^2 = 258.8$, df = 11, $p < 0.001$) Within both trap and gun hunting, porcupines and red duikers were sold more often than expected, and smaller-bodies species were sold less frequently. Within gun hunting, monkeys were sold more than expected. The number of blue duikers sold or eaten did not vary significantly from expected values, within trap or gun hunting. In both cases, red river hog were not present in large enough numbers to include in the analysis.

Species Category	Number of animals eaten	Number of animals sold	% Sold	Expected values		Standardized Residuals	
				Eaten	Sold	Eaten	Sold
Brush-tailed Porcupine (	349	450	56	451	348	-9.31	9.31
Red duikers (*Cephalophus sp.)*	77	168	69	138	107	-8.43	8.43
Bay/Peter's *(C. dorsalis, C. callipygus)*	53	133					
White-Bellied *(C. leucogaster)*	6	11					
Ogilby's *(C. ogilbyi)*	5	6					
Black-fronted *(C. nigrifrons)*	1	2					
Water chevrotain *(Hyemoschus aquaticus)*	4	9					
Red river hog *(Potamochoerus porcus)*	5	13	71	10	8	-2.47	2.47
Blue duiker *(Cephalophus monticola)*	152	154	50	173	133	-2.60	2.60
Sitatunga *(Tragelaphus spekeii)*	6	6	50	7	5	-0.46	0.46
Monkeys	87	55	39	80	62	1.19	-1.19
Moustached guenon *(Cercopithecus cephus)*	65	35					
Putty-nosed guenon *(Cercopithecus nictitans)*	10	9					
Grey-cheeked mangabey *(Lophocebus albigena)*	1	3					
Crowned guenon *(Cercopithecus pogonias)*	5	2					
Black colobus *(Colobus satanus)*	0	2					
African palm civet *(Nadinia binotata)*	42	17	29	33	25	2.31	-2.31
Hyrax/potto *(Dendrohyrax dorsalis, Perodicticus potto edwardsi).*	16	0	0	9	7	3.50	-3.51
Large birds *(Corythaeola cristata, Tauraco persa, Bucerotidae sp.)*	29	3	9	18	14	3.92	-3.92
Cane rat *(Thryonomys swinderianus)*	33	3	8	20	16	4.29	-4.29
Small birds	33	1	3	19	15	4.79	-4.80
Squirrels and small rats *(see appendix x for all squirrel and rat sp. recorded)*	33	0	0	19	15	5.04	-5.06
Civets, genets and mongooses *(Civettictis civetta, Genetta servalina, Herpestes sanguinea, Atilax paludinosus, Bdeogale nigripes, Herpestes naso)*	47	3	6	28	21	5.40	-5.41
Pangolin *(Uromanis tetradactyla, Phataginus tricuspis)*	106	26	20	75	57	5.70	-5.70
Reptiles *(see appendix x for all reptile sp. recorded)*	48	1	2	28	21	5.90	-5.90
Giant pouched rat *(Cricetomys emini)*	111	4	3	65	50	8.87	-8.88

Table 5. 4: The number of animals of each species category that were sold and eaten, and the expected values and standardised residuals calculated from a Chi-squared test. Chi squared = 391.462, DF = 15, P-Value <0.001. Species are ranked by their standardized residuals.

5.3.2.3 State

Analysed by numbers of individuals, 10% of trap-caught animals were alive, 50% fresh, 22% decomposed and 8% rotten. An additional 10% percent of animals were subsequently smoked, which disguises their previous state; animals may have been smoked when the length of the hunting trip would result in decomposition of the animal before reaching the village. Animals were also smoked when they are already very rotten, to remove maggots and rotten flesh, preserve the meat from further decomposition and possibly to disguise the original state when trying to sell meat.

Rotten animals were neither sold nor eaten. As the state of meat worsened it was less likely to be sold, and less likely to be sold to town, and as a result of this, the state of meat that reached the market did not reflect the state of meat originally caught (Figure 5. 3).

Figure 5. 3: The state of meat with fate of the catch.

Chi squared Eaten vs. sold for different states (excluding rotten): $\chi^2 = 198.14$, df = 3, p <0.001

Chi squared sold village vs. sold town for different states (excl. rotten): $\chi^2 = 15.32$, df = 3, p = 0.002

5.3.2.4 Hunting type

Overall, 31% of animals were caught through gun hunting, and 68% through trap hunting. Animal were more likely to be sold if they were caught through gun-hunting (69% sold) than trapped (47% sold) (χ^2 = 34.58, df = 1, p <0.001), and gun hunted animals were more likely to be sold to town rather than the village (53% of the sold gun hunted animals, 36% of sold trap-caught animals; χ^2 = 45.71, df = 1, p < 0.001) with overall the result that 49% of animals sold to town were gun-hunted animals.

5.3.2.5 Season

There was no difference between seasons in the proportion of the catch that was sold (42% of individuals sold in the wet season, 41% in the dry season, χ^2 = 0.32, df = 2, p =0.85), nor in the proportion of animals that were sold to town, rather than to the village (59% sold to town in the wet season, 51% in the dry season, χ^2 = 2.94, df = 1, p= 0.086).

5.3.2.6 Protected status

Species that were partially or completely protected were sold less frequently than those with no protection (27% of completely protected species and 31% of partially protected species were sold, compared with 42% of unprotected species, χ^2 = 6.04, df = 2, p = 0.049). Due to small sample sizes (41 protected individuals, 42 partially protected), it was not possible to test whether this was an effect of the protection and enforcement, or simply due to other characteristics of the species. However, the mass of the partially and completely protected species used in the above analysis was significantly greater than that of non-protected species (Kruskal Wallis, H_{1875} = 32.13, df = 2, p <0.001).

5.3.3 Associations among catch characteristics

Table 5. 5 describes the interactions among catch characteristics:

5.3.3.1 Species, mass and state

Species type and mass are not independent from each other, as each species has its own mass distribution. Some species are more likely to be found decomposed than others, and more decomposed animals are found in the dry season. Decomposed animals are lighter than fresh animals.

5.3.3.2 Hunting type

Trap and gun catches have significantly different species compositions (Table 5. 6) Gun hunting catches significantly more monkeys, blue duikers, red duikers palm civets and large birds than trap hunting, whereas porcupines and the smaller-bodied species are caught significantly more through trap hunting. Gun hunted animals are heavier than trap-hunted animals, even within species (ANOVA mean gun hunted porcupine = 3.0 kg, trap hunted = 2.8 kg; $F_{1, 758} = 4.63$, $p = 0.032$; blue duiker gun hunted = 3.8 kg, trap hunted = 3.3 kg, $F_{1, 312} = 12.9$, $p < 0.001$).

5.3.3.3 Season

The number of gun hunting tours does not vary between the seasons, whereas the number of trap tours declines significantly in the dry/planting season, as does the trap catch (Figure 5. 4). Species composition of the overall catch varies with season, with the mainly trap-caught porcupines decreasing during the dry season, and gun-hunted species, such as African palm civets, blue duikers and monkeys, increasing. It seems that these changes in species composition with season are due partly to the change in hunting technique to favour gun hunting, and partly due to shift in species composition of trap-caught animals in the dry season, as more blue duikers and fewer porcupines are caught in traps during the dry season ($\chi^2 = 27.92$ df = 9 p = 0.001). The species composition of gun hunted animals does not vary with season ($\chi^2 = 9.45$ df = 6 p = 0.15). There is no difference in species' mean mass between seasons.

	SPECIES	WEIGHT	STATE	HUNTING TYPE
WEIGHT	Each species has its own weight range, so species and weight are not independent (Kruskall Wallis mass by species category, $H = 1075.8$, $df = 19$, $p < 0.001$)	N/A		
STATE (Just trap-caught animals)	More porcupines (38%) and less pangolins (23%) and reptiles (21%) are found decomposed/rotten than expected values. $\chi^2 = 23.22$, $df = 9$, $p = 0.006$	Median weight (kg) Decomposed/rotten = 2.6 Fresh/alive = 2.8 Mann Whitney U test: $W_{290, 828} = 152072$, $p = 0.03$	N/A	
HUNTING TYPE	There are significant differences in the species composition of trap and gun hunted animals ($\chi^2 = 92489$, $df= 13$, $p<0.001$). The species composition of trap and gun hunting is described in Table 5.6.	Median weight (kg) Gun caught = 3.5 Trap caught = 2.6 Mann Whitney U test: $W_{657, 1250} = 1074606$, $p <0.0001$	Gun-caught animals are, by the nature of gun hunting, always fresh, whereas trap hunted animal can decompose.	N/A
SEASON	In the dry season there are more African palm civets (58% caught in dry season), blue duikers (43%), and monkeys (33%) caught than in the wet season, and fewer porcupines (24%). $\chi^2 = 101.45$, $df = 13$, $p <0.001$	No significant difference Median weight (kg): Wet = 2.9 Dry = 3.0 Mann Whitney U test: $W_{1317, 618} = 1257906$ $p = 0.13$	More animals are found rotten in the dry season (16% dry, 8% wet), and more found alive in the wet season (4% dry, 12% wet) than expected values. $\chi^2 = 25.40$, $df = 3$, $p <0.001$	No difference between wet (407 trips) and dry season (402 trips) for gun hunting, but trap hunting decreases from 1364 (wet) to 432 (dry) trips. $\chi^2 = 168.43$, $df = 1$, $p <0.001$

Table 5. 5: Correlations between catch characteristics

Species Category	Number of animals caught gun hunting	Number of animals caught trap hunting	% Gun hunted	Expected values		Standardized Residuals	
				Gun	Trap	Gun	Trap
Monkeys	160	5	97	51	114	18.92	-18.90
Moustached guenon *(Cercopithecus cephus)*	114	4					
Putty-nosed guenon *(Cercopithecus nictitans)*	20	0					
Grey-cheeked mangabey *(Lophocebus albigena)*	4	0					
Crowned guenon *(Cercopithecus pogonias)*	7	0					
Black colobus *(Colobus satanus)*	6	0					
Blue duiker *(Cephalophus monticola)*	250	159	61	127	282	14.36	-14.36
Large birds *(Corythaeola cristata, Tauraco persa, Bucerotidae sp.)*	38	0	100	12	26	9.25	-9.23
African palm civet *(Nadinia binotata)*	50	19	72	21	47	7.54	-7.54
Red duikers (*Cephalophus sp.)*	114	155	42	83	186	4.25	-4.25
Bay/Peter's *(C. dorsalis, C. callipygus)*	91	113					
White-Bellied (*C. leucogaster)*	9	11					
Ogilby's *(C. ogilbyi)*	4	8					
Black-fronted (*C. nigrifrons)*	1	2					
Water chevrotain *(Hyemoschus aquaticus)*	2	12					
Hyrax/potto *(Dendrohyrax dorsalis, Perodicticus potto edwardsi).*	3	14	18	5	12	-1.20	1.20
Small birds	7	43	14	16	34	-2.63	2.63
Pangolin *(Uromanis tetradactyla, Phataginus tricuspis)*	30	127	19	49	108	-3.33	3.33
Civets, genets and mongooses *(Civettictis civetta, Genetta servalina, Herpestes sanguinea, Atilax paludinosus, Bdeogale nigripes, Herpestes naso)*	8	58	12	20	46	-3.36	3.36
Squirrels and small rats *(see appendix x for all squirrel and rat sp. recorded)*	2	41	5	13	30	-3.77	3.77
Reptiles *(see appendix x for all reptile sp. recorded)*	6	67	8	23	50	-4.27	4.27
Cane rat *(Thryonomys swinderianus)*	1	47	2	15	33	-4.38	4.38
Giant pouched rat *(Cricetomys emini)*	3	152	2	48	107	-8.07	8.07
Brush-tailed porcupine *(Atherus africanus)*	119	871	12	307	682	-16.53	16.53
Red river hog *(Potamochoerus porcus)*	*4*	*14*	*22*				
Sitatunga *(Tragelaphus spekeii)*	*2*	*11*	*15*				

Table 5. 6: The number of animals of each species category that were caught by gun and by trap, and the expected values and standardised residuals calculated from a χ^2 test. χ^2 = 969.28, DF = 13, P-Value = 0.001. Species are ranked by their standardized residuals. Values for Sitatunga and Red river hog were too low to be included in the analysis.

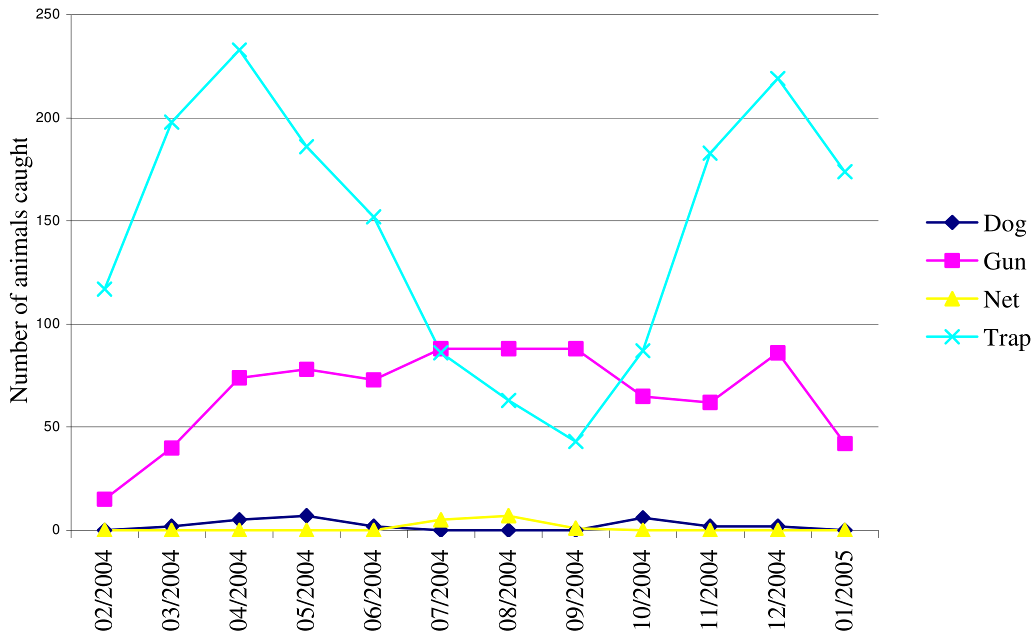


Figure 5. 4: The number of animals caught using different hunting methods changes over the year.

5.3.4 Predictors of whether an individual animal is eaten or sold

5.3.4.1 Brush-tailed porcupines:

A binomial GLM was used to find the best predictors of whether an animal was eaten or sold (Table 5. 7). Three predictors were tested: mass, hunting type/state, and season, and the 2-way interactions between these predictors. Mass was a significant predictor of whether a porcupine was eaten or sold, with heavier porcupines more likely to be sold. Hunting type/state was also a significant predictor, and the estimates and associated standard errors in Table 5. 7 suggest that the state of the meat is the main influencing factor, as there was little difference in the probability of being eaten rather than sold between fresh trap caught meat and gun caught meat. There was no effect of season on whether a porcupine was eaten or sold, and there were no significant interactions between the three predictors.

5.3.4.2 Blue duikers

The sample size for blue duikers was not large enough to test for the effect of interactions between the predictors, or for the effect of state. The three predictors used in the model were therefore mass, hunting type and season. Of these, only hunting type was a significant predictor (Table 5. 7), with gun hunted animals more likely to be sold than trap hunted.

a.

General model:	d.f (change, residual)	Deviance	p (chi square)
Weight (kg)	1, 618	75.9	<0.001
Hunting Type/State	2, 619	172.8	<0.001
Season	1, 617	0.4	0.529
Minimal model:	**Estimate**		**s.e**
Constant	-2.002		0.480
Weight	1.091		0.136
Trap decomposed	-3.422		0.381
Trap fresh	-0.510		0.305

Hunting type/state reference level: Gun fresh

b.

General model:	d.f (change, residual)	Deviance	p (chi square)
Weight (kg)	1, 235	0.5	0.499
Hunting Type	1, 237	8.3	0.004
Season	1, 236	3.3	0.071
Minimal model:	**Estimate**		**s.e**
Constant	0.190		0.165
Trap hunting	-0.784		0.275

Hunting type reference level: Gun hunting

Table 5. 7: General Linear Model Output, with a binomial error structure, showing the terms associated with:

a. The fate (eaten or sold) of a captured brush-tailed porcupine
b. The fate (eaten or sold) of a captured blue duiker

5.3.5 How the characteristics of the catch are associated with variation in price

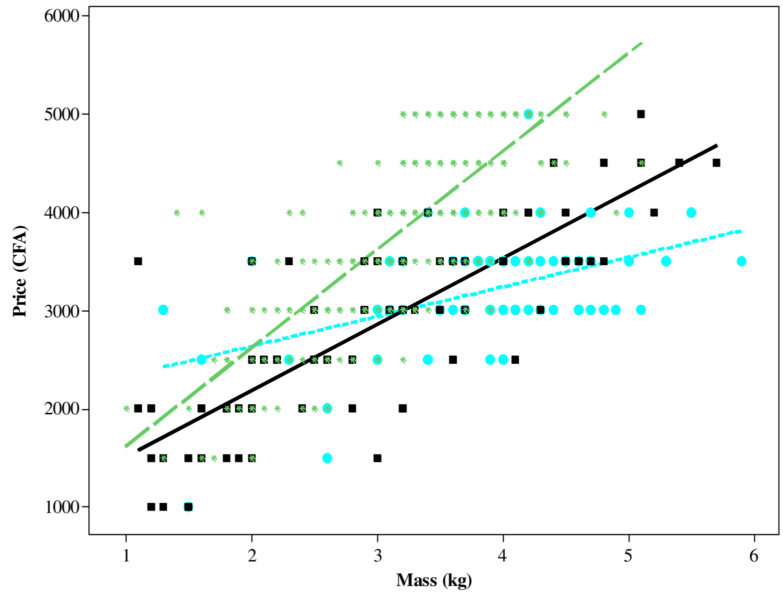
5.3.5.1 Species and Mass

Table 5. 8 shows that larger-bodied species generally fetch higher prices per individual, and lower prices per kg. However, within species price also increases with mass, and that the regression lines for price and mass vary depending on the species (Figure 5. 5). Among medium-bodied species (mostly pangolins, blue duikers, porcupines and monkeys; Figure 5. 5 a), the price of porcupines increases much more steeply with mass than for other animals; while the increase in price with mass is lower for blue duikers. The price with red duikers shows a decelerating increase with increasing mass (Figure 5. 5 b).

Species	Mean weight (kg)	Mean Price (CFA) *s.e.*	Mean Price per kilo (CFA) *s.e.*
Pangolin (tree and long-tailed) *Uromanis tetradactyla, Phataginus tricuspis*	1.8 *0.11*	2107 *167*	1129 *163*
African palm civet *Nadinia binotata*	3.0 *0.17*	3346 *154*	1114 *47*
Brush-tailed porcupine *Atherus africanus*	3.3 *0.04*	3908 *54.3*	1207 *14*
Moustached guenon *Cercopithecus cephus*	4.1 *0.24*	3407 *175*	852 *27*
Blue duiker *Cephalophus monticola*	4.1 *0.09*	3250 *49*	825 *23*
Bay duiker *Cephalophus dorsalis*	15.7 *0.43*	10241 *267*	663 *16*

Table 5. 8: Mean prices, and price per kilogram, by species. Only fresh or decomposed individuals, and only species where both the mass and price was known for more than 5 animals, were used to calculate mass, price and price per kilogram for each species.

a.



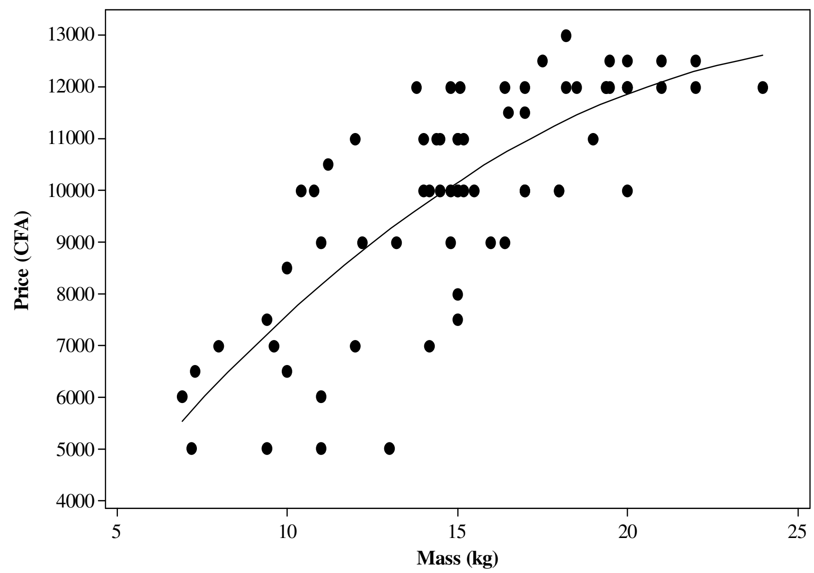


Figure 5. 5: Correlations between price and mass for

a. Animals under 5kg:

Porcupine (green dashed): Price = 614 + 1002 Mass, r_2= 0.58, $F_{1, 325} = 441.42$, $p < 0.001$

Other (black continuous): Price = 862 + 660 Mass, r_2 =0.56, $F_{1, 70} = 93.94$, $p < 0.001$

Blue duiker (blue dotted): Price = 2112 + 280 Mass, r_2 = 0.22, $F_{1, 104} = 29.72$, p <0 001

Regressions are significantly different from each other (linear regression with factors, $F_{2, 503}$ = 37.49, $p < 0.001$)

b. Red duikers: Price = -212 + 953.4 mass –17.5 $mass^2$, $r_2 = 0.61$, $F_{2, 67} = 53.34$, $p < 0.001$.

5.3.5.2 State and hunting type:

The state of the meat is significantly correlated with its price (Table 5. 9); gun-hunted and fresh-trapped animals fetch the highest prices, whereas decomposed animals have significantly lower prices.

Hunting type/State of meat	Mean Price (CFA)	z
Gun Fresh	4947	2.61
Trap Fresh	3904	-1.36
Trap Decomposed	3261	-2.6
Kruskall Wallis: $H_{2, 571} = 9.38$ $p = 0.009$		

Table 5. 9: Fresh meat has a higher price than decomposed meat

When meat is smoked, it loses mass; for instance, smoked porcupines are 37% lighter than non-smoked porcupines. The mean price for a smoked animal was 2995 CFA, but due to the low mass, the price per kilogram was much higher than for non-smoked animals, at 1682 CFA.

5.3.5.3 Season:

The mean price attained for an animal was slightly higher in the dry season (mean wet season price = 4018 CFA, dry season = 4636 CFA, Mann-Whitney U test: W_{747} = 193218.5, $p = 0.015$), but did not differ significantly within species (brush-tailed porcupines, n = 421, wet = 3683 CFA, dry = 3864 CFA, $p = 0.07$; blue duikers, n = 142, wet = 3117 CFA, dry = 3281 CFA, $p = 0.13$). It seems instead that this price difference may be due to changes in species composition due to differences in hunting methods employed.

5.3.5.4 Sold within the village, or to town:

Prices are significantly higher for animals sold to town, compared to those sold within the village (mean price of animals sold within the village = 3462 CFA, sold to town = 4740 CFA, Mann-Whitney U test: W_{564} = 55953, $p < 0.0001$). This may be due to the already described difference in the composition of the catch sold to the town compared to the village, or could be an effect of higher demand in the town influencing price.

5.3.5.5 Percentage sold, and price

The percentage of animals sold per species category was compared with their mean price. Only categories where 10 or more animals had been sold and priced were used, reducing the analysis to seven categories. As price increased, so did the percentage of animals sold (Figure 5. 6).

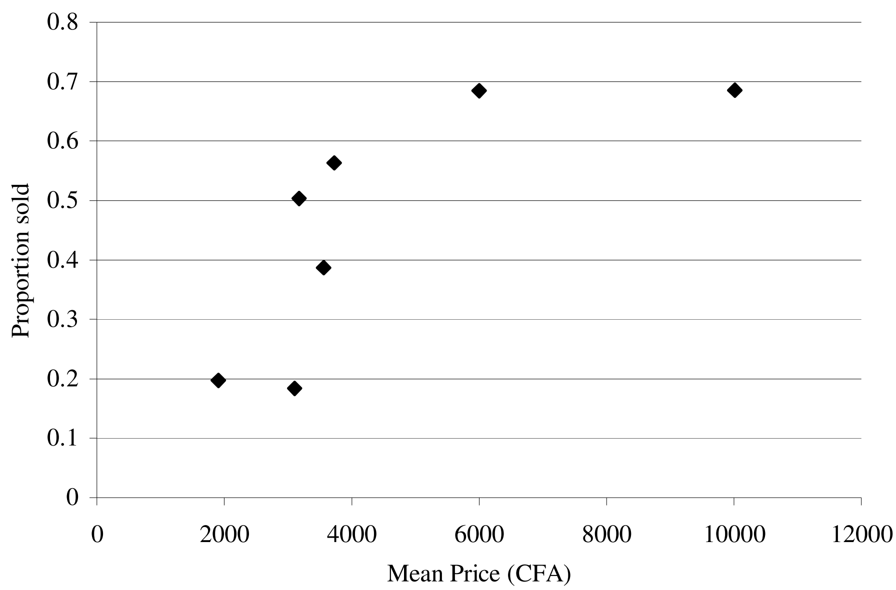


Figure 5. 6: The proportion of animals sold per species category increases with the mean price attained for animals in the species category.

5.3.6 Predictors of price

5.3.6.1 Brush-tailed porcupines

A GLM was used to find the best predictors of price, for brush-tailed porcupines (Table 5. 10 a). Three predictors were tested: mass, hunting type/state, and season, and their two-way interactions. Of these, mass and hunting type/state were significant predictors. Gun hunted animals gained a higher price than trap caught animals, and within trap caught animals, decomposed animals gained a lower price than fresh or live animals.

This analysis was repeated, using a subset of the dataset where the destination of the sold meat was known (Table 5. 10 b). Using this dataset it was possible to test whether the destination of the meat influenced its price, or whether the higher prices for town-bought meat were a result of the characteristics of the meat. However, while other results were largely unchanged, destination was not a significant predictor of price.

5.3.6.2 Blue duikers

The sample size for blue duikers was not large enough to test for the effect of state, destination, or interactions between the predictors. The best predictor of price for blue duikers was mass (Table 5. 10 c).

a.

General model: Price (CFA)	d.f (change, residual)	F	p
Mass (kg)	1, 312	462.34	<0.001
Hunting Type/State	3, 312	8.45	<0.001
Season	1, 312	0.28	0.598
Minimal model:	**Estimate**	**s.e**	
Constant	820	170	
Mass	1012.8	47.1	
Trap decomposed	-771	163	
Trap fresh	-271.4	83.8	
Trap alive	-312	117	
Hunting type/state reference level: Gun fresh			

b.

General model: Price (CFA)	d.f (change, residual)	F	p
Mass (kg)	1, 236	283.57	<0.001
Hunting Type/State	1, 237	10.46	<0.001
Destination (village/town)	1, 235	0.56	0.453
Minimal model:	**Estimate**	**s.e**	
Constant	952	209	
Mass	968.4	57.5	
Trap decomposed	-796	189	
Trap fresh	-312	94.5	
Hunting type/state reference level: Gun fresh.			

c.

General model: Price (CFA)	d.f (change, residual)	F	p
Mass (kg)	1, 103	29.97	<0.001
Hunting Type	1, 102	0.00	0.944
Season	1, 102	2.48	0.188
Minimal model:	**Estimate**	**s.e**	
Constant	2121	212	
Mass (kg)	279.7	51.1	
Hunting type reference level: Gun hunting			

Table 5. 10: Results for General Linear Models, using a normal distribution, showing the terms associated with:

a. Price of brush-tailed porcupines, with mass, hunting type/state, season and their two-way interactions as predictors

b. Price of brush-tailed porcupines, using a subset of animals where the destination (town/ village) was known, with mass, hunting type/state and destination as predictors

c. Price of blue duikers, with mass, hunting type and season as predictors

5.3.7 Gigots:

Over the study period, 161 of the 2647 animals caught were cut into pieces, known as 'gigots', before they were sold or eaten. Larger animals were often cut up in the forest, to reduce the weight of the animal by leaving the entrails, and occasionally the head, in the forest. Most of the animals that were cut into gigots had been trap-caught, despite most larger-bodied species being caught by guns (for example, 63% of red duikers were caught by gun hunting, but only 12% of red duikers cut into gigots were caught gun-hunting). This may have been because large animals found in a trap visit often had to be carried while checking the rest of the traps, and cutting the animal into pieces eased its transport.

Eighty percent of animals that were cut into gigots were red duikers, and this accounted for 46% of all red duikers caught. The vast majority (15/18) of red river hogs and sitatunga (12/13) caught were divided into gigots. Red duikers were generally cut into five pieces, and sitatunga and red river hog were cut into six or seven pieces. The mean number of gigots sold per animal in each species category varied from 33% to 67%, with a mean of 57% (+/-3.1) sold for all animals. Nearly all (96%) of all heads were eaten, with the remaining 4% left in the forest.

The probability of a gigot being sold increased with its mass; sold gigots were significantly heavier than those eaten (Mean mass of sold gigots = 2.8 kg, eaten gigots = 2.3 kg, Mann-Whitney U test: $w = 45435$, $n = 550$, $p = 0.0002$). This was also the case within species (bay duiker, mean mass of sold gigots = 2.4 kg eaten = 2.1 kg, Mann-Whitney U test: $w = 18897.5$, $n = 340$, $p = 0.006$), and fewer of the lighter front haunches (56%) were sold than the back haunches (71%).

Entire animals are significantly more expensive than gigots of the same weight. The coefficient determining the rate of change of price with mass does not vary significantly between gigots and whole animals, but the intercept is lower (Gigots regression: Price (CFA) = 843 + 572 mass (kg), $r = 57.8$, $p < 0.001$, Entire animals regression: Price (CFA) = 1656 + 569 mass (kg), $r = 49.5$, $p < 0.001$). Linear regression with groups used to test between differences in slopes and intercepts: Intercept: $t = -4.32$ (gigots), $p<0.001$, slope: $t = -1.47$, $p = 0.141$).

As the vast majority of animals cut into gigots were red duikers, these were used to compare the potential total price of an animal butchered into gigots (taking the mean price gained from 31 bay duikers where all the gigots were sold) with the price gained for an entire animal. An entire red duiker fetched a mean price of 10,300 CFA (+/- s.e. 231), compared with 7, 990 (+/- 302) for a red duiker that had been cut into gigots.

5.4 Discussion

5.4.1 The bottom-end of the commodity chain: What gets sold?

This study has provided a quantitative assessment of the bottom-rung of a bushmeat commodity chain, and how the characteristics of animals found in the market compare with the original catch. Fifty percent of the biomass of the total catch was sold, and the characteristics of the catch that was sold varied significantly from the original catch. Only 34% of the species found in the original catch were represented in the market. Brush tailed porcupines, red duikers and blue duikers were sold more than other species, and these three species represented 90% of the market animals, compared with 65% of the original catch. Large-bodied, fresh animals were more likely to be sold. These biases held when looking within species, with heavier, fresher porcupine being preferentially sold. Gun hunted animals were more likely to be sold than trap hunted animals, and this is partly because gun hunting always produces fresh meat, compared to trap hunting where the meat can decompose. Gun hunting also targeted larger-bodied species, and within species gun hunted animals were also heavier than trap-hunted animals. However, GLMs to look at the best predictors of whether an animal was eaten or sold found that, taking account of the characteristics of gun hunted animals, an animal was still more likely to be sold if it had been gun-hunted.

Protected species were less likely to be sold than unprotected species, even though they were generally larger-bodied species. This suggests that the current level of enforcement (by the Gabonese 'Eaux et Forets') may be dissuading hunters from selling, or vendors from buying, protected species. De Merode and Cowlishaw (2006) have also found that during times of peace in the DRC, the numbers of protected species sold in urban markets was much lower than in times of war, where there was little enforcement. However, Rowcliffe et al (2004) have shown that enforcement had no effect on the prey choice of hunters in the DRC, and so while enforcement may be reducing sales and urban demand of species, it may not be reducing the number of animals caught. The ineffectiveness of hunting law enforcement in Dibouka and Kouagna can be seen in the widespread use of illegal hunting techniques; in Gabon trapping is illegal, yet it is the main form of hunting in these two villages. During the study period these were no arrests and no fines despite obvious daily signs of illegal hunting and trading. Enforcement may be reducing the trade of endangered species, but is likely to have had little effect on village hunting techniques and offtakes.

5.4.2 Do bushmeat sales make economic sense?

Animals that sold for the highest prices were sold the most often, which suggests that market demand influenced which animals were sold. Price was highly correlated with weight, which meant that heavier species were sold more, but the price of porcupines, which was the species sold the most, increased more steeply with mass than other species, again suggesting that hunters are selling the most profitable species, and also demonstrating an interesting market preference for porcupines. During semi-structured interviews, many of hunters in Dibouka and Kouagna said that they preferred to catch porcupines over other species. Reasons given included abundance, taste and ease of sale. A recent taste test in Libreville also found that of the consumers who expressed a preference for bushmeat, 56% preferred porcupine (Schenck et al, 2006).

Does this mean that hunters are acting in a profit-maximising way, by selling the species that will make them the most money? There are two ways of interpreting this data. Buyers could be controlling which animals are sold, by choosing from the original catch which animals to buy. In this case, hunters are not making economic decisions, buyers are. On the other hand, hunters could be choosing what to display for sale, from what they know of demand, and prices; in this case the hunter is acting in a profit-maximising way. Observations suggest that to a certain extent hunters are profit maximising. When weighing animals and asking hunters questions on the hunting trip, I often observed that hunters would give a proportion of the catch directly to the women of the household, in order to begin food preparation. Other animals would then be put on the market wall, or outside the chiefs house ready for sale. This suggests that hunters are deciding which animals to sell and which to eat.

Larger animals, such as red duikers, sitatunga and red river hog were often cut into gigots, however, prices for whole animals were on average higher than the sum of gigots. There are three plausible explanations for why hunters chose to cut animals into gigots despite this profit loss. Firstly, hunters often cut animals into gigots to reduce the weight (head and entrails) and ease the transportation of the animal back to the village. Hunters may also cut animals into gigots to allow part of the animal to be sold and part to be eaten, gaining protein and profit rather than one or the other. Animals may also be cut into gigots because of a lower demand for whole, large animals, and this is likely to be the case within the village, where there are unlikely to be villagers who have the money, or need, for an entire red duiker or red river hog. Of the red duikers that were sold whole, 83% were sold to the town, whereas 95% of red duiker gigots were sold in the village, which may be a reflection of the lower demand for whole red duikers in the village. However, the destination of gigots was only known for 16% of red duiker gigots, which means that this percentage may not be a true reflection of the whole dataset.

5.4.3 Why don't hunters sell their catch in town?

The price obtained for an animal was not influenced by whether the animal was sold in the village or to town. Hunters can generally get a higher price for animals if they travel to town to sell them, rather than selling in the village (as demonstrated by Delvingt, 1997, and Gally and Jeanmart, 1996), and so one might expect to see an increase in profits through selling to the market. However, in these villages, animals are not sold directly to the market, but are sold to buyers travelling through the village, into the main town; Dibouka and Kouagna lie on the main road from Iboundji to Koulamoutou, which is also a route to Libreville when the *route economique* closes. People travelling into town bought animals when taxis and logging trucks stopped briefly in Dibouka or Kouagna, possibly in order to fund their trip by selling the meat in town. Drivers also bought meat on the road. From observations, and informal talks with the hunters and drivers, it seems that commercial bushmeat vendors did not come to the village with the express purpose of buying bushmeat; most meat was sold to people travelling through the village for another purpose.

Very few hunters took advantage of higher bushmeat prices in town by travelling into town in order to sell their meat. This may have been due to prohibitive transport costs; a one-way taxi to Koulamoutou cost 1350 CFA, and each large bag transported was an extra 500CFA. A return journey would therefore have cost a minimum of 3200

CFA. Trips into town to sell animals were made on 12 occasions, incorporating catches from 15 hunting trips, over the 12-month study period; hunters took a mean of 2.4 animals (+/- 0.4), and a mean of 11.9 kg (+/- 3.6), and the species sold included 6 red duikers, 5 blue duikers, 19 porcupines and 2 African palm civets. An estimate of the profits for each of these trips was calculated using the mass of each animal multiplied by the species-specific price per kilogram from WCS market data from nearby markets, and the price per kilogram gained in the village. The mean profit per trip, net of costs, was 3582 CFA (+/- 3438 CFA), which is equivalent to $4.3. Only three of these trips were estimated to have made a profit net of costs, and all three of these made the majority of their profit from bay duikers.

So why don't other hunters make the trip into town to chase this profit? An estimate of the number of hunting trips that would have made a profit from taking their catch into town was calculated using the estimated market price from the animals caught from each hunting trip (using average WCS market data prices for each species) compared to the average village price, and subtracting the difference from the transport costs. Only 68 trips (37 gun, 31 trap), or 5% of all hunting trips, caught enough for the trip into town to have potentially been worthwhile, and the average potential profit from a hunting trip was –1811 CFA (+- 38.2), which suggests that this may be one of the reasons that hunters do not often take their catch directly into market. An added cost of taking meat into town was that Koulamoutou was far enough away from Dibouka that if hunters left the village after a hunting trip to go into town and sell animals, they were likely to miss the next taxi back into the village, and would have to stay in town over night, incurring a real cost, due to higher costs of living in town. Towns also contain family members and friends in need, who will expect you to share your profit with them. An average meal of rice and fish in Koulamoutou costs 1000CFA, and so the profit from bushmeat can easily dissipate in town.

There are advantages, which were not measured, of selling animals in town. Taking the catch into market may increase the likelihood of sale. Hunters travelling into town were also observed using their hunting profits to buy goods in town, which they then sold in the village at a mark-up. Solly (2004) found that hunters in Cameroon were using their hunting profits in this way.

The lack of hunters travelling into town to sell their catch would suggest that there is a niche for commercial bushmeat traders along this road. However, there were no regular traders observed during the study period. This may, to a certain extent, be a result of enforcement or taxation. This type of taxation was observed with other goods that were traded between the town and the village. During the study period, a group of Malian traders would come from Koulamoutou into the villages, selling frozen fish and chicken. This trading ceased due to a tax on trading along the road, imposed on these traders by Koulamoutou town officials, which made it unprofitable to continue trading. It is possible that due to the hunting regulation in place, which are officiated by the 'Eaux et Forets' guards in Koulamoutou, traders perceive that any potential profits would be negated by fines, or forms of taxation, imposed on them by Eaux et Forets.

5.4.4 Is demand influencing what is caught, and what repercussions might this have?

In these villages, there is a market demand for larger-bodied species, mainly red and blue duikers and brush-tailed porcupines. Evidence suggests that gun hunting, and not trap hunting, is selective for easily saleable individuals. Although there is no direct evidence of selectivity for gun hunting in this study, such as that shown by Alvard's (1993) hunter follows, there are a number of indicators that suggest selectivity. Gun hunting catches larger-bodied individuals, which are more likely to be sold and will fetch the highest prices, and gun-hunted animals are sold in much higher proportions than those trap hunted. The commercial use of gun hunting is also evident from the reasons that hunters gave for going on each hunting trip. For each hunting trip, hunters were asked why they had decided to go hunting (see Section 3.4.2.3, Chapter 3 for methods). In the case of trap hunting, 67% of the time there was no specific reason for the trip; traps are set and then checked every few days as routine, so a trip is not prompted by, and cannot be relied on to provide for, any specific needs or events. Only 3% of trap visits were carried out specifically to find food, make money or for a ceremony. In comparison, among gun hunting trips, 33% were specifically to earn money, 3% were to make money and find food, 19% were to find food and 7% were for ceremonies; where hunters gave a reason for gun hunting it was never 'just to go gun hunting'. If gun hunting is selective, then commercial hunting could be directly targeting larger-bodied species. Trap hunting, however, does not lend itself so well to commercial hunting. Traps caught a range of species from crab to red river hog, which suggests a low level of selectivity, and trap catches cannot be organised for a specific date.

If hunting is not selective, the bias towards selling larger-bodied species could still be affecting hunting behaviour. Small-bodied species may become the equivalent of fishing 'bycatch', where hunters view their catch in terms of large-bodied species only. In the case of trap hunting, traps may be set further into the forest as catches decline, in order to catch the larger-bodied species, or trapping intensity may be increased, which would then result in greater hunting pressure on smaller-bodied species as a result, even though these are not the animals being targeted.

5.4.5 How should market data be used?

There is a large difference in the characteristics of the original catch and the catch that arrives in town, with fewer species represented in the market, and three species representing 90% of market animals. As well as ignoring animals eaten within the village, market data also cannot tell us about the levels of wastage occurring, generally through traps not being checked often enough for animals to be found before they decompose. Overall, eight percent of animals caught in Dibouka and Kouagna were too rotten to be eaten once they had been found in the trap (increasing to 16% in the dry season, when there are less trap visits). This figure is quite probably an underestimate, as it represents the number of animals reported wasted, and is not calculated from trap follows, and a comparison with wastage estimates from hunter follows will be considered in Chapter 7. Market data therefore greatly underestimates the number of species targeted by the bushmeat hunters, and the proportion of the trade that they represent, and therefore is flawed in its use as a snapshot of the bushmeat trade, and should not be used to directly calculate hunting sustainability.

The use of ratios of small: large animals as indicators of sustainability are not affected by these biases, if the change in ratios seen in the market reflects those seen in the original village offtakes. This study has shown that there is a large difference between the ratio of small: large animals that is seen in the original catch compared to that with reaches the town due to the demand for large-bodied species by the commercial trade. If the change in ratios resulting from large bodied species becoming depleted in the village is reflected in the market, the use of ratios is still valid. However, if as the number of larger-bodied species in the catch declines, a greater proportion of these are sold to market in order to continue supplying the market demand (as might well be the case with the observed bias towards large-bodied species being sold) the number of rats to duikers will fall more slowly in the market than in the village, and hunting sustainability will be overestimated. It would therefore be advisable to look at whether this is the case before relying too heavily on market data as an indicator of hunting sustainability.

Another possible problem with the use of ratios has been highlighted by Milner-Gulland and Clayton (2002) and Crookes et al (2005), who show that over time, market traders travel further for the market to buy animals, suggesting that as animal populations are depleted, the number of large-bodied animals seen in the market does not decrease with local depletion, rather the area depleted increases. Local areas could therefore be suffering high levels of unsustainable hunting, but this would not be visible in market ratios, due to animals being sourced from further away. This could also be occurring at the local village level; as larger-bodied species become harder to catch, hunters could be moving further away from the village in order to satisfy market demand. Muchaal and Ngandjui (1999) found that 64% of animals found close to the village were consumed locally, compared to areas further than 1.5km from the village, where 64% of animals were sold, suggesting that commercial hunting was pushing hunters further into the forest. This idea will be revisited in Chapter 6. In this scenario, the ratio of rodents to duikers seen in the village catch and the market animals would not change, even when levels of hunting are locally unsustainable.

Chapter 6 :

Landscape use and predictors of trap success

Chapter 6

6.1 Introduction

Landscape is a vital but often overlooked component in understanding the nature and impacts of village hunting. Studies of village hunting often use hunting offtakes to study hunting sustainability (e.g. Fitzgibbon et al, 1995; Fa and Juste, 2001), but have generally done this without studying the hunting catchments from which these offtakes come. Although village offtakes are a vital source of information, their potential to inform is limited if the size of the hunting area, and the hunting effort, is unknown (for example, the effect of a certain hunting offtake on prey populations will be markedly different in a catchment of 10 km^2, compared to that of 100 km^2). As previously mentioned when discussing the merits of market data, spatial data are also required when studying temporal changes: the overall offtake level may stay constant over time, but be changing over space, as hunters move further from a village to keep their catch rates constant (e.g. Clayton et al, 1997). The same is true of hunting effort: hunting from a declining prey population may still provide the same offtake, if hunting effort is increased. For these reasons, it is very important that information on catchment areas and measures of hunting effort be collected in tandem with village hunting offtakes.

Investigating how hunters use the landscape is also important in its own right. Information on the amount of land used for hunting can provide estimates of the extent to which village hunting covers the surface of a landscape, region or country. By collecting spatial data on hunting characteristics and offtakes, we can also evaluate the effect of different landscape and hunting variables on catch rates and animal populations. Understanding the effects of different hunting and landscape characteristics, together with how these characteristics are represented in a village catchment, can provide us with a powerful tool for assessing the impact of village hunting.

The first step in understanding hunting land use is to determine the hunting territory of the village. A village hunting territory is generally loosely defined as the land that is traditionally seen as being the property of that village, available for use to the hunters from that village, and not to other villages. To delimit it therefore requires not only data on the location of hunting areas, but also local information on where traditional boundaries exist. The most common tool for this is Participatory Resource Mapping (PRM), where a researcher encourages participants from the community to draw a basemap of their surroundings, often using features such as rivers, hills and human settlements. Using this map, participants then indicate relevant features, areas of interest, and different type of land use. The result is a map of the participant's environment covering themes that reflect the object of the exercise and the perceptions and knowledge of the participants (Mbile et al, 2003). With the advent of high-power, easily portable GPS receivers, PRM methods can now be integrated with GIS mapping, combining local knowledge and perceptions with accurate geographical information (Broseth and Pedersen, 2000). PRM has been employed in Canada and the US since the 1970s where it was often used during land disputes (Chapin et al, 2005), but there has been much less published work from the developing world, especially Africa, where PRM studies only really started appearing in the 1990s (e.g. Ekwodge et al, 1999, Smith et al, 2000). A review of mapping indigenous lands by Chapin et al (2005) suggests that much of the PRM work in Africa has gone unpublished, possibly due to political, legal, economic or cultural sensitivities, and focuses on mixed economy agriculturalists rather than hunter/gatherer groups.

Information on landscape use by villages in Central Africa has mainly resulted from studies into the encroachment of village hunting into national parks, where traditional rights and park boundaries overlap. The majority of these have been commissioned by ECOFAC (Ecosystèms Forestiers d'Afrique Central), with researchers from Gembloux University, Belgium. These include studies from villages in Congo (Lia and Gami, 1995; Vanwijnsberghe, 1996), CAR (Dethier, 1996; Vermeulen, 1997; Fankap, 1997; Dethier and Ghurghi, 1999) and Cameroon (Debroux and Dethier 1993; Dethier, 1995; Ngnengeu and Fotso, 1996; Jeanmart 1997; Jeanmart 1998). A mixture of PRM techniques and hunter follows with GIS groundtruthing were employed, and the results from these studies were presented as part of unpublished final project reports. Aside from these ECOFAC reports, the sizes of hunting territories have been calculated during village hunting studies by Noss (1998) in the Dzanga-Sangha Special Reserve in CAR, Muchaal and Ngandjui (1999) in the Dja Reserve, Cameroon, Eves and Ruggiero (2000), in Bomassa, Congo, Hart (2000), working in the Ituri forest, DRC, and Kumpel (2006) in the Monte Mitra reserve, Equatorial Guinea. Due to the creation of the new parks in Gabon, village hunting territories are currently being delimited in Waka and Biroughou National Parks, in order to determine how much the new national park boundaries and village territories overlap, and to provide a basemap for management options (Starkey, pers. com.). Another current project, which aims to learn about the traditional land use in order to provide an integrated management approach, is the Central African Regional Program for the Environment (CARPE) in communities around Mount Cameroon. Here, community perceptions of how timber and non-timber forest resources are currently used and managed are being mapped, in order to create models for forest resource management (Ekwodge et al, 1999). All of these studies have been/are being undertaken in villages within, or next to, national park boundaries, and studies conducted away from parks are rare. Auzel and Hardin (2001) is the exception, where village territories were estimated in order to illustrate the overlap between traditional village territories and logging territories, as part of a detailed report on the logging industry in Cameroon. However, they are still looking at conflicting use of landscapes, and not an undisturbed village system.

Through a comprehensive literature search, thirty-four estimates of village hunting territories were found from 18 hunting studies; only two of these being peer-reviewed publications and three from book chapters, illustrating how much valuable information can potentially be lost in the grey literature. Because these territory estimations are mainly found in the grey literature, they have generally been overlooked and have not previously been pooled and compared. The first section of the results for this chapter therefore collates and analyses the available data, alongside that collected during this study, to provide a first look at hunting territories for Central Africa.

More detailed information on trap numbers, densities, and land-use cover, to varying extents, all provide a measure of hunting effort. Controlling for hunting effort means that hunting offtakes can be compared over space and time, and positions of traps and hunting camps can provide insight as to how much of the hunting landscape is likely to be heavily hunted, and whether there are unhunted refuges within this landscape. To date, mapping and quantifying hunting effort has focussed on trap hunting, and ignored gun hunting. This is probably partly because trap hunting is generally the dominant form of hunting in villages (Noss, 1998b), and partly due to methodological constraints. Mapping the use of hunting territories by gun hunters requires night follows with a GPS unit, and it is difficult to keep a lock on satellites with the GPS without slowing the hunter down. Hunters also tend to modify the length and destination of their hunting trips when accompanied by researchers (pers. obs.), hence the act of observing changes the observed.

Even studies that have estimated trapping density estimates are rare, as they generally require an intensive survey of village hunters. During hunting studies in the village of Ekom, adjacent to the Dja reserve, Cameroon, Dethier (1995) and subsequently Jeanmart (1998), attempted to quantify the trapping density, and draw community maps of the distribution of traplines, using a mixture of PRM and hunter follows with GPS mapping. The same methods were used to estimate trapping densities in the village of Kanare, in the forest of Ngotto, CAR (Dethier, 1996; Dethier and Ghurghui, 1999). The reports however, do not properly account for sampling effort. In Dja only 24% of hunters cooperated with the study, which means that the densities of traps given in these reports are greatly underestimated. Jeanmart's (1998) study was also undertaken during dry season months, where he admits that most hunters had turned their attention to agriculture. However, this work does provide us with a snapshot of trapping effort for the 37 hunters who cooperated with the study. The Kanare study also does not mention the proportion of hunters that participated in the study, an estimated proportion of traplines that were seen, or the number of times these traplines were visited, which again makes it difficult to use these data to estimate trap densities.

Good estimates of trapping densities have been calculated by Muchaal and Ngandjui (1999) and Kumpel (2006). Muchaal and Ngandjui carried out transect surveys, in which they calculated the density of traps at three distances from the village Mekas in Cameroon, in order to look at the effect of trap density on animal populations. Kumpel carried out an intensive 1.5-year study in which she mapped and counted the traps for all 56 hunters in Sendje village, Equatorial Guinea, and this probably represents the only detailed study on the spatial locations and densities of traps to date.

Data on the distances of traplines, traps and hunting camps from a village are more common than density estimates (Dethier, 1995; Vanwijnsberghe 1996; Dethier, 1996; Delvingt, 1997; Wilkie et al, 1998; Jeanmart 1998; Yasouka, 2005; Kumpel, 2006; Maisels, 2006). As with hunting territories, a comparative study of trap densities, number and distances, and hunting camp distances has been carried out using these studies, and has been presented in the results section, in order to highlight any trends in landscape use.

The real attraction of getting information on the spatial elements of hunting is that we can then look at how different landscape and hunting characteristics influence offtakes, and how these characteristics are represented in the village landscape. Ideally, this requires that the spatial location of hunting offtakes are known (i.e. the trap location of each catch if we are looking at trap hunting), along with the hunting and landscape information for that location (such as type of trap, trap life, surrounding trapping densities, forest type, etc). However, this type of data collection is labour-intensive, which is one of the reasons why there are so few studies investigating trapping densities. Instead of using trapping densities, distance from the village has generally been used as a proxy for hunting intensity. If it is assumed that hunters start hunting directly around the village, and then move further out as the prey base is depleted (central place foraging theory), then increasing offtakes or changes in prey from small to large animals with distance from the village would suggest a depletion of the prey base. This is used to investigate the impact of village hunting on animal populations, with offtake rates with distance from the village being used as a proxy for prey abundance over time. As with reductions in actual prey abundance with hunting pressure, changes in offtake with distance alone does not mean that hunting is unsustainable, but can still quantify the relationship between different levels of hunting pressure and offtake.

A number of studies have looked at the effect of hunting on animal populations by comparing prey densities/ offtakes rates for site at varying distances from a village/road, and most have found an effect of hunting on offtakes or abundance; interestingly many have found that this varies with species. Fimbel and Curran (2000) estimated the abundance of duikers with distance from a main road in Lobeke, Cameroon. They found an effect of distance for red duikers; densities in the reserve

(20 – 30 km from the road) were 6.2 times higher than for near the road (0 – 10 km). However, there was no increase in densities with distance from road for blue duikers, suggesting that different species may react differently to hunting pressure, assuming no hunter selectivity. Ngnegueu and Fotso (1996) collected information on habitat (4 categories) and distance from village (zone 1: <5 km, zone 2: 5-10 km, zone 3: 10-15km) for each trap for 11 of 30 hunters in Mekas, Cameroon. Standardising trapping effort, the catch rate increased with distance from the village, and secondary forest was the most productive forest type. Muchaal and Ngandjui (1999) carried out a study that combined these two methods. They studied trap offtakes from 14 hunters, and abundance of a number of species at four zones at different distances from the village, and similarly found blue duiker densities were higher closer to the village, whereas red duiker densities increased with distance from the village, although it is not known if this difference was significant.

Transect surveys have also been used to study the effects of hunting on prey densities. Blom et al (2005), using eight 20 km transects in southern Gabon, collected information on habitat, distance from villages and roads, and the density of human and hunting sign, and investigated the effects of these variables on the density of a range of large-bodied species. The abundance of most species was negatively correlated with the density of either hunting or human sign. Laurance et al (2006) used five 1 km transects at difference distances from roads, in six study sites in Gabon, and looked at the effect of a measure of hunting pressure (density of human and hunting sign) and forest type on the abundance of 18 species. Again, they found that the effect was species-specific, and hunting had the greatest effect on large-bodied species. Kumpel (2006) looked at how trap type and age, and distance from village affected the success rate of traps in six hunting camps in Sendje, Equatorial Guinea. She found that catch rate was higher for neck snares, and with distance from the village. Similar studies have been carried out on hunting in the Amazon. For instance, Lopes and Ferrari (2000) found a decrease in games species and increase in non-game species in sites with higher human disturbance in the Eastern Amazon. Naughton-Treeves (2003) found that hunting intensity was a better predictor of the average body-mass of species found in fields and forest in Peru than forest type, and (Escamilla et al. 2000) found that disturbed, hunted habitat around villages in Campeche, Mexico, had different prey composition than the forest surrounding it, with more smaller-bodied species. From these studies, we can see that hunting pressure can have significant effects on offtakes and animal populations, and seems to be species-specific.

However, by using distance, or transect surveys to look at the effects of different prey densities or on offtake, information on how these variables are represented in the village, or forest landscape is neglected. For instance, a transect survey may find that trapping densities negatively predict animal densities. But what range of trapping densities exist in the village hunting territory, and how are they distributed in space, and so how is this relationship likely to affect animal populations around villages? A certain type of trap may have a large impact on a certain mammal, but how many of these traps exist in the village landscape, and where, and so what impact are they going to have in the actual landscape? By combining information on the effect of different variables on offtakes and prey densities with information on landscape use by villages or hunters, we can learn a lot more about the impacts of village hunting.

The aim of this chapter is to provide a detailed case study of the use of landscape by trap hunters in Dibouka and Kouagna, and an investigation of the effects of hunting and landscape characteristics on hunting offtakes. Hunter follows and PRM were used to delimit the hunting territories of Dibouka and Kouagna. Data on the trap locations, and trapping and landscape characteristics were collected for each individual trap, for 95% of hunters in Dibouka and Kouagna, through accompanying hunters on their trap visits over a period of 16 months, providing accurate estimates of trapping numbers, densities and landscape use. The frequency of trap visits, and the hunting offtakes for each trap were determined through monitoring of hunter activity, and the kills brought back to the village by each hunter, over a 12-month period. This information has been used to look at how different hunting and landscape variables affect offtakes. As the study has been carried out at the scale of the individual trap, this means that many more hunting and landscape variables can be tested for their effect on offtakes than was previously possible. The results have then been discussed in terms of how this use of landscape, and patterns of offtake could affect both prey populations, and the future use of landscape by hunters.

6.2 Methods

Information on individual trap characteristics and catches collected during hunting follows and village returns (detailed in section 3.4.2.2 and 3.4.2.3, Chapter 3), combined with information from community mapping exercises (3.5.1), was used in this chapter in order to examine:

1. The dimensions and characteristics of the village hunting territories of Dibouka and Kouagna.
2. The best predictors of individual trapping success.
3. How species diversity varies with distance from the village.
4. How the state of meat varies with distance from the village.
5. How the hunting landscape is used for food and income.

The majority of the analyses in this chapter had a spatial component, and were carried out with the use of ARCGIS (by means of Spatial Analyst and Hawth's tools), with an Access database. A basemap of Gabon, with major rivers, roads and villages was provided by WCS Gabon. Satellite data from 2001 collected by SBL, a logging company owning (but not currently using) forest permits around Dibouka and Kouagna, provided data on the maximum extent of plantation use around the two villages, and minor river tributaries. Information collected during the study on the position of traps, paths, hunting camps and old villages was then added to this basemap.

6.2.1 Village hunting territories and the distribution of hunting pressure

Data collected on the geographical location of individual traps, and their characteristics, were collected for 74 hunters between November 2003 and February 2005 (Data collection methods in Section 3.4.2.2, Chapter 3) and these, combined with further information from community mapping exercises (Section 3.5.1, Chapter 3) were used to produce a detailed description of the village hunting territories of Dibouka and Kouagna.

The hunting territory of Dibouka and Kouagna was delimited, and its area in km^2 calculated, using the positions of traps, hunting camps and old villages. A more detailed picture of land use by trappers in these two villages was produced by calculating the number of traps, the total length of principal and private paths and mean distances of traps, hunting camps and old villages from the village. Changes in hunting pressure with distance from the village were determined by buffering each village in concentric 1 km rings, and calculating the number of traps/ length of paths/ km^2 within each ring. Changes in forest type with distance from the village were determined by looking at the distance from the village of traps in a particular forest type. This case study was then added to others from Central Africa, studies were compared, and any trends revealed.

6.2.2 Hunting offtakes and correlates of trapping success

Total offtake rates (per trap, or per trap/month) were estimated using the individual trap catch data collected during hunter follows and from village returns. As described in section 3.4.2.2, Chapter 3, these datasets have different strengths and weaknesses and so were employed in the analysis accordingly. Hunter follow catch data (information on the animals caught in each trap, provided by the hunter during a hunter follow) provides detailed information on the success of each trap, but lacks dates for each capture. Village returns data (collected by field assistants on the return of each hunter from the forest with his catch) provides detailed information on the catch characteristics of each animal, and the exact date of its capture. However, due to catches previous to the start of the study, and the hunter participation required for this method, it does not provide complete catch data for each trap.

Hunter follow catch data were used to investigate which of the individual trap characteristics (described in Section 3.4.2.2) were the best predictors of trapping success (whether a trap caught one animal or more, or did not), using a General Linear Model with a binomial error structure. In total, the hunter follow catch data from 39 hunters (4978 traps, 1402 catches) was used in the analyses, and the mean number of traps/hunter for this sample was 94 traps +/- 16.3. The mean number of traps/hunter for all hunters in the village was 63 traps +/- 9.4, which means that the sample use over-represented the more active hunters.

As well as these trap characteristics, a number of other measures of hunting pressure were calculated using the ArcGIS map. The trapping density around each trap was calculated by drawing a 250m buffer around each trap, and counting the number of adjacent traps contained within the buffer. The distance (in kilometres) of each trap to the nearest village, and nearest road was also calculated. The number of animals that each trap caught was not considered, as less than 5% of traps caught more than one animal. The catch rate from village returns data was not used for this analysis, as the sample sized proved to be too small.

Trap success was examined independently according to body size of the animal caught. A combined analysis was not carried out due to the fact that body size could not be considered a continuous variable, as it was not recorded for individual animals in the hunter follows data. Thus analyses were carried out to determine the factors influencing whether a trap had caught a small-bodied (<2 kg), medium bodied (2 – 8 kg) or a large-bodied animal (<8 kg).

For each question, the GLMs were repeated using the ‘Pouvi’ and ‘Detailed’ forest categories (Table 3.3, Chapter 3). As described in Section 3.4.2.2, a basic classification of forest type was used until half way through the study, when a scientific classification was added. These analyses used both classifications in order to benefit from a complete sample size when using the ‘Pouvi’ category, and to fully explore the effect of forest type when using the ‘Detailed’ category. The fit of each GLM was tested using a cross-validation test.

As part of these General Linear Models, Hunter ID could have been added as a random factor, to control for pseudoreplication; hunters own a number of traps. Failing to take the owner of each trap into account could mean that the results of the analysis were influenced by the differences between individual hunter success rather than individual trap success. After some preliminary analyses, however, it was decided that the analysis would not use a random factor for two reasons:

1. Hunter trapping areas were discrete in space, and partly due to this each hunter often chose similar trap characteristics for all his traps. Looking at differences in trapping success within the traps for each hunter therefore did not provide a

range of trap types or distances from the village, and there were therefore only small differences in trap characteristics within the traps of each hunter. This meant that the range of trapping techniques could not be well compared by using hunter as a random factor.

2. A successful hunter may chose traps with certain characteristics, because he knows that those characteristics are successful. The success may be due to the trap characteristics, but because these traps are grouped by hunter, the random factor may more powerfully explain the difference between the traps success, compared with that of another hunters traps. However, the differences between the two hunters is actually due to the individual trap characteristics, but masked by the inclusion of the random factor.

Because trap success and hunter success are confounded in this way, the analysis was firstly conducted at the individual trap level, shown here, and then was repeated at the hunter level (taking mean values for each of the trapping characteristics for each hunter) in Chapter 7.

Village returns data included information on the date when each animal was caught, and so could be used to investigate the best predictors of how long it took each trap to make a kill. This was done using a survival analysis with censorship (using the program ‘survival’ in ‘R’), where instead of the time until death, the time until first catch was predicted. A reduced dataset of 13 hunters (3823 traps, 588 catches), where 80% of catch locations were known, was used to reduce the chance of false negatives (classifying a trap as not having caught anything, when in fact, it did but the number was not returned). The 13 hunters were also followed frequently enough (mean number of follows = 8.3) that the lifespan of each trap could be estimated to the nearest two months. Time until first catch was estimated to the nearest month, using the month the trap was laid and the date the animal was caught. The reduced dataset of 13 hunters was not representative of hunters in general, as they again over-represented the more active hunters, who tended to bring back trap numbers more consistently (mean traps/ hunter for the 13 hunters = 137 traps +-38.3).

6.2.3 Species diversity with forest type and distance from the village.

Species diversity was calculated for all traps combined in different forest types, and at different distances from the village, using the village returns dataset, where there was confidence that species had been identified correctly. Traps generally do not catch more than one animal, and so species diversity was calculated from group of traps, rather than at the individual level. Due to this grouping, and the close relationship between distance and forest type, it was not possible to separate the effects of distance and of forest type on species diversity from each other. As forest type is correlated with distance from the village, this means that the results from this analysis must be interpreted carefully.

Two facets of species diversity were investigated: species richness (number) and species evenness (dominance), and EstimateS software (http://viceroy.eeb.uconn.edu/Estimates) was used for all calculations. Species richness was estimated using the Chao 1 estimator of species number (Chao, 1984). The Chao 1 estimator was chosen because it less sensitive to sample size than more traditional measures such as the Shannon-Wiener index (Magurran, 2006), and provides an estimate of the actual number of species in the environment, rather than the observed number, by taking account of the number of singletons and doubletons in the sample.

A major problem with estimates of species richness is their dependence on sampling effort (Gaston, 1996). As the sampling effort increases, the number of species increases until it reaches an asymptote (the true number of species). Because catches were grouped by forest type, or distance from the village, the sample sizes for each group differed. In order to make sure that sample size alone was not responsible for any trends seen, species accumulation curves were plotted by randomly sampling each group with replacement, and looking at the rate at which new species were added with an increase in the sample size, until the original size of the sample had been attained. This was repeated 100 times and the results averaged to produce the species accumulation curves. The species accumulation curves for each group could then be compared, to assess whether the curves had reached an asymptote, or were beginning to level off, in which case the estimate of species richness, and any differences between groups, could be trusted.

The Chao estimator was also calculated in the same way, by randomly selecting an individual animal, calculating the Chao estimator, and then randomly selecting another individual (with replacement), adding this to the first, and recalculating the estimator and so on until the number of animals in the original sample had been added. Again this was repeated 100 times.

Species evenness or dominance looks at how much the sample is dominated by one species. This measure is much less sensitive to sample size than richness. Evenness was calculated using the Simpson's reciprocal index (Simpson, 1949), a diversity measure that emphasizes dominance over richness, where a value of 1 represents complete evenness, and values of over 1 represent increasing dominance of one or more species.

6.2.4 The state of animals found in traps with distance from the village.

Using the entire village returns dataset where the trap identity was known, Chi squared tests were used to look at whether the state of the animal when found deteriorated with distance from the village. As concerns the state of the meat with distance, the village returns data is probably biased, as rotten animals far from the village are more likely to be thrown away at the trap site rather than carrying a useless weight back to the village, and are therefore more likely to be under-reported. Rotten animals close to the village may be brought back to the village to see if any use can be made of them, as this takes little effort. This bias could not be corrected for, and will be discussed further.

6.2.5 Use of the hunting landscape for food and income

Using the entire village returns dataset, I investigated whether the percentage of animals sold varies with distance from the village, and looked at how the total number and biomass of hunting returns was distributed with distance from the village, in order to understand landscape use by hunters for the purposes of food and income. The methods for this work follow previous results from this section, and so are described in full in the results section.

6.3 Results

6.3.1 Village hunting territories: A case study from Dibouka and Kouagna

Figure 6.1 shows the distribution of all the hunting paths, traps, hunting cabins and old villages, around the two villages of Dibouka and Kouagna, which were mapped during the study period (November 2003 – February 2005).

6.3.1.1 Inter-village territory boundaries

Dibouka and Kouagna have shared history and are perceived as a regroupement, and this is reflected to some extent in the overall combined use of the landscape by the two villages. Hunting camps far from the villages are shared (Figure 6.1) and hunters from Dibouka can gun hunt in Kouagna's territory if they are hunting with someone from Kouagna, and vice versa. However, as Figure 6.1 shows, there is a clear boundary between the trapping areas of Kouagna and Dibouka, which is only on rare occasions broken when trappers from two villages are trapping together. Trapping rules between hunters will be investigated further in Chapter 7.

Through hunter interviews, I established that the territory boundaries with the neighbouring villages of Mouila Pouvi (Dibouka) and Massambi-Njole (Kouagna) were much more rigid than between Dibouka and Kouagna. This was corroborated during hunter follows; often when following a hunter who trapped on the edge of the village territory they would point out to me that we were close to where the trapping areas of the next village began. However, we never came across a trap from another village while trapping with hunters from Dibouka and Kouagna, as the trapping areas never overlapped, and trappers from Dibouka and Kouagna never trapped with those from Mouila Pouvi or Massambi-Njole. Even within shared hunting camps (such as Loa Loa, which is used by Dibouka and Mouila Pouvi) each village has their own 'side' to the hunting camp on which they hunt. These strict boundaries are a result of the traditional land use practices that were employed the old villages before the regroupement, and will be discussed further in Chapter 7. Because of these territory rules, I can be confident that by following only hunters from Kouagna and Dibouka I did not underestimate the landscape use due to hunting from outsiders.

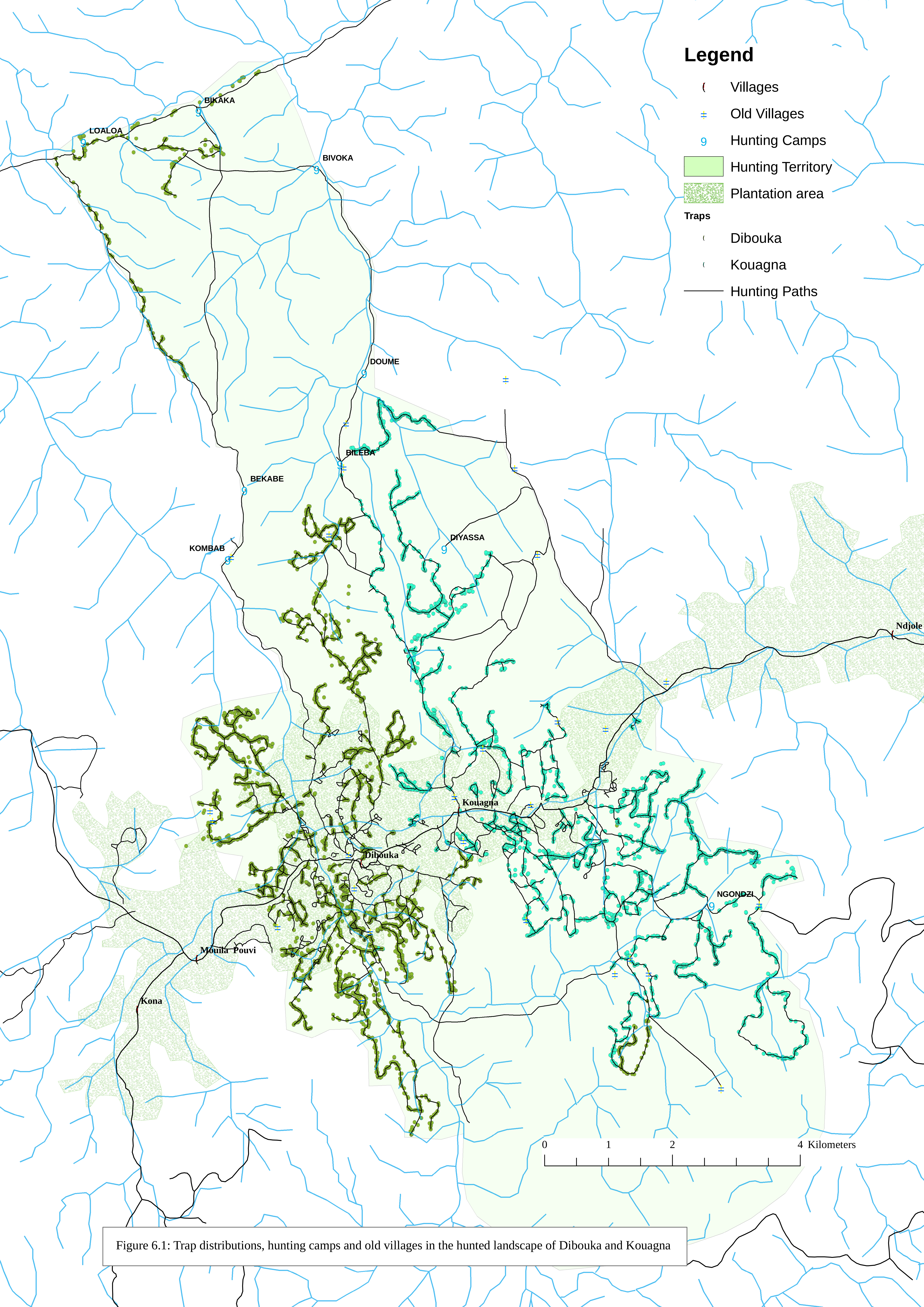


Figure 6.1: Trap distributions, hunting camps and old villages in the hunted landscape of Dibouka and Kouagna

6.3.1.2 Estimates of village territory size

From distances of approx. 8 – 10 km from a village, there were overlaps in territory between the two villages, and so the overall village hunting territory was calculated as the land used by both Dibouka and Kouagna, and is shown in Figure 6.1. This is defined as the landscape used for trapping or hunting during the study period, plus the land known to be used frequently by villagers but not during the study period, ascertained during PRM exercises. Trap, path, hunting camp and old village locations were all used to help delimit the hunting area. The combined hunting territory of Dibouka and Kouagna was estimated as 102 km^2. Accounting for some overlap in territory far from the village, the hunting territory used by Dibouka was estimated as 50 km^2, and for Kouagna 61 km^2. The amount of this territory that was actually used for trapping during the study period was calculated by drawing a 100m buffer around each trap, dissolving any overlap between buffers, which gave an estimated 16 km^2 for Dibouka and 14 km^2 for Kouagna.

Gun hunters were asked which named areas of the forest they had used on their trip, and this information was used during PRM to help delimit the village territory. A couple of hunting trips known to me during the study period crossed the river (the Lolo) to the north of the study area, which was not perceived by villagers to be within the territory of Dibouka and Kouagna, but such trips were very infrequent as they involved absences from the village in excess of four days, which most hunters were reluctant to do.

6.3.1.3 Hunting camps, old villages and trapping distances:

Nine hunting camps were in use during the study, and two of these, (Loa Loa and Bikaka, in the north of the hunting area) were shared between Dibouka and Kouagna hunters. The mean distance of hunting camps from the village was 7.9km, with the furthest camp at 12.1 km and the nearest 5.1 km away. Old villages are also frequently used as overnight hunting camps, and using a mixture of hunter follows and PRM exercises the location of as many of the old villages as possible was ascertained. In Kouagna, I am confident that the majority of old villages were located, with 19 villages mapped. However, in Dibouka, this knowledge seemed to have been lost to a greater extent, with only the most recent old villages remembered, and only eight were mapped. The mean distance of old villages from the main village was 3.2 km, with the furthest being 6.8 km away and the nearest 0.2 km (IQR 1.1 – 4.9 km). The mean distance that traps were found from the village was 2.8 km, with the furthest trap found at 12.5 km from the village, and the nearest 0.3 km (IQR 1.4 – 3.6).

6.3.1.4 Traps and hunting paths: numbers, lengths and densities.

Over the entire study period (Nov 2003 – Jan 2005) 9470 traps were recorded as present: 3766 in Kouagna and 5704 in Dibouka. However this included traps that had been laid in some cases as far back as June 2003. Using information collected on when each trap was laid, the number of traps laid in one year (beginning of Dec 2003 – end of Nov 2004) was calculated (the month laid was known for all but 272 of the traps surveyed). Overall, 6319 traps were laid during this period; 2771 in Kouagna and 3344 in Dibouka. Figure 6. 2 describes how the number of traps laid varied over the year; the trapping effort was highest during the wet season, especially October, November and December, and declined four-fold in the dry season, or plantation season.

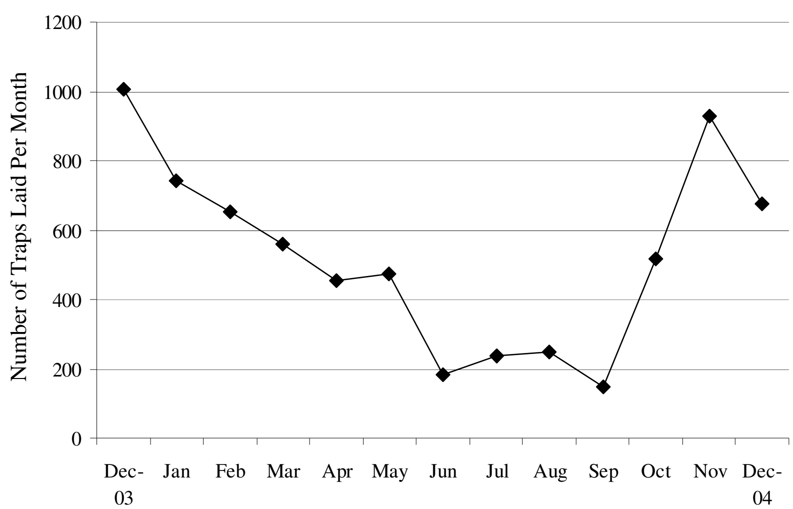


Figure 6. 2: The number of traps laid per month over time.

The traps that are laid have different life spans, ranging from a couple of months to over a year (discussed further in Chapter 7), and therefore the number of traps laid over a year does not give us an accurate idea of the number of traps active at any one period in time. It was not possible to gain reliable data for all traps on when each trap was removed, and so an estimate of the number of traps present at one time was calculated using the hunter follow data. For each hunter, the average number of traps recorded during each follow was calculated. This number was then divided by the proportion of months in a year that each hunter trapped for, to take account of hunters who only trapped for a certain number of months each year. These estimates were then combined to give the total trapping pressure at a certain point in time. For Kouagna, the estimate was 1670 traps at any given time, and for Dibouka 2873, giving a total of 4543 traps. These two estimates were used to calculate the overall density of traps within the village territory of the two villages, which are given in Table 6. 1:

Estimate of trap numbers	Combined territory (101 km 2)	Dibouka hunting territory (61 km2)	Kouagna hunting territory (50 km2)
Number laid over 1 year	63 traps/km^2	55 traps/km^2	55 traps/km^2
Number present at one time	45 traps/km^2	47 traps/km^2	33 traps/km^2

Table 6. 1: Trap densities, using different estimates of hunting territory size and trap number.

In total, the path network covered a length of 245 km; 159 km of principal paths and 86 km of private paths. Within the combined hunting territory the density of paths was 2.4 km/ km^2.

6.3.1.5 Changes in hunting pressure and forest cover with distance from village

Trap densities of 180/km^2 were found within 1 km of the village, declining sharply to 30/km^2 by 6 km away, and path densities declined similarly (Figure 6. 3). Figure 6.1 shows that there are areas of the landscape that are not trapped, and these tend to be the more hilly areas. Hunters tend to avoid these hills, which can make trapping trips quite demanding, instead often using river valleys during their trapping trips.

The effect of the density and distribution of traps on the number of prey territories that were likely to be free from trapping effort, with distance from the village, was explored using circles with an area of 0.04 km^2 and 0.2 km^2, to represent blue and red duiker territories (territory sizes taken from Kingdon, 1997). Using ArcGIS, within each 1 km band from the two villages, 1000 ‘duiker territories’ were randomly assigned a location within the hunting territory. The number of territories that were free from traps was then counted, at each km from the village, and the results are shown in Figure 6. 4. Close to the village, there is nearly a 100% chance that red duiker territories would contain a trap, and this falls sharply with distance from the village to less than 20% by 7 km. Blue duikers show less of a dramatic difference, as their territories are smaller, and there is therefore a better chance (around a 40% chance) of a territory being free from trapping close to the village.

The type of trap also varied with distance (Figure 6. 5). Overall, 82% of traps were foot traps. Neck traps were used predominantly close to the village, but there was an almost complete switch to the use of foot traps outside 3 – 4 km, and the reasons for this will be discussed further in Chapter 7.

There is also a change in forest cover with distance from the village. The mean distance from the village to the edge of the plantation zone (from satellite data provided by SBL) was 1.7 km, with the furthest plantations at 3.3 km from the village. Although these data were collected three years before this study, plantation locations tend to be familial plots; old plantations are left for six or more years, and then re-cleared and used again. Women use the old plantation sites that their parents and grandparents used, and so the general area under cultivation is not likely to expand a great deal over time. Trap data on forest type was used to quantify the change in forest type with distance to the village (n = 2803 traps), and Figure 6. 6 shows the median distances from the village for each forest type. As would be expected, there is an obvious change from disturbed forest to primary forest with distance from the village, and the mean distance from the village of young primary forest was 6.8 km (IQR = 2.9 – 11.5 km).

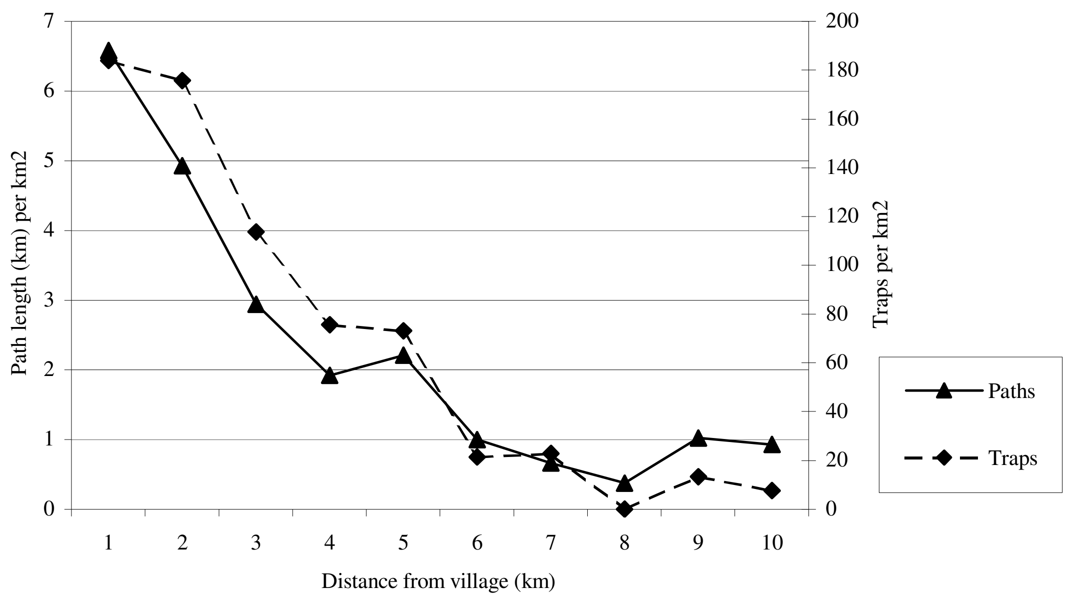


Figure 6. 3: Declines in trap and path density with distance from village

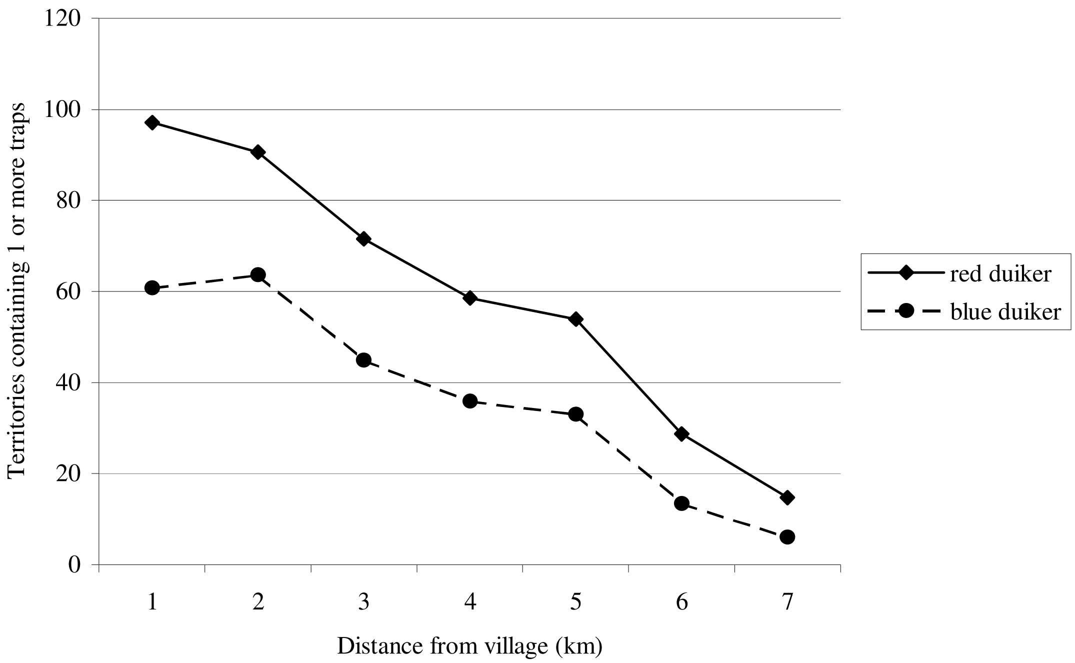


Figure 6. 4: The proportion of randomly assigned red and blue duiker territories that contained a trap, with distance from the village.

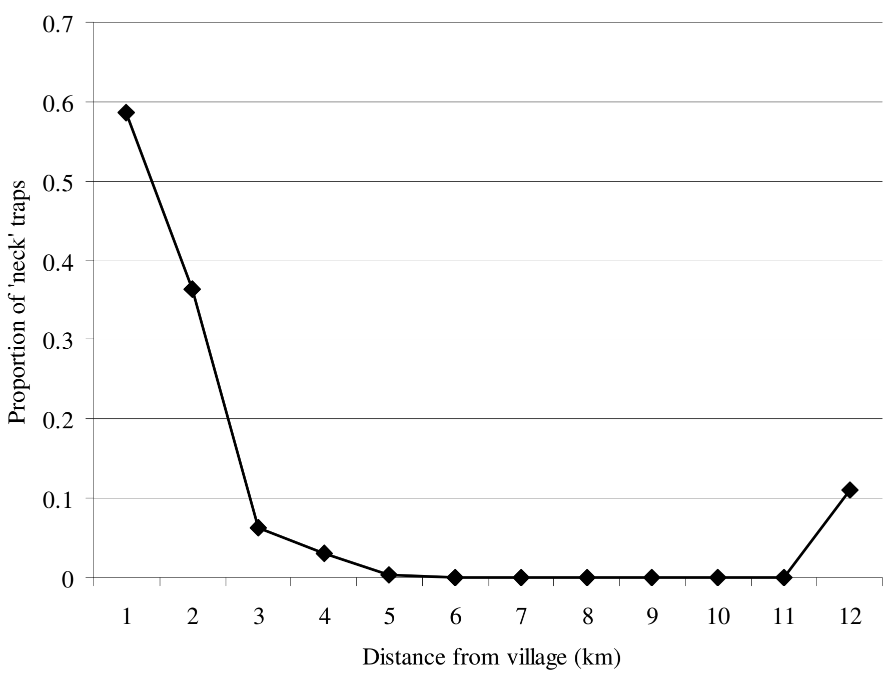


Figure 6. 5: Changes in trap type with distance from village

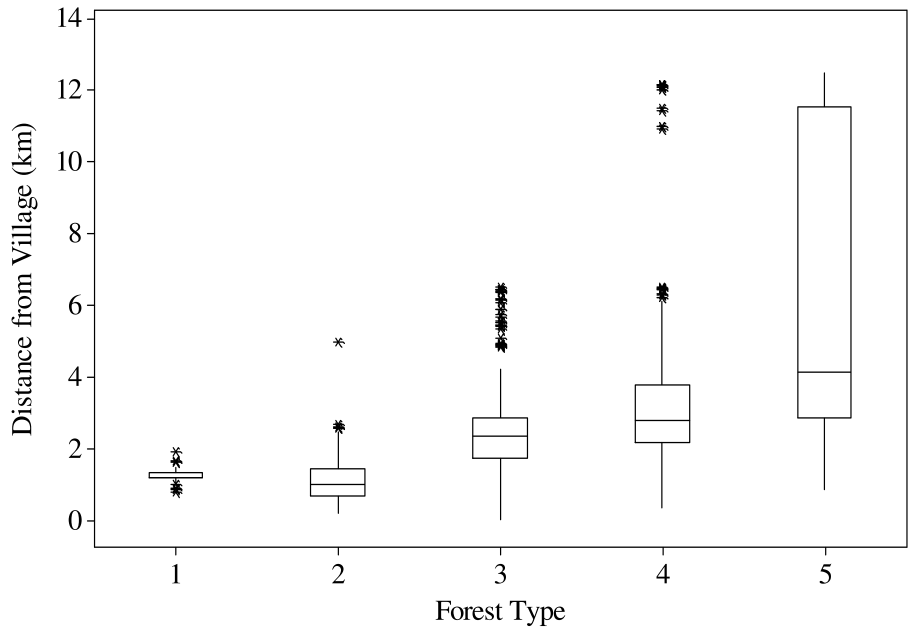


Figure 6. 6: Boxplot showing changes in forest type with distance from village. Boxes contain the range of the data, and the middle line shows the median distance for each forest type. Outliers are shown as individual points. 1 = old plantation, 2 = old plantation/ young secondary, 3 = young secondary, 4 = old secondary, 5 = young primary

6.3.2 Village hunting territories in Central Africa: a comparative study

6.3.2.1 Village territory sizes

Thirty-four estimates of village hunting territories have been analysed, along with information on each village, and the sources and their findings have been summarised in Appendix A3.3. As already shown, there are different ways of delimiting a hunting territory. The methods in these reports was predominantly PRM, establishing the hunting territory of the village and not the current land use by hunters, which corresponds to the higher estimate of 101 km^2 for Dibouka and Kouagna and not the estimate of trap coverage.

Hunting territory sizes for single villages ranged in size by an order of magnitude; the smallest territory was 52 km^2 (Essiegenbot, Cameroon; Vermuelen 1997), and the largest 570 km^2 (Ituri Forest DRC; Hart 2000). The mean size of a hunting territory was 196 km^2 (+- se. 27.9). Territory size was significantly correlated with the number of inhabitants in the village (Figure 6. 7), which provides us with a useful yardstick for estimating village land-use cover in Central Africa.

The median amount of land used per village inhabitant was 0.96 km^2 (+/- 0.107, range: 0.25 – 1.96 km^2/person). The territory per village inhabitant for Dibouka and Kouagna is lower than would be expected from this relationship (combined hunting territory estimate of 0.26 km^2/person, Kouagna = 0.47 km^2, Dibouka = 0.19 km^2). This may be due to differences in the techniques used for measuring territory size, or may reflect lower or more concentrated land use for Dibouka and Kouagna than is generally found elsewhere. The only other example of village land use in Gabon can be found in Lahm (1993b), who provides an estimate of 1.6 km^2/person for a village in northeast Gabon, and sample size made it imprudent to look at territory size by country.

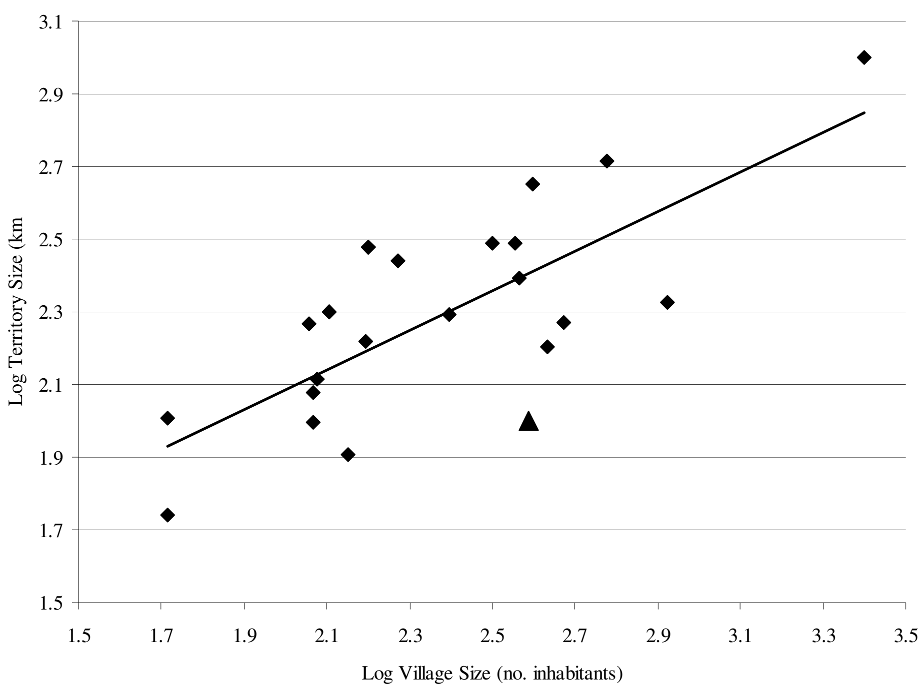


Figure 6. 7 Territory size increases with the number of inhabitants in a village. r = 0.750, p <0.001. This study represented by the large triangle data point.

6.3.2.2 Trap and hunting camp distances, and trap densities

Table 6. 2 provides a summary of those studies from Central Africa that contain information on the distances of traps and hunting camps from villages. Although these studies are few, they provide some useful comparisons. In this study (Dibouka and Kouagna) the bulk of hunting pressure radiates from the village, and this seems to hold true for most of the studies, even though all studies have active hunting camps. This is not the case for Sendje, Equatorial Guinea (Kumpel, 2006), where hunters walk to camps up to 20 km from the village, and then trap from these camps rather than hunting directly from the village. Varying degrees of this are seen in the Lope reserve, Gabon (Maisels, 2006), where pygmies walk to a camp 20 km from the village and hunt from the camp, and also in the Ituri (Hart, 2000), where the Mbuti hunt from the village, but also have satellite forest camps.

There are also differences in trapping styles. Dethier (1996) and Vanwinjnsberghe (1996), in Cameroon and the Congo, report that hunters use ‘traplines’, whereas this study and Kumpel (2006) in Equatorial Guinea suggest a more ‘scattergun’ approach to trapping; hunters have their own paths, but traps are laid independently from each other to a large extent (covered further in Chapter 7). This could be a difference in observer descriptions, but F. Maisels (pers. comm.), who has worked in the Congo, Cameroon and Gabon, reports that these differences are true.

Similarities exist in the trapping and hunting camp distances reported. The furthest the hunters went was 30 – 40km from the village, and hunting camps were generally found 10 – 25km from the village. However, the area used by trappers was generally much smaller. Mean distances of traps or traplines from the village were quite low (2.2 to 4.5km, excluding Sendje, where traps radiate from camps and not the village) but more relevant is how far from the villages traps extended. Estimates of the furthest distance that traps were found from the village ranged from 6.5 to 12.5 km, and after accounting for the tail end of the trapping distribution by taking the 90th quantile, most traps were found within 4 to 7 km of the villages.

Location	Source	Methods	Distances from village (km)			Density Estimates			
			Hunting camps $\overline{X}$ (range)	**Traps** $\overline{X}$ (range) 90^{th} quantile	**Other**	**Hunters surveyed/ total hunters**	**No. Traps**	**Territory size** (km2)	**Density Estimate** (Traps/km2)
Sendje, Eq. Guinea	Kumpel, 2006	Hunter follows	10 camps 12.0 (6.5 – 19)	13.1 (11.8 – 15.3)		55/55	5060 at one time	307	16.5
Dibouka and Kougna, Gabon	This study	Hunter follows	9 camps 7.9 (5.1 – 12.1)	2.8 (0.3 – 12.5) Q90: 5.2		76/76	4543 at one time	101	45
Kanare, CAR	Dethier, 1996	PRM, hunter follows		Under 1 hours walk		14/?	1105 at one time	120	9.2
Ekom, Cameroon	Dethier, 1995, Jeanmart 1998	PRM, hunter follows	8 camps 13.6 (10 - 18)	21 traplines 2.2 (0.2 – 11.3) Q90: 5.0		37/135	1551: 538 village 1013 forest	307: 37 village 270 forest	5.1: 14.5 village 3.8 forest
Mekas, Cameroon	Muchaal and Ngandjui 1999	Transect surveys		<40					0 – 10km: 16.5 10 – 30km: 7.6 30 – 40km: 5.9
Lope reserve, Gabon	Maisels, 2006	Transect surveys	2 camps: 20km 25km		Human sign: $\overline{X}$: 12.3 95%C.I.: 10.9 – 13.7 Max: 40km				
Bomassa, Congo	Eves and Ruggiero, 2000	Hunter questionnaire			Regularly used territories: 10 – 15km				
Malen, Cameroon	Delvingt, 1997	PRM, hunter follows	19 camps 9.4 (1.8 – 19)						
Oleme, Congo	Vanwinjnsberghe 1996	PRM, hunter follows	3 camps: 3,4 and 5km	18 traplines: 4.5 (0.4 – 9.4) Q90: 7.4					
Diba, Congo	Vanwinjnsberge 1996	PRM, hunter follows		18 traplines: 3.0 (1.7 – 6.5) Q90: 4.3					
Bakota, CAR	Dethier, 1996	PRM, hunter follows	7 camps: 25.3 (12.7 – 40.5)						
Zoulabot ancient, Cameroon	Yasouka, 2005	Hunter follows	6 camps: 10 – 20km						
Ituri forest, DRC	Wilkie et al, 1998	Hunter follows/ interviews			Most forest extraction <15km				

Table 6. 2: Distances and densities of traps and hunting camps: studies from Central Africa

There are very few estimates of trapping density, of which those of Muchaal and Ngandjui (1996, using transect counts) and Kumpel (2006) stand out as being the most reliable, and compared with these two studies Dibouka and Kouagna have very high trap densities (approximately 3 times higher). Although hunter follows provided estimates of trapping densities in Ekom and Kanare (Dethier, 1995), the researchers had problems with hunter participation in both these studies, and were only able to get trap numbers for some of the hunters, which will have produced an underestimate of trap densities.

6.3.2.3 Village hunting land use in Gabon

The relationship between the number of individuals in a village and the size of the village's territory provides a tool with which to estimate the amount of land in Gabon covered by village territories. Estimates of trapping and hunting camps distances allow further insight into the amount of land in Gabon that is likely to be free from village hunters. The most obvious way of calculating village territories, given their population sizes, would be to calculate territory size on a village-by village basis. However, the 2004 census, which contains this level of information, was not available for use at this time, and it is hoped that this work can be continued when the census data become available.

There are, however, estimates from the 1997 census of the total number of people living in rural areas. The number of rural inhabitants (181,700) was therefore multiplied the mean territory/person calculated in section 3.3.2.2 (0.96 km^2/person), to provide a rough estimate of total village territory coverage of 174,432 km^2, or 65% of Gabon's total surface are (266,299 km^2). To check these results we can see how many km^2 this would represent per village. There are 2402 mapped villages in Gabon, and so this would represent a territory size of 72.6 km^2 per village. This is not unreasonable given that the mean territory size calculated for the studies from Central Africa was 196 km^2, and the territory sizes for Dibouka and Kouagna are 50 km^2 and 61 km^2 respectively.

The distances of traplines and hunting camps from Table 6.2 were also used to estimate land use in Gabon. Using a GIS program, each village in Gabon was buffered with a circle of radius 5 km, to represent the land used intensively for trapping, and by 10 km to represent the furthest from the village that villagers hunted. As can be seen from table 3.3, these are both conservative estimates. Where village territories overlapped, these overlaps were dissolved so that the overlapping territory was not counted twice. Using this method, 69,420, or 26%, of Gabon's surface area is estimated to be trapped intensively and 145,513 km2, or 55%, is hunted to some extent (Figure 6. 8). This does not include hunting from logging camps, or account for increased access along roads, and does not account for the influence of large towns. These are very rough estimates, but do provide some idea of the potential coverage of village hunting.

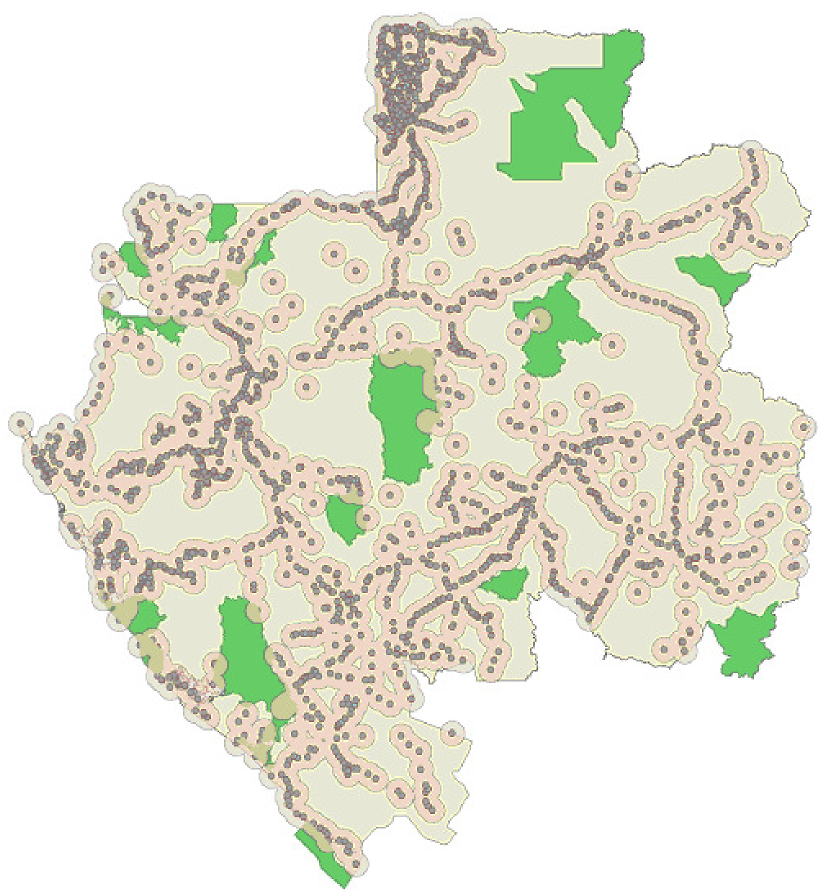


Figure 6. 8: **Village landuse in Gabon. Villages are shown by purple dots, and are surrounded by a 10 km dissolved buffer. National Parks are shown in Green.**

6.3.3 Correlates of trap success

6.3.3.1 Estimates of total offtake rates

Several estimates of trap offtake rates were calculated from hunter follows data and from village returns data. The village returns data provides an estimate of the mean number of animals caught per trap over the 12-month study period. The hunter follows estimate provides an estimate of the mean number of animals that had been caught in a trap up until the time that it was surveyed.

Hunter follows data suggest a mean offtake rate of 0.28 animals per trap (1402 catches/4978 traps). Village returns data suggest a lower catch rate of 0.12 animals/trap (calculated from catch rates of traps laid between Jan - Dec 2004). Village returns are more subject to underestimation, as some catches will have slipped by undetected. The real catch rate per trap is therefore likely to exist between 0.12 and 0.28 animals/ trap laid.

Catch rate/trap/month (a more accurate way of using the hunter follow data) was also calculated, as the trap age at the time of the hunter follow was known, and this was estimated as 0.048 animals/trap/month.

6.3.3.2 Predictors of trapping success

Binomial GLMs were used to investigate the best predictors of whether a trap was successful in catching anything or not. The outputs of these GLMs are displayed in Appendix A3.4, and the minimal model for each is summarised in Table 6. 3.

The age of a trap was a consistent predictor of whether it had caught something or not when surveyed, and Figure 6. 9 shows how the likelihood of trap success increases with the time a trap is out for, using data from hunter follows. The proportion of traps having caught something increases steeply until the trap has been in place for five months, and then levels out.

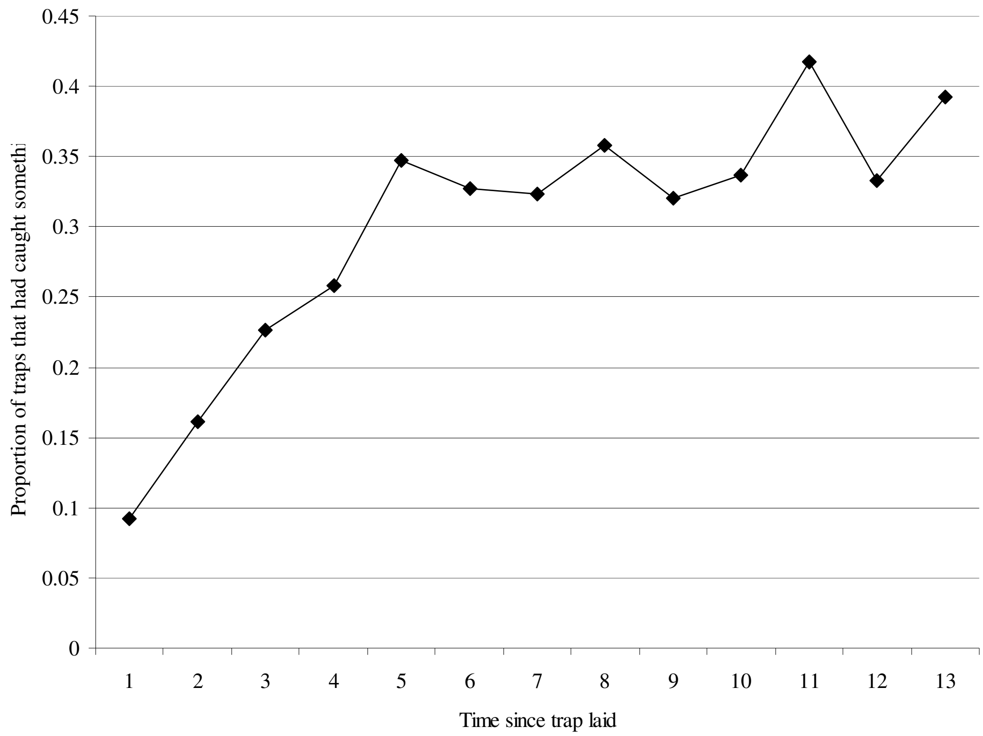


Figure 6. 9: The proportion of successful traps, defined as having caught 1 or more animals, increases with the number of months since the trap was laid.

GLM and dataset	**Trap Life**	**Trap Type (Neck)**	**Trap Density**	**Understory Density**	**Forest Type 1- 5**	**Distance from Village**	**River (yes)**	**Human Track (private)**	**Interactions**
TOTAL CATCH Complex forest (n = 1774)	+++	+++	- - -	- -	+++				Distance from village* Forest Type (+++)
Pouvi Forest (n = 4053)	+++	+++	- - -	N/A	+		- -	-	
SMALL CATCH Complex forest		+++	- - - (with interaction, otherwise non-sig)	2 = - 3+4 = +	+++	- - -			Distance*Trap Density (+)
Pouvi Forest	++	+++	-	N/A	+++	- -		-	
MEDIUM CATCH Complex forest	+++				+++		-		Distance from Village*Forest type (- - -)
Pouvi Forest	+++			N/A	+		-		
LARGE CATCH Complex forest	+++	- - -	-			+ + +	++		
Pouvi Forest	+++	- - -	-	N/A		+ + +	+ +		

Table 6. 3: Summary of the minimal models produced from Binomial GLMS, showing the best predictors of whether a trap catches an animal or not, and whether it catches a small/medium/large animal or not. The '+' symbol signifies a positive relationship, and the '-' signifies a negative relationship. The number of symbols signifies the size of the p-value. 1: 0.01 - 0.05, 2: 0.001 – 0.01, 3: <0.001

The type of trap was also a significant predictor of whether an animal was caught, apart from for medium-sized animals. Figure 6. 10 shows the success rate for neck and foot traps by species category. Neck traps were more likely to be successful than foot traps; however, foot traps catch larger animals, and therefore the mean total biomass caught per month was higher for foot traps (0.21 kg/trap/month caught per foot trap; 0.11 kg/trap/month caught per neck trap, using mean weights per species, calculated from weights of animals during the study.).

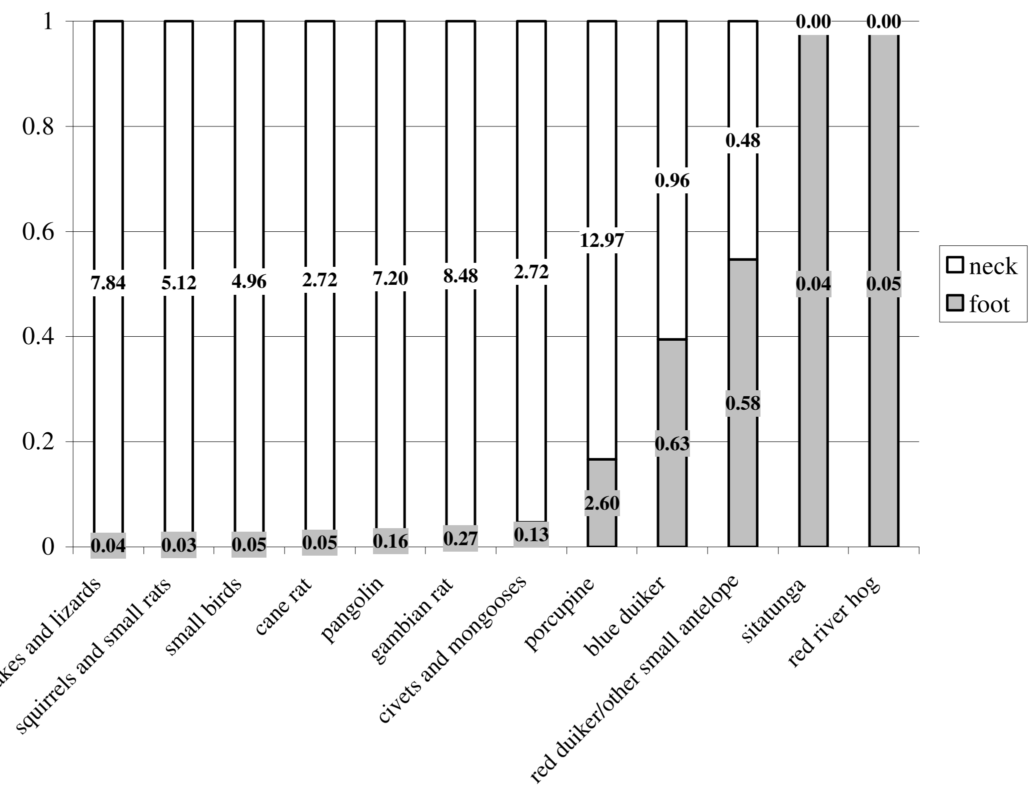


Figure 6. 10: Catch rate of neck and foot traps by species category. Catch rates (catch/trap/month*100) are in bold type, and the relative size of the catch rates in neck and foot traps for each species category are shown by the relative size of the bars.

Trap density and forest type are both correlated with distance, and by including these three variables in the model, the effects of these variables can be considered independently from one another. Overall, the distance of a trap from the village does not influence whether the trap is successful or not. However, distance does affect the type of animal that the trap catches: trap success for small animals is significantly higher close to the village, distance is not a significant for medium-sized animals, and trap success for large animals is significantly higher further from the village. As the body size of an animal increases, the mean distance of traps that are successful in catching it increases (Figure 6. 11). There are three obvious exceptions. Sitatungas are caught much closer to the village than their body size would predict. They are well-known crop-raiders, and so are probably moving into plantation areas, and being caught close to the village in traps set specifically for sitatunga around the plantations. Cane rats generally weigh around 4 kg, yet they are caught closest to the village. Cane rats, like sitatungas, are crop raiders, and known to live in plantations and degraded habitat, and so their presence close to the village is not unexpected. Gambian rats, which generally weigh around 1kg, are caught relatively far from the village. This is contrary to expectation, as Gambian rats have a wide habitat distribution, and sometimes even become pests in urban areas (Novak and Paradiso, 1991), so from their body size we would expect to find them closer to the village.

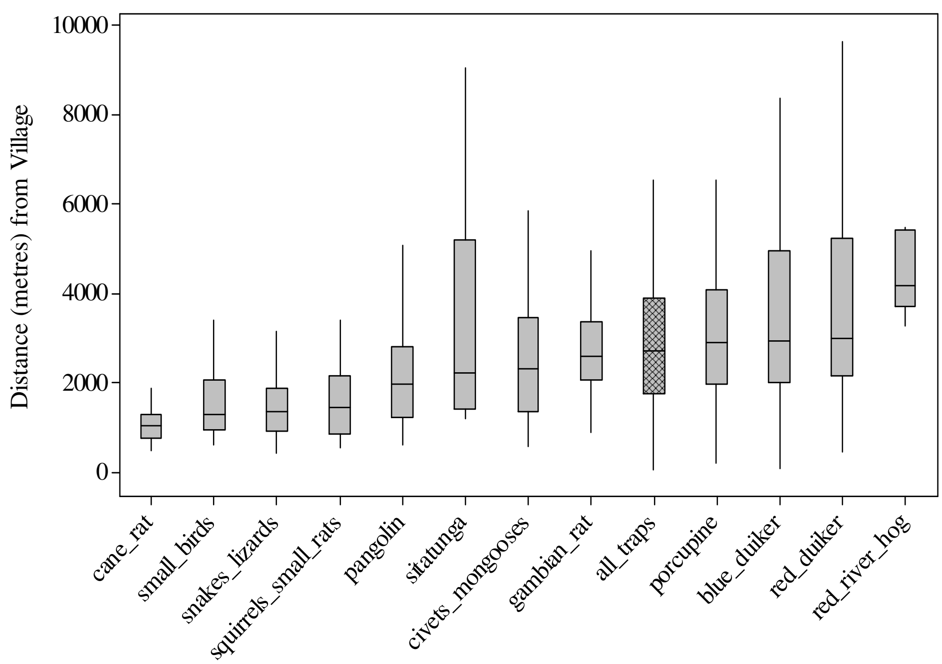


Figure 6. 11: The mean distance from the village at which species are caught. Correlation of log weight of animal (mean species weight kg) and log distance from village (km): r = 0.244, p <0.001).

To investigate whether within species, the weight of an animal increased with distance from the village, the village returns data were used to look at weight with distance for three species: porcupine, blue duiker and bay duiker. There was no significant correlation for any of these species.

The effect of distance on the catch/trap/month in numbers of animals, and in biomass (kg) is shown in Figure 6. 12. Although, as mentioned, distance from the village does not have a significant effect on the number of animals caught per trap month, because the animals close to the village are small 'weedy' species, and the mean mass of species caught generally increases with distance from the village, the mean biomass (kg)/trap/month increases with distance from the village.

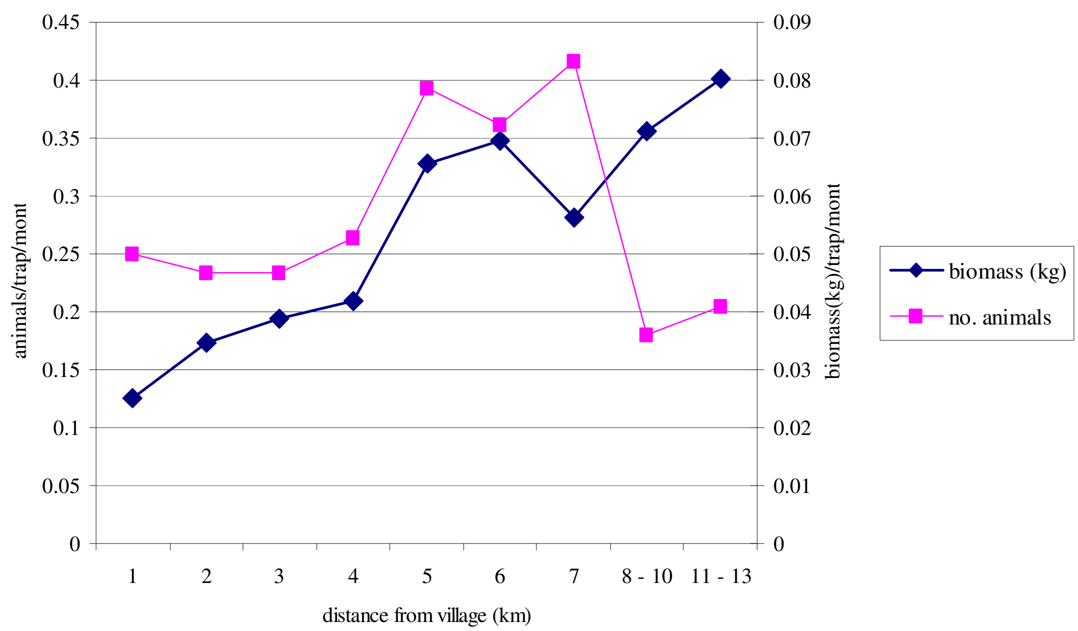


Figure 6. 12: The number of animals, and biomass (kg) caught per trap month, with distance from the village.

Whether a trap catches anything or not is negatively affected by the density of traps surrounding it (Figure 6. 13), and success in catching both small and large animals is also reduced in areas of high trap density, but there is no significant effect of trap density on medium-sized animals.

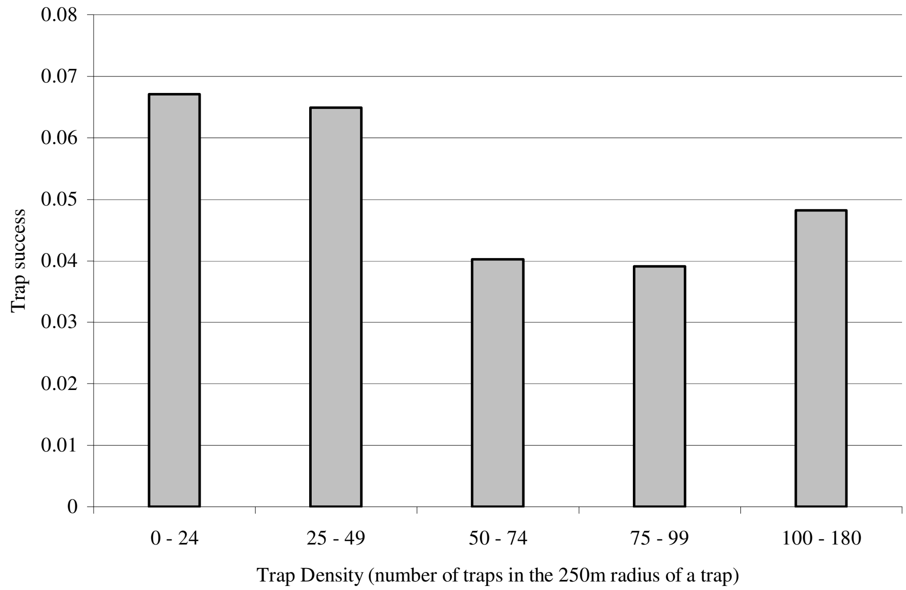


Figure 6. 13: Trap success declines at higher trap densities. Trap success is defined as the number of traps catching 1 or more animals, using hunter follows data.

Overall, trap success is higher in mature forest, and clear understorey. When looking within the three size-classes, trap success for small and medium-sized animals is also significantly predicted by more mature forest. Small animals however are more likely to be caught in dense understorey, whereas there was no effect of understorey on medium or large animals. The capture of large animals was not influenced by forest type; distance seems to be one of the most important predictors for large animals. The confounded nature of distance from village, trap type and forest type means that, although the presence of mature forest is a significant predictor of trap success for some animals, the actual catch/trap/month is higher in degraded forest types (Figure 6. 14).

The final significant predictor from these models was the proximity of a trap to a river. Overall, this did not influence whether a trap caught anything or not, but medium-sized animals were less likely to be caught close to a river and large animals were more likely to be caught close to a river.

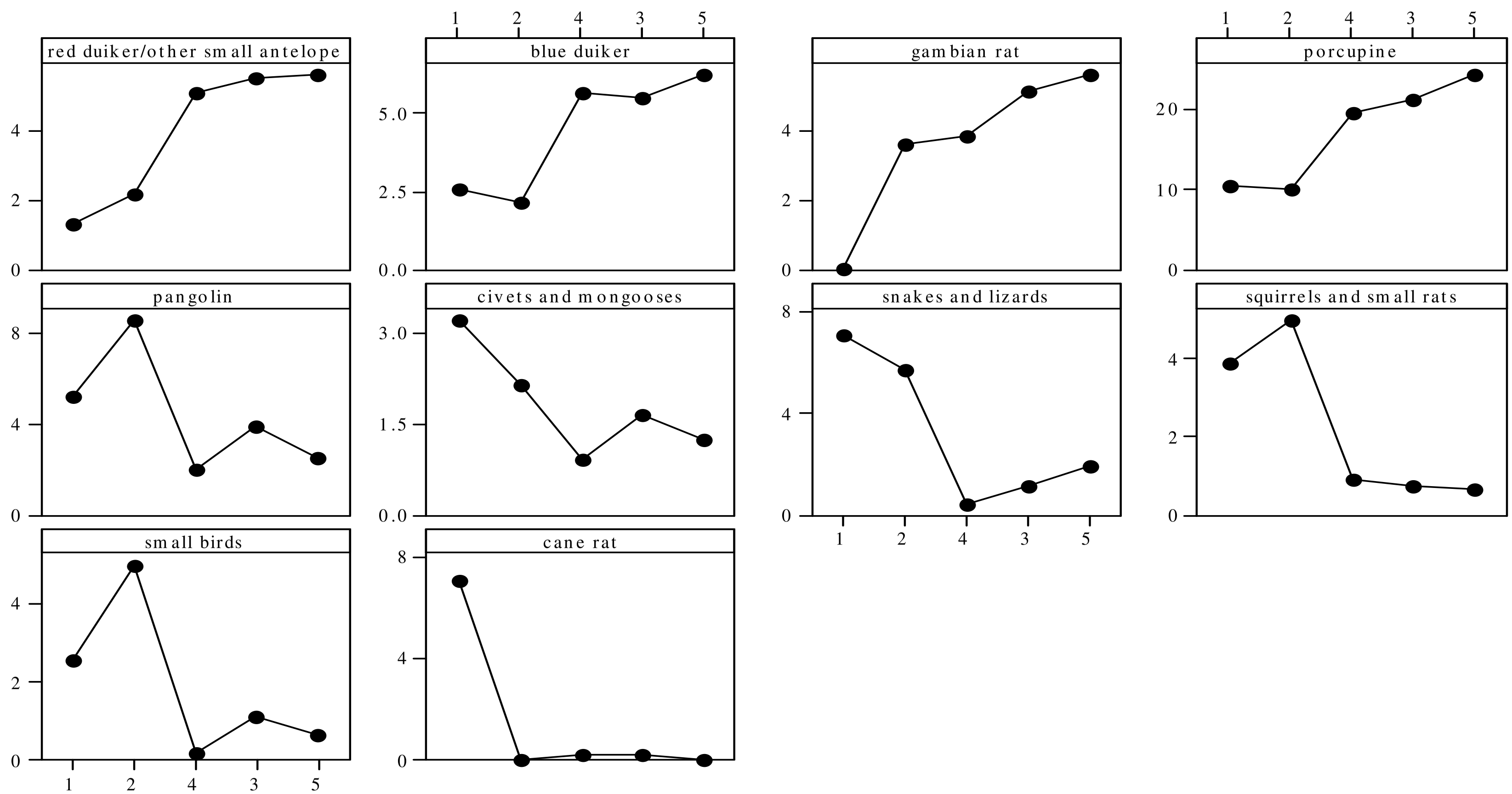


Figure 6. 14: Catch/trap/month for different species/ species categories, with forest type. Catch./trap/month has been multiplied by 1000 for data display purposes. Forest type is numbered 1 – 5, where 1 = plantation, 2 = old plantation/young secondary, 3 = young secondary, 4 = old secondary and 5 = young primary.

6.3.3.3 Predictors of the time until first catch

Table 6. 4 shows the results of a survival analysis with censorship, used to find the best predictors of how long it would take a trap to make a catch. The predictors for time until first catch are very similar to those for whether a trap will catch anything or not. Neck traps are quicker to catch animals than foot traps, as are traps further from the village, traps in less degraded habitat, and traps in areas of low trap density.

General model:	**d.f (Change, residual)**	**Deviance**	**p (chi square)**
Forest Type	2, 3011	11.09	0.003
Distance	1, 3011	45.95	<0.001
Trap Type (Neck/Foot)	1, 3011	26.44	<0.001
Trap Density (250m radius)	1, 3011	21.99	<0.001
River (yes/no)	1,3011	0.98	0.322
Human Track (principal/private)	1, 3011	0.24	0.89
Minimal model:	**Estimate**	**s.e**	**p (chi square)**
Constant	16.715	1.32	<0.001
Trap type (neck)	-2.93	0.058	<0.001
Distance to Village	-1.232	0.177	<0.001
Forest Type (ngoma)	-2.852	1.058	0.007
Forest Type (evosso)	-1.556	1.038	0.266
Trap Density	0.0355	0.008	<0.001
Log (scale)	1.2918	0.034	<0.001

Reference level forest type: kange
Reference level trap type: foot

Scale = 3.64
Logistic Distribution
Loglik (model)= -2316.4 Loglik (intercept only)= -2395.7
Chisq= 158.65 on 5 degrees of freedom, p <0.001
Number of Newton-Raphson Iterations: 4
N =3018

Table 6. 4: Results from a survival analysis, with censoring, showing the best predictors of time (in months) until the first catch of a trap. A negative relationship shows a decrease in time until first catch.

6.3.4 Changes in species diversity with distance from village and forest type

Figure 6. 15 shows the species accumulation curves, Chao 1 estimator of species abundance and Simpson's reciprocal index with distance from village, and Figure 6.16 shows the same with forest type. Species richness is much higher within the 1.5 and 3.0 km bands than for those found further out, within the 4.5 and 6 km bands. The differences between 4.5 and 6.0 km should not be over-interpreted, as the species accumulation curves suggest that differences are likely to be due to sample size. The Reciprocal Simpson's Index provides an estimate of species evenness, and low values suggest an uneven distribution, with most individuals represented by only a few species. Figure 6. 15 shows that there is more species evenness closer to the village (1.5km).

The Chao 1 estimator of species richness is not obviously higher in more degraded forest types (Figure 6. 16), however, species accumulation curves show that the plantation curve has not begun to even off, suggesting that the difference in species abundance between the plantation sample and young secondary forest may be higher if there was a larger sample size. The Simpson's reciprocal index shows a clearer decrease in species evenness in more mature forest, possibly because the Simpson's index is less sensitive to sample size.

Care must be taken in the interpretation of these results. Because the effects of distance and forest type on species diversity and evenness cannot be studied independently from each other (forest type changes with distance from the village), these results cannot tell us whether it is distance, forest type, or a combination of the two that are producing these changes in abundance and evenness.

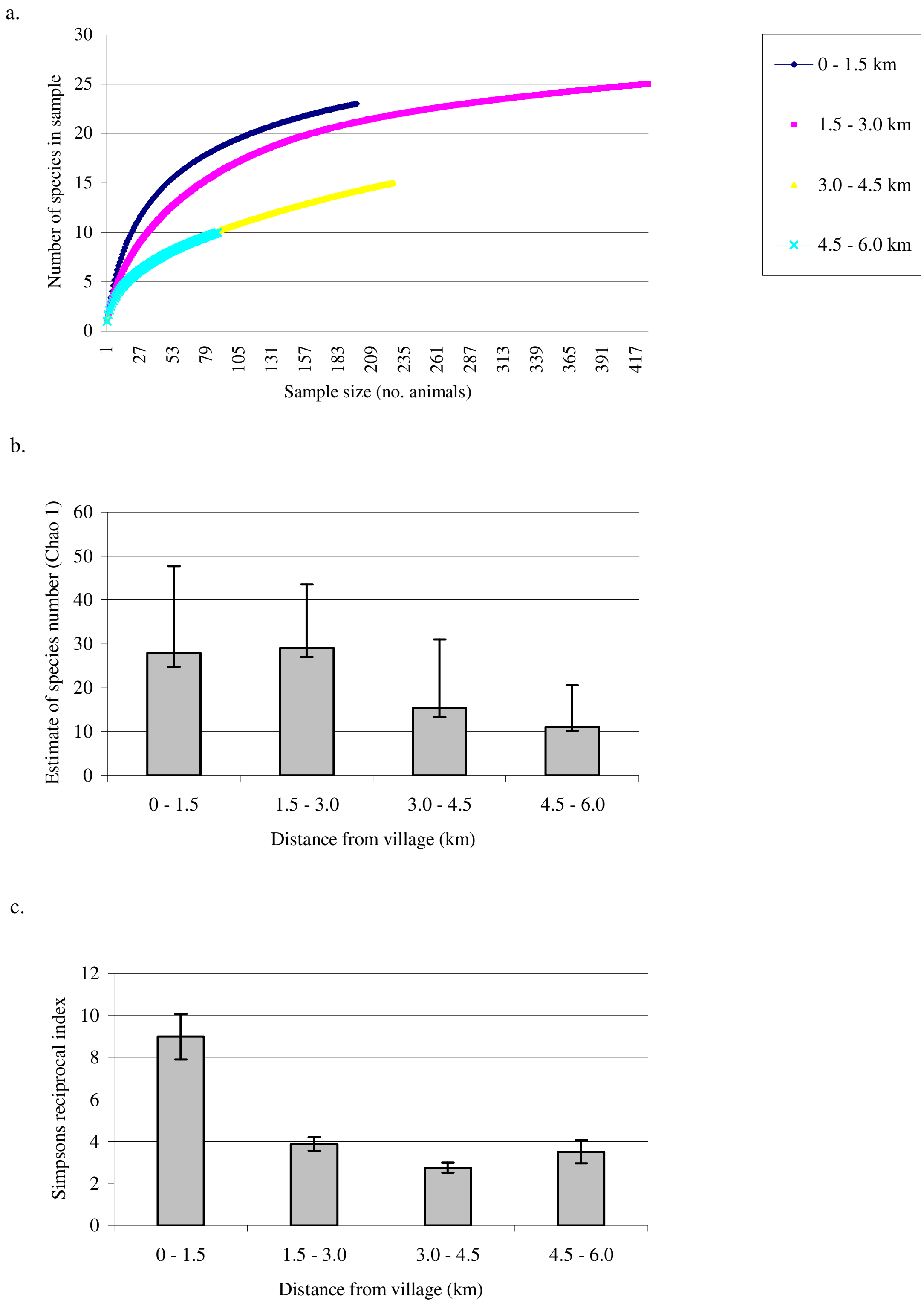


Figure 6. 15: (a) Species accumulation curves, (b) Chao 1 abundance estimates (95% confidence intervals) and (c) Simpson's reciprocal index (+- 1 s.d.) with distance from village. Animals are grouped by distance, in four 1.5km bands. 200 iterations were used to produce the estimates.

a.

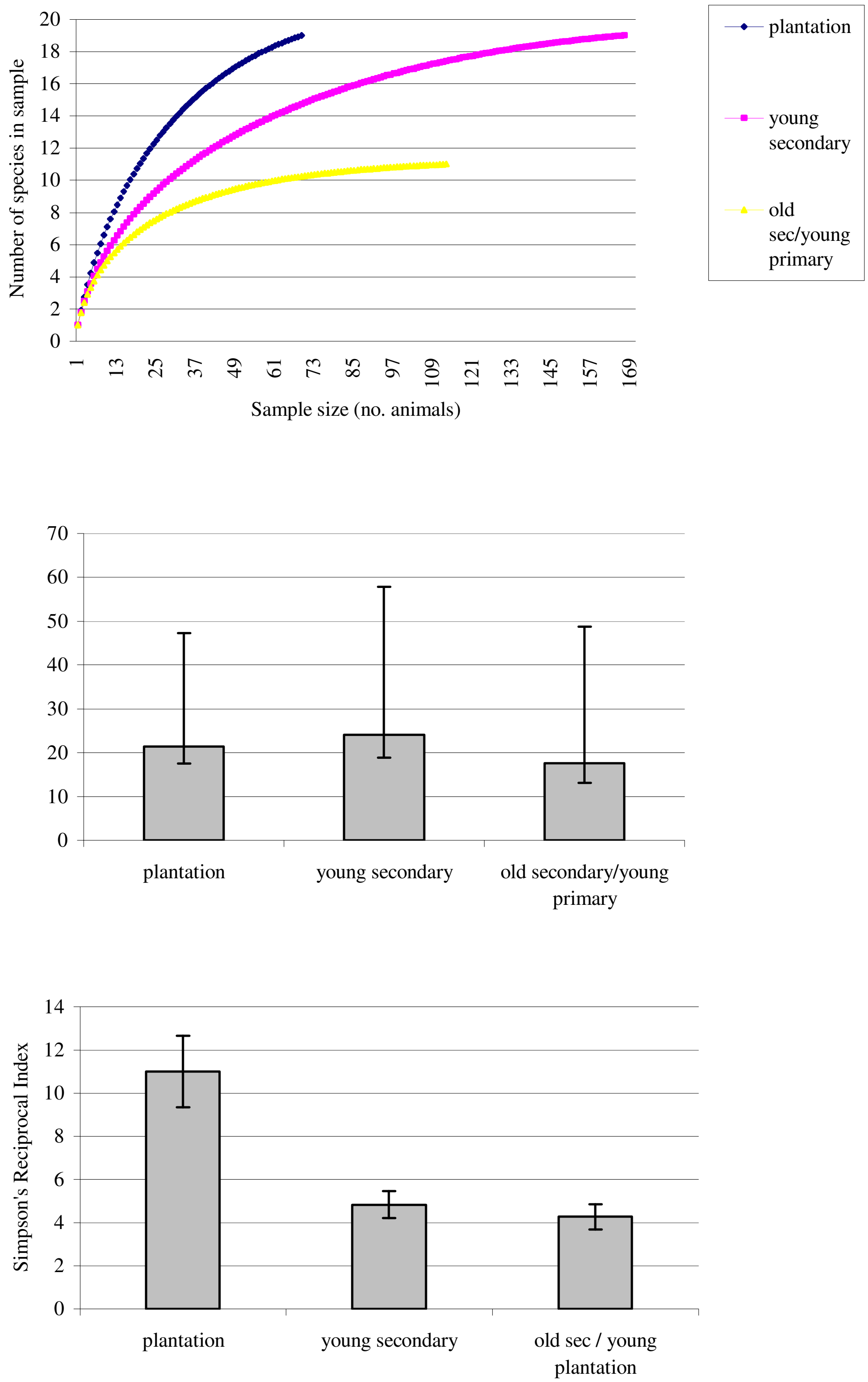


Figure 6. 16: (a) Species accumulation curves, (b) Chao 1 abundance estimates (95% confidence intervals) and (c) Simpson's reciprocal index (+- 1 s.d.) with forest type. Animals are grouped by forest type (types 1 and 2, and 4 and 5 have been merged for sample size reasons. 200 iterations were used to produce the estimates.

6.3.5 State of the animals found in traps, with distance from village

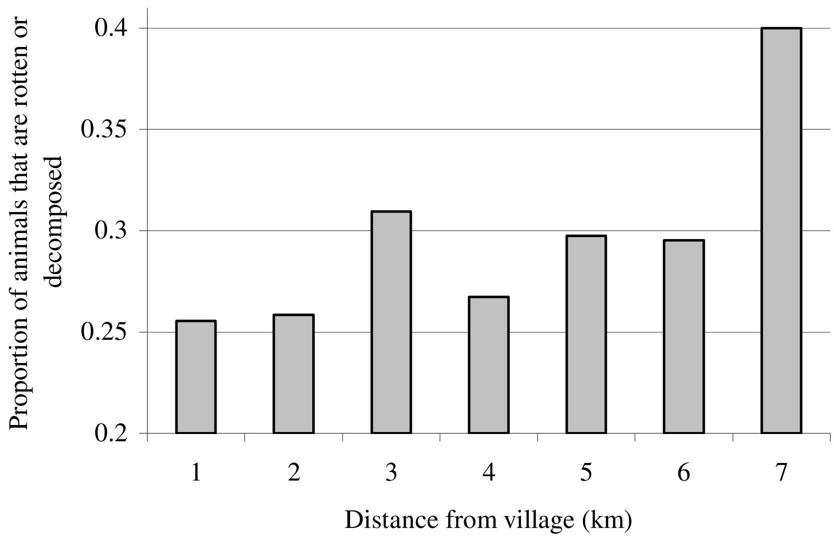


Figure 6. 17: The proportion of animals that are decomposed or rotten when found in a trap increases with distance from village. Chi Squared: $F_7 = 21.57$, p=0.001

There is a significant increase in the proportion of rotten or decomposed animals found with distance from village (Figure 6. 17). Twenty-five percent of animals were found in some state of decomposition within 1 km from the villages, and this had risen to 40% at 7 km from the villages.

6.3.6 Differences in landscape use: hunting for food vs. hunting for profit

The size of animals increases with distance from the village, and more animals are sold at a higher price as their size increases (Sections 5.3.2.1 and 5.3.5.1, Chapter 5), so we would expect to find that the number of animals sold/trap increases with distance from the village, and this is indeed the case (Figure 6. 18). Within 1 km of the village only 14% of animals are sold, but this increases to 44% from 4 – 5 km. Interestingly, when a GLM was used to control for the state and weight of the animals caught (found to be the main predictors of whether a trap-caught animal is sold or eaten), distance from the village was still a significant predictor of whether an animal is sold or not (Table 6. 5).

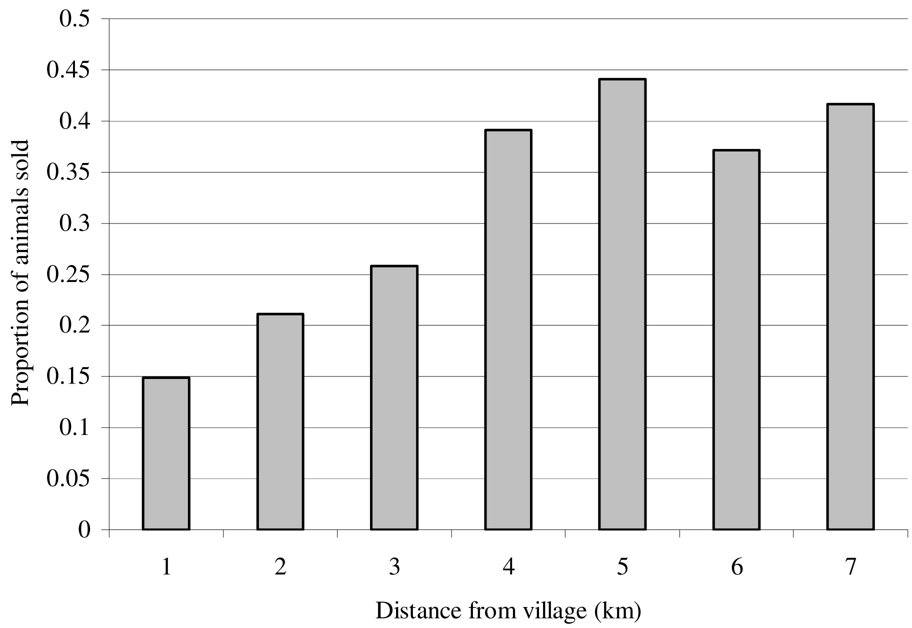


Figure 6. 18: the proportion of animals sold increases with distance from the village. Chi squared of eaten or sold for whole animals (excluding gigots): $F_5 = 38.1$, $p = 0.001$

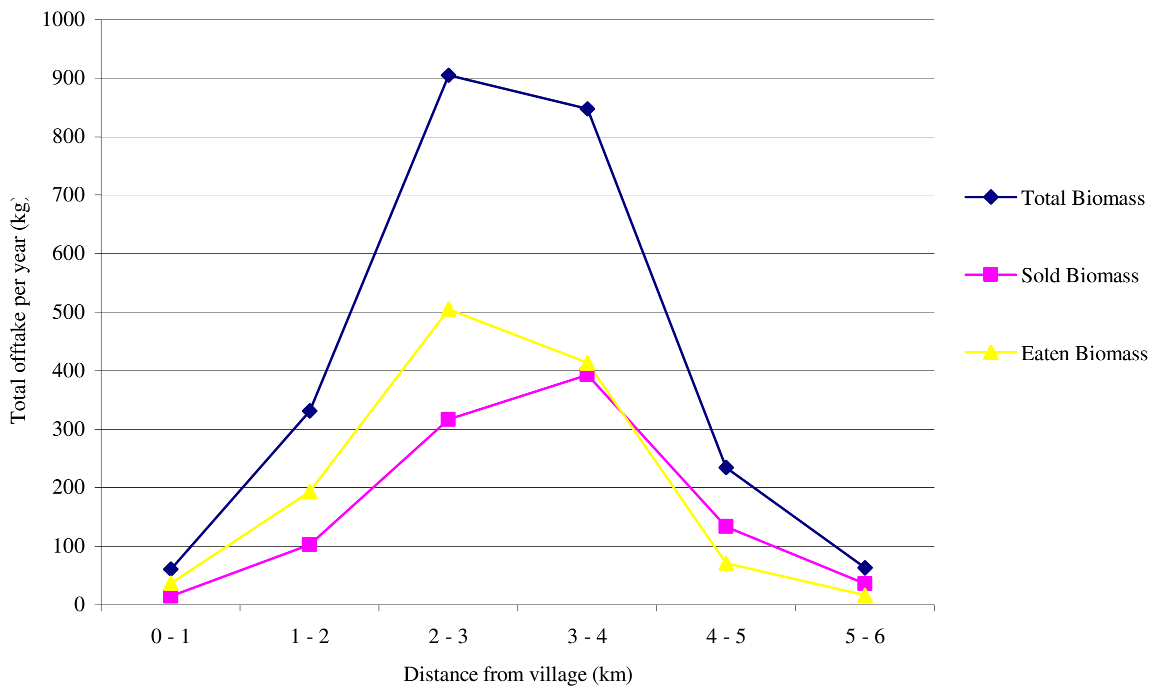
General model:	**d.f (Change, residual)**	**Deviance**	**p (chi square)**
Distance From Village	1, 325	6.50	0.011
State of Meat	3, 327	15.88	<0.001
Trap Type	1, 325	6.43	0.011
Weight (kg)	1, 325	15.97	<0.001
Minimal model:	**Estimate**	**s.e**	**p (chi square)**
Distance from Village	0.328	0.131	0.013
Type of Trap (Neck)	-0.968	0.396	0.015
State: Decomposed	-2.337	0.667	<0.001
Fresh	0.421	0.438	0.337
Smoked	0.935	0.673	0.165
Weight (kg)	0.2966	0.0942	0.002

Reference Level: State of meat: Alive
Type of Trap: Foot

Table 6. 5: General linear model, with a binomial error structure, showing the terms associated with the fate (eaten (0) or sold (1)) of a captured animal.

Figure 6. 19 shows the total, eaten and sold biomass within each kilometre band from the village, and the production per kilometre within each kilometre band. Total biomass produced peaks at 2 - 3 kilometres from the village, and due to a higher proportion of animals being sold further from the village, sold biomass peaks at 3 - 4 kilometres. Dividing the biomass per km by the area of the hunting territory at each kilometre controls for the increased area that is available at each kilometre out from the village, and so allows the productivity of the landscape with distance to be assessed. Even accounting for increased land surface, production is highest at around 2 - 3 km.

a.



b.

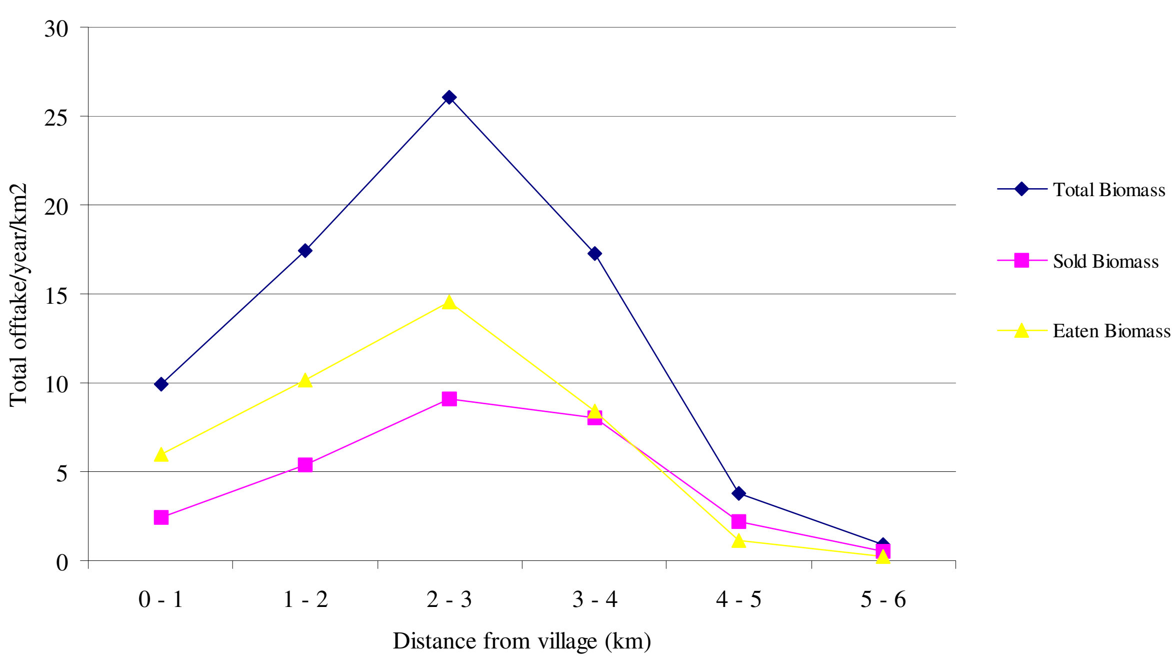


Figure 6. 19: Offtakes at each km band from the village in (a) the kg/year of meat produced within each km band, and (b) the kg/year/km^2 of meat produced within each band.

6.4 Discussion

By combining data on hunting land use and the effects of hunting on offtake, this study has been able to investigate the impact of hunting on the village landscape. At the broadest scale, hunting territory estimations paint quite a gloomy picture. Individual village hunting territories often cover large areas, with each inhabitant using around 1 km of land. As shown in this case for Gabon, combined village hunting territories can cover a great deal of a country's landscape; in this case possibly up to 60% of the surface area. If all of the landscape within these territories is subject to hunting pressure, then taking into account the increased effect of roads, logging companies and the dispersal of prey species, this leaves little room for unexploited populations to exist.

The case study provided by Dibouka and Kouagna suggests that hunting pressure within these landscapes is not uniform. Trapping densities begin at extremely high levels (180/km2) around the village, and decrease almost linearly until there is a low level of hunting pressure at around 8 km from the village. In this case, the hunting territory extends up to 12 km from the village, and the furthest points of the territory from the village are under much less hunting pressure than those around the village. Hills tend to be less densely trapped than rivers, as hunters tend to use river valleys to navigate and move through the forest, producing trapping densities that, to some extent, follow the contour lines of the landscape. Trapping strategies also change with distance, and traps within 1 km of the village are mainly neck traps, which catch smaller species than foot traps. This changes rapidly with distance from village, and neck traps are really only a feature of the first couple of kilometres.

Compared with other studies that have produced estimates of trapping density (Muchaal and Ngandjui, 1999; Kumpel, 2006), trapping densities in Dibouka and Kouagna are high, and as shown in the case of blue and red duikers, there are very few areas within the hunting landscape where animals of medium/large size are unlikely to have a trap within their home-range. Catch rates, as might be expected from this, are low compared with estimates from two other studies. Kumpel (2006) recorded a mean offtake of 5786 animals from the 6024 traps laid in Sendje over the course of a year or 0.96 animals/trap, compared with 0.28 animals/trap for Dibouka, and Ngengueu and Fotso (1996) recorded a mean offtake of 0.22 animals/trap/month for Ekom, Cameroon compared with 0.048 for Dibouka. Both these studies, however, are bordering national parks, and there are no other examples of offtakes from villages that are not bordering national parks with which to compare Dibouka and Kouagna.

Differences in trap type and trap density create large differences in the species composition and offtake levels with distance from the village, even when the effect of forest type on the abundance of different species is taken into account. Large-bodied species were more likely to be caught in traps further away from the village, and this finding agrees with those of previous studies. Fimbel et al (2000), found that red duiker abundance decreased with distance from a road, Naughton-Treeves (2003) found a negative correlation between hunting pressure and the biomass of observed species along transects in Peru, as did Lopes and Ferrari (2003) in Eastern Amazonia, and Laurance et al (2006) in Gabon found an a decrease in the abundance of large bodied species, and an increase in the abundance of rodents and pangolins with an increase in hunting pressure.

Smaller-bodied species were more likely to be caught close to the village, and on principal rather than private human paths. Species abundance also increases and dominance decreases close to the village, as there is an increase in ‘weedy’ or colonising species, such as rats, squirrels and snakes, in comparison to the large ungulates that display less diversity within their order. Previous studies have shown similar trends; Linares (1976), observed that in her study site in Panama, there were a few ‘adaptable’ or ‘anthropogenic’ terrestrial mammal species, such as the agouti and paca, whose densities increased in the disturbed village environment and plantations, compared with the surrounding forest. Wilkie (1989) also found that in the Ituri forest, DRC, the secondary forest around settlements and roadsides was frequently exploited for hunting, and provided similar capture weights and species as found in old secondary and climax forest. It has been suggested (eg. Starkey, 2004; Anaudu, 2004) that species such as cane rats, and porcupines may be resilient species in Central Africa, and although, as shown in this case study, high levels of hunting pressure may have negative effects on large-bodied mammals, and change the species composition of the fauna in hunted areas, the sustainability of hunting from a social point of view (i.e. the production of enough protein for village inhabitants) may be possible through the persistence of these weedy species.

This increase in small-bodied species catch rates close to the village does not seem to be due to a preference for disturbed habitat, as although dense undergrowth is a significant predictor of whether a small animal is caught or not, the relationship with forest type is positive. This suggests that, taking into account the effect of distance, most prey species are more likely to be caught in less disturbed habitat. Another hypothesis to explain the increased catch rates of small-bodied species close to the village is that this may be a case of ‘ecological release’, due to a reduction in inter-specific competition from some of the larger species.

Care must be taken with the interpretation of these catch rates. Distance from the village can be seen as a proxy for the depletion of the prey base over time if starting from an unhunted situation. However, if the system has reached equilibrium these patterns may still be present when depletion of the prey base has halted, and these data cannot differentiate between a system with ongoing depletion and a system at equilibrium. Although weedy species are of higher abundance close to the village, this does not mean that the abundance of these species is increasing close to the village under high hunting pressure. In fact it is quite possible that these species are declining over time in the same way as the large-bodied species, and the difference that we see between plantation and mature forest areas is simply a relative difference, with abundance declining throughout the hunted landscape, but populations close to the village declining more slowly than those in the forest, and ‘weedy’, smaller-bodied species declining more slowly than large-bodied mammals.

Changes in prey size with hunting pressure result in a disparity between the area of the village landscape that has the most hunting effort, and the area that produces the most trapped biomass. Although trap densities are highest between 0 – 2 km, decreasing sharply with distance, the traps further out catch larger animals, and the majority of the biomass harvested by the village is in the area 2 – 4 km from the village.

Changes in species abundance, due to hunting pressure, have also affected the way that hunters use the landscape. Animals caught further from the village are more likely to be sold, and this is significant even when difference in state, weight and capture method have been accounted for, suggesting that hunters are travelling further from the village in order to catch saleable animals. Jeanmart (1998) suggests that this is also the case in Ekom, Cameroon, where he reports that during the plantation season, hunters trap close to the village to catch animals for food, but in the wet season they trap much further out, to catch more commercial species.

Speaking with older members of the village, I determined that hunting used to be carried out much closer to the village than it is now, suggesting that hunters have moved further out from the villages in search of animals as offtakes have declined. Two of Dibouka's older hunters described to me how easy it was to catch red river hog in the past:

[At the time of independence in 1960] people went to kill the animals behind the house. Chief Dissinga there, when he was young, when the minister says 'come on lets go hunting' he goes, behind the house there, he kills the pigs, but today, today you can go from here to Kouagna, without even seeing one. The youngsters, they know [where the animals are] and go behind the big hills, and they can bring back some. But for me, I have to stay on the path, and there is none. No, there was meat, but today it has reduced. It does exist over there [pointing to hills], but you must go far, far, far, Like the Pounou area [villages east of Dibouka], where the Bandjabi [ethnic group] live.
Hunter 41, aged 60

To find pigs you need to trap far away, around Mikagha. Before we found them in Loba, around 3 km from here, in 1960 – 1970. Now it is more like 12 km.
Hunter 16, aged 53

The increase in the percentage of animals sold with distance also suggests a move outward from the village, in search of larger animals. But will hunters continue to move outwards in search of bigger prey?

There are two arguments against this, both observational. Firstly, it is unlikely that what we see in the village territory of Dibouka is hunters riding the edge of a depletion wave, as the whole territory is likely already to be highly depleted. During the study period, a WCS project was carried out in the hunting territory of Dibouka, in order to look at leopard densities in hunted areas (P.Henschel, pers. comm.). This employed the use of camera traps, at 5 – 12 km from the village, which provided photographic capture rates on a number of prey species, including duikers. Comparing the capture rate of Dibouka with all the other study sites in Gabon used in the leopard project showed that Dibouka's hunting territory is already heavily depleted; photographic rates of duiker in Dibouka were on average 165 times lower (range = 86 – 338, n = 3) than for national parks, and 85 times lower (range = 21 –103, n = 6) than logging camps. Given that the prey base has already been depleted to such an extent, and hunters are still hunting in this highly depleted area, this suggests that they have stopped moving outwards from the village already.

Kumpel (2006) found in Sendje, Equatorial Guinea that between 1990 and 2003 hunters had not been moving their hunting territories further from the village or hunting camp, as would be predicted by central place foraging theory with the depletion of a resource, but rather that the trapping effort had increased from 56 traps per hunter to close to 100 traps per hunter to accommodate the reductions in catch per unit effort. The same may be happening in Dibouka. Although there is no data to support this hypothesis, older hunters did talk about the inordinate number of traps that are presently used by the more active hunters in Dibouka; Hunter 8 put over 1000 traps down over the study period alone. This in itself cannot be used as proof that effort is increasing to accommodate changes in CPUE, as we have no data on how many he may have laid ten years previously, but we can hypothesise that this large number may have resulted from reductions in CPUE over time. Reductions in CPUE may explain the high trapping densities found in Dibouka, and argues against an equilibrium situation.

The second argument against hunters moving further from the village is social. Each village has its own hunting territory, and so hunters are constrained in the distance that they can hunt from the village. The length of time that it takes hunter who trap furthest from the village to check their traps already uses up most of the day, and moving further out from the village would probably require that hunters switched strategies and moved into hunting camps, rather than carrying out day trips. Although there many not be a high economic cost to this switch, there may be a prohibitively high social cost. Hunters enjoy their village life, have responsibilities at home, and also feel that they need to protect their family (wives) from other men. Moving out into the forest is seen as slightly mad. However, one of the more active hunters did exactly this towards the end of the study. Hunter 16 moved his traps from of 2.7 km from the village at their furthest point, and built a hunting camp with hunters from Kouagna, at a distance of 5.4 km from the village. His reason that he gave for this was that a number of his children were now of secondary school age, and he needed to raise enough money for them to continue their education. It is unlikely that his motivation was completely altruistic, as Hunter 16 was one of the largest drinkers in the village, but does show that with an increasing need for money, some hunters may be willing to switch strategies. It remains to be seen how many hunters would be willing to follow suit.

Chapter 7 :

Trapping strategies and hunter decision-making

Chapter 7

7.1 Introduction

Incorporating human behaviour into resource management is a hugely important but often ignored. Resource users are a dynamic part of the system, and their responses to economic, social and biological (including prey population) changes will affect the system's sustainability. Analysis of harvester behaviour enables us to understand and anticipate these responses, and investigate their impact on the sustainability of the system. Fisheries scientists acknowledged the importance of human behaviour in fisheries management as early as the 1980s; Hilborn (1985) declared that "a major element of fisheries science should be the study of fishermen and fleet dynamics", and suggested that the collapse of many fisheries could be best explained as the result of misunderstanding fisher behaviour, rather than a lack of knowledge of fisheries resources. The treatment of bushmeat hunting however has lagged behind and the majority of studies still work with static indices, even though they are shown to be misleading (Ling and Milner-Gulland, 2006).

The sustainability of bushmeat hunting is generally assessed using very simple 'maximum sustainable yield' indices (e.g. Robinson and Redford, 1991), which work on the premise that that if current harvests are below the maximum sustainable yield (MSY) the current hunting system is likely to be sustainable. This approach was taken from the fisheries sector, where MSY indices were widely used in fisheries management during 1960's and 1970's (FAO, 1995). However, the fisheries literature (but unfortunately not the actual fisheries management) has quickly moved on from these simple indices, realising that fisheries systems are too complex, and dynamic, for such simple indices to work effectively, and bio economic models are have been suggested as a tool for understanding fisheries processes. Salas and Gaertner (2004) define a complete fisheries system as "a combination of subsystems (e.g. human, natural resources and management) that interact dynamically and are influenced by external and internal factors". There is however, scant empirical data describing the behaviour of bushmeat hunters, and few bushmeat hunting studies have taken a bio-economic approach, and incorporated hunter decision-making, when modelling the sustainability of hunting.

This chapter aims to increase our knowledge of hunter behaviour and decision-making in village landscapes, by providing empirical data of hunting strategies and behaviours. To place this study in context, I will first explain the theoretical behaviours that hunters may exhibit (predicted by optimal forging theory), outline the empirical data currently available in the bushmeat literature, and describe how hunting strategies and behaviours have been incorporated into hunting models. I will then introduce the precise aims of this chapter.

7.1.1 Optimal foraging theory

An important tool for incorporating hunter behaviour into the study and management of the impact of bushmeat hunting on prey populations is the use of optimal foraging models. These models can predict the effects of hunting on the prey base, and observed behaviour (collected from case studies) can then be compared with model predictions. There are four concepts relevant to the behaviour of human harvesters; prey choice, patch departure, ideal free distribution and central place foraging.

Prey choice, or the ‘optimal diet’ models (Charnov, 1976) describe how animals maximise their net rate of energy intake, through their choice of prey species. The preference (or rank) for a prey species is calculated by the food value of the prey, taking into account the energy used during the search and handling time. As encounter rates for higher ranked prey decline (and the loss of calories through increased search times increases), predators will start to target lower-ranked prey.

Patch choice models (also known as marginal value theory) predict at what point a forager at a food patch will decide to leave this patch in search of another, in order to maximise calorific returns (Krebs et al, 1974). The mathematical development of this theory predicts that a forager should leave a patch when its rate of food intake in the patch drops to the average rate for the habitat (Pyke et al, 1977). This has been used widely to model the movements of fishing fleets from one fishing area to the next (e.g. Hilborn and Walters, 1987, Dreyfus-Leon, 2006), but few empirical data have been collected.

Ideal Free Distribution (IFD, Fretwell and Lucas, 1970) states that foragers will distribute themselves across the landscape according to the amount of food available; hence patches with a high level of resources will have the most foragers. The ideal distribution of foragers across a landscape, assuming foragers make optimal decisions concerning their patch choice, would result in each forager gaining the same amount of resources per unit effort regardless of the resource level of the patch that they were in. This theory was used to highlight one of the issues with using catch per unit effort (CPUE) as a measure of fish abundance (Harley et al 2001). The assumptions of the IFD model, highlighted by Gillis (2003), are freedom of movement (including costs of travel), ideal knowledge and uniform skill and fishing gear type.

Central place foraging is a special case of the marginal value theorem, and concerns animals that leave to forage from a fixed site, such as a burrow or colony (or in the case of hunters, a village). It predicts that the forager will maximise its calorific returns, and so will show a preference for larger prey with increased distances from the central place, due to increased travel costs (Orians and Peterson, 1979). Applied to hunters, this predicts that as the territory surrounding villages becomes depleted, and hunters move further from the village in search of food, they will preferentially target larger bodied species due to the increased travel costs.

7.1.1.1 Limitations of optimal foraging theory

Optimal foraging models are useful tools for looking at hunting behaviour in that they show us the behaviour that hunters would exhibit if they were hunting in a completely optimal way in an ideal world. There are a number of reasons however, why human hunter behaviour is likely to deviate from optimal in the real world. One of the criticisms of marginal value theorem, (for all animal foragers) is that is assumes perfect knowledge; for example it assumes that hunters know how resources are distributed over the landscape and therefore when to change hunting patches. This assumption is highly unlikely to hold for village hunters. The hunting ability and motivation of individual hunters is also likely to vary, as they possess different physical and social characteristics. Optimal foraging theory assumes that foraging is the only way of capturing resources, but village hunters do not hunt in isolation, they pursue other activities in order to provide food and income. This is likely to affect the effort that they invest in hunting and the type of hunting they do. Traditional land use rules can also impact foraging behaviour (Bousquet et al, 1999), and traditional rules outlawing the hunting of certain species may also affect prey choice, despite the erosion of rules due to the commercial trade in bushmeat (Rose, 2000). Studies of fisher behaviour have also found that not all fishers aim to maximise their catch, and many are satisfied with keeping the catch constant, or recovering their operating costs (Jacobson and Thompson 1993, Babcock and Pikitch 2000). This is more common in small-scale fisheries, where lower capital investment is required (Salas and Gaertner, 2004), and could be applicable to bushmeat hunting.

7.1.2 Empirical studies of hunter behaviour

Empirical studies of hunting behaviour are scarce in the bushmeat literature. Gun hunting has received more attention than trap hunting, and Mithen (1989) and Alvard (1993, 1995), have both produced thorough studies of prey choice by gun hunters. Mithen compared the behaviour of the Valley Bisa pursuit hunters in Zambia, and found that although the optimal diet models were reasonably good at predicting prey choice by hunters, a modified model, in which hunters aimed to improve, rather than maximise, their catch, was a better fit. Alvard (1995) found that for the Piro shotgun hunters in Peru, an optimal diet model fitted hunter behaviour better than a 'conservation' model, but also found that their behaviour deviated from optimal foraging in some ways (some large species were never pursued due to taste and taboos, and hunters showed partial preferences for some species; see Alvard 1993 for further discussion).

There has been little opportunity in the bushmeat literature to study patch dynamics because it requires detailed information on hunter effort and catch over time. Kumpel (2006) provided the first detailed study of hunting area dynamics through mapping the use of hunting areas over the course of 1 year in Equatorial Guinea, and found that hunters were changing their trapping areas within their hunting camps, and the hunting camps that they used, from every few months to a year (in the case of this village, hunters used hunting camps and did not hunt directly from the village). This behaviour, she suggests, may be in response to declining catch rates, although she points out that there was no evidence of this occurring. There is some evidence that hunters may be responding to changes in prey by switching hunting techniques. Both Kumpel (2006) and Muchaal and Nganjui (1999) recorded changes in hunting gear over the course of their study periods. Kumpel (2006) recorded a switch from trapping to firearms in hunting camps over time, suggesting that hunters may be responding to a reduced prey base. Muchaal and Nganjui (1999) following 14 hunters near the Dja reserve, Cameroon over two years, found that hunters shifted to gun hunting during the dry season, when the ground was too hard to trap effectively.

The distribution of traps within and between hunting camps in Kumpel's study was suggestive of Ideal Free Distribution. Other studies suggest that Ideal Free Distribution may not occur for all villages, due to the influence of village social structures. Through hunter interviews, Bousquet et al (2001) found that in Djemong, Cameroon, hunting areas for each individual were determined more by social factors (such as family heritage) than by changes in catch. Similarly, hunters interviewed by Starkey (2004) reported that old village rules governing familial forest territories were still in place in six villages surrounding Koulamoutou, restricting the forest area that individual hunters could use.

Social factors also affect the amount of effort that an individual will put into hunting. Kumpel (2006) found that trapping strategies of individual hunters were best predicted by their age, and by whether they were a native of the village or not; the effort that a hunter expended on hunting (in distance travelled, number of traps set and days spent trapping per month) declined with age, and was lower for non-native hunters. This suggests that hunting strategies may vary among hunters, depending on their social characteristics. Other livelihood activities have also been shown to affect hunting effort. Muchaal and Nganjui (1999) found that hunting effort was greatly affected by family problems, illness and alternative paid employment opportunities, illustrating how hunting is part or a larger dynamic system, and hunting behaviour will be affected by external activities.

Studies of prey base depletion also shed light on hunter behaviour. Central place foraging results in local depletion around villages/ hunting camps, and this depletion has been observed in studies by Hill and Padwe (1997), Alvard (1995), Muchaal and Ngandjui (1999), Blom (2005) and Kumpel (2006) among others, suggesting that hunters may move out from villages as the prey base is depleted.

7.1.3 Modelling hunter behaviour in bushmeat systems

The paucity of empirical data on hunting strategies and behaviour makes it hard to parameterise hunting models, and very few studies have attempted to incorporate hunter behaviour. Rowcliffe (2003) used a multispecies hunting model to look at the impacts of gun and snare hunting on prey communities. A modified prey choice model (such as those described by Alvard and Mithern) was used to simulate gun-hunting behaviour, parameterising the model using encounter rates, handling times and catch rates from published case studies. Damania et al (2005) also used a multi-simulation model to look at the impacts of changes in bushmeat and agricultural prices on the sustainability of bushmeat hunting, and parameterised their model with data from Ashanti, Ghana. The model assumed that hunters are risk-neutral and will switch activities (or hunting techniques) depending on which will provide them with higher incomes: i.e. they have economically optimal behaviour. Under these circumstances they found that increases in bushmeat prices lead to increased hunting with guns, whereas changes in agricultural prices had ambiguous effects.

Three studies have used spatially explicit models (which can therefore incorporate patch dynamics). Clayton et al (1997) used a two-species bio economic model to assess the sustainability of wild pigs in Borneo, assuming profit-maximising behaviour by dealers, and Siren et al (2005), assessing the sustainability of prey in a multispecies system, used a case study village in the Amazon to provided parameter data on pursuit hunting effort with distance from the village, but did not assign a prey-choice model to the pursuit hunters. The effect of prey movement patterns on the sustainability of hunting was incorporated, but not hunter movement patterns or spatial decision-making.

Bousquet et al (2001) have been the first to examine how differences in hunter decision-making can influence the sustainability of the prey species, using a spatially explicit model with one prey species. Hunter interviews in Djemong, Cameroon were used to discover how hunters moved their traps over time, and it was discovered that hunters moved their hunting patch to a new location once a year. To measure the effect of this behaviour on the prey populations, two models were produced, one looking at the effect on population densities if the hunter behaviour was as observed, and another looking at the effect on densities if the traps were instead replaced in the same area as the last year, for comparison. The study found that if traps were replaced in the same area, the prey population was less depleted (and hunter's catches were smaller) than if the traps were relocated each year, demonstrating the importance of incorporating hunter decision-making when looking at hunting sustainability.

7.1.4 Chapter aims

This chapter will provide a detailed analysis of hunting strategies and behaviours. Specifically it aims to:

1. Measure the extent to which hunting strategies can be predicted by social characteristics.
2. Test whether hunters are making decisions that will maximise their catch, by comparing optimal trapping behaviour (drawn from the results of Chapter 6) and observed trapping behaviours for individual hunters.
3. Describe the spatial movement of hunters and hunting areas, and the decision-making processes behind these movements.

These results will then be discussed in terms of the factors that shape hunter behaviour, the possible effects of this on hunting returns, and the way in which this could be incorporated into, and improve, bioeconomic models to look at hunting sustainability.

7.2 Methods

In order to study hunter behaviour, data on trap characteristics and catches (the collection of which has been fully described in Chapter 3) were analysed at the level of the individual hunter, and the following questions asked:

7.2.1 What are the best predictors of individual hunting success, and individual hunting technique?

The variables used to describe the trapping technique of each hunter, for the purposes of this study, were his trap characteristics, the mean number of traps he had out at one time, and the number of times that he went to check his traps during the study. Table 7. 1 displays the full list of variables used to describe each hunter's trapping technique, and their provenance. Appendix A3.5 gives the values for these variables for each hunter. There were sufficient trap data for 64 trap hunters to be included in this analysis.

These data were used to test which trapping techniques had an effect on a hunter’s trapping success, (as described by the biomass (kg) that a hunter caught overall during the study period, and on each hunting trip), and to examine whether hunting technique was influence by the socio-economic characteristics of the hunter (variables listed in Table 7. 2, and data collection described in Section 3.4.1, Chapter 3). The analyses used are described fully in the results.

7.2.2 What are the patterns of landscape use by hunters?

A trapping area is defined, for the purposes of this study, as a group of traps belonging to one hunter, which are all found along the same linked path network, and are checked by the hunter in the same day. From data collected during hunter follows, the trapping areas used by each hunter, and the month that the use of each trapping area was begun and finished, were known for 63 hunters from October 2003 until January 2005. From information collected on the positions of individual traps, and the month that they were laid, more detailed information on trap positions and movements within each trapping area could be obtained, using ArcGIS.

Hunter Trapping Technique variable:	**Description:**
Traps	Mean number of traps observed during a hunter follow (gives the mean number of traps out at one time, rather than the total laid over the study period; two measures correlated at r = 0.89, p <0.001)
Trips	Total number of visits to check traps over the study period
Trap Characteristics	
Distance	Mean distance of traps from the village (km)
Trap Density	Mean trap density (number of traps in the surrounding 250m).
Forest	Proportion of traps in forest type ‘ngoma’ (old secondary/primary forest).
Hill	Mean steepness of hill (considered for the purposes of this chapter as ordinal data) that traps were located on.
Path	Proportion of traps on path type “private”, as opposed to on a “principal” path
River	Proportion of traps close to a river (within 20m)
Cable	Mean number of lengths of cable used on traps (1 – 7)
Trap Type	Proportion of traps that were foot traps, as opposed to neck traps

Table 7. 1: Description of the variables used to define a hunter’s trapping technique. Collection of variables is described in full in Chapter 3. Each variable calculated as a mean or proportion, from all the traps that the hunter laid during the study period.

Hunter socio-economic variable	Description
Age of hunter	Continuous variable
Born in village	Binomial: born in Dibouka/Kouagna (1) or born outside (0)
Gun hunter	Binomial: Also a gun hunter (1) or just a trap hunter (0)
Employed?	Binomial: Employed (1) or not employed (0)
Household Possessions	Value of household possessions in CFA (H)
Household size	Number of individuals in the hunter’s household (H)
Proportion of dependants in household	Proportion of individuals <16 and >=65 in the hunter’s household (H).

Table 7. 2: Socio-economic characteristics of each hunter, used to examine whether a hunter’s trapping technique could be predicted by his socio-economic characteristics. (H) denotes household variable.

Data on the number of hunting areas used by a hunter, their duration (in months), and the months in which new hunting areas were begun were used to describe general hunting area use by hunters. This was related to the socio-economic variables that had been found to be important predictors of hunting technique in the previous analysis described in Section 7.2.1. Maps of hunting areas, produced using ArcGIS, were used to investigate whether there were trends in the pattern of trapping areas, and a case study hunter (where data on trap-laying date was known to be very exact) was used to illustrate the patterns of trap additions to a hunting area per month, over one year.

7.2.3 To what extent do hunters exhibit catch-maximising behaviour?

In order to evaluate the extent to which hunters are making decisions that maximise their catch, or are exhibiting behaviour that is in accordance with optimal foraging strategy, four components of trapping strategy were examined:

7.2.3.1 Prey choice through trap location

Each trap is placed on an animal track, for which the hunter identifies the species. Using catch data from hunter follows (Section 3.4.2.1, Chapter 3), the species caught in each trap was compared with the species that the hunter had expected to catch on that track, in order to estimate the extent to which hunters can choose which prey to catch when trapping.

7.2.3.2 Trap life

In Section 6.3.3 the correlation between catch rate and the length of time (in months) that a trap has been in use for was determined. This information is used in this chapter to estimate the point at which a trap should be removed and moved or replaced, in order to maximise catch rate. This was then compared with the mean length of time that seven hunters (for whom there were adequate data) left their traps out for before removing them, to investigate whether hunters are moving traps at the right time in order to maximise their catch.

7.2.3.3 Time between trapping trips

The way in which the time between trapping visits influenced the size and profitability of a hunter's catch was assessed in three ways:

1. The state of the meat (Table 3.4, Chapter 3).
2. The size of the catch: This was assessed using information on the catch per trapping visit, and the date of the previous trapping visit, from village returns data (Section 3.4.2.3).
3. The number of active traps: This was analysed using data on individual trap status from hunter follows (Section 3.4.2.2), and the date of the previous trapping visit.

These three metrics were then used to determine how long hunters should leave between trapping trips in order to maximise their catch (or profit). This was compared with the mean time actually observed between trapping trips, for all hunters and for the most productive hunters.

7.2.4 Hunting area trap additions and changes in CPUE over time

To investigate whether there are any changes in a hunter's catch per month, trapping effort and catch per until effort, depending on the age of the trapping area, the following data (for nine hunters for whom there was sufficient hunter follows) were examined:

1. The number of traps present in the hunting area in a given month (the month when a hunter follow was carried out).
2. The number of traps added in the two months preceding the hunter follow (providing information on the number of 'fresh traps' added to the area).
3. The cumulative number of traps added every month in the hunting area (trap laying dates were recorded during hunter follows).
4. The total catch for that month (calculated from village returns data).

This enabled analysis of the way in which the number of traps in a hunting area varies over time, whether there were changes in catch per month over the life of the hunting area, and how the catch per unit effort (taking into account the effect of young and old traps in the area) changes as the time that the hunting area has been in use increases.

7.2.5 The influence of traditions and laws on the choice of hunting areas

To investigate the extent to which village law dictates where a hunter will place his traps, and to what extent he can make free choices, based on prey populations, 28 semi-structured hunter interviews were recorded. During these interviews hunters were asked four questions about village hunting laws; whether there were any restrictions or laws influencing where he hunts today, whether any such laws existed in the past, what the penalties for breaking these laws were and, if there have been any changes in land-use laws, why these changes have taken place. Hunters of a range of ages (14 – 75) were interviewed. Each interview was translated from the original French and the answers to these four questions summarised.

7.3 Results

7.3.1 Predictors of individual hunting success, and hunting techniques

7.3.1.1 Which hunting techniques best predict individual hunting success?

Individual hunting success, measured in kilograms caught over the entire study period, was best predicted by the amount of effort employed by each hunter, as measured by the number of traps laid, the number of hunting trips that the hunter went on, and the mean distance from the village that he placed his traps at (GLM, Table 7. 3a). When hunting success was measured as the mean catch per trip (kg), distance and the number of traps were also the best predictors (GLM, Table 7. 3b). Of the variables found to predict individual trap success in Chapter 6, only distance from the village also predicted individual hunter success. This difference in the best predictors of trapping success with the scale at which it is being tested (individual hunter or individual trap) will be examined further in the discussion.

7.3.1.2 Which socio-economic characteristics best predict hunting technique?

Principal Components Analysis

To simplify the hunting technique variables into two components, and to detect any structure in the relationships between the variables, a Principal Components Analysis (PCA) was employed. The variables used in the analysis were those that best predicted individual trap success and individual hunter success (Figure 7. 1b). The first two components created by the PCA explained 63% of the variance. Component 1 (40% of the variance) was mainly explained by the trap and forest type, and the distance from the village (all predictors of individual trap success) and Component 2 (23% of the variance) by the effort variables; number of traps and number of trips, and by the density of traps. The biplot and loadings produced from this analysis are displayed in Figure 7. 1.

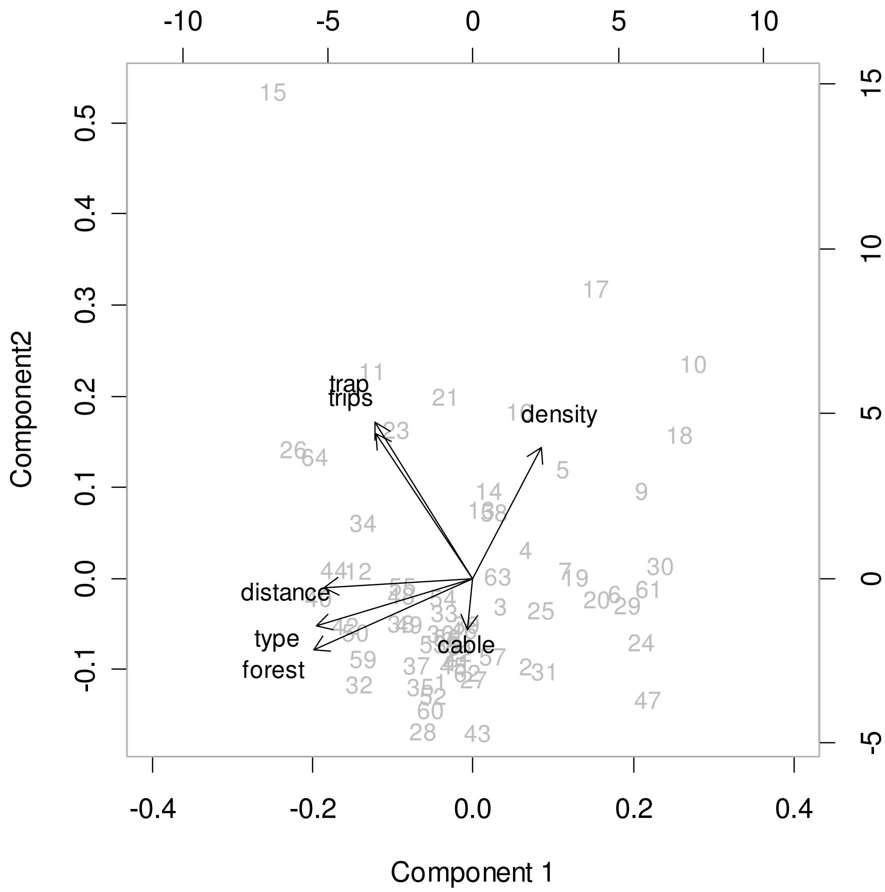
a:

General model: Biomass (kg)	d.f (change, residual)	F	p
Traps laid per year	1, 61	49.00	< 0.001
Distance	1, 61	10.21	0.002
Trips per year	1, 61	5.16	0.027
Avg. trap density	1, 60	0.01	0.926
Avg. forest type (% ngoma)	1, 60	0.84	0.362
Avg. hill	1, 60	0.28	0.601
Avg. path type (% private)	1, 60	0.14	0.705
Avg. river (% near river)	1, 60	0.04	0.848
Avg. cable	1, 60	0.21	0.649
Avg. trap type (% foot)	1, 60	0.96	0.332
Minimal model:	**Estimate**		**s.e**
Constant	-53.8		18.3
Distance	0.02037		0.00638
Traps laid per year	0.6270		0.0896
Trips per year	1.038		0.457

b:

General model: Biomass/Trip (kg)	d.f (change, residual)	F	p
Traps laid at one time	1, 62	9.90	0.003
Distance	1, 62	29.44	< 0.001
Trips per year	1, 61	2.47	0.121
Avg. trap density	1, 61	1.81	0.184
Avg. forest type (% ngoma)	1, 61	1.19	0.280
Avg. hill	1, 61	0.54	0.467
Avg. path type (% private)	1, 61	0.29	0.593
Avg. river (% near river)	1, 61	0.15	0.702
Avg. cable	1, 61	0.12	0.731
Avg. trap type (% foot)	1, 61	0.02	0.876
Minimal model:	**Estimate**		**s.e.**
Constant	0.0112		0.0943
Distance	0.0002368		0.0000436
Traps laid per year	0.001782		0.000566

Table 7. 3: The best predictors of individual hunting success as measured by a) the total catch over the study period (Feb 2004 – Jan 2005) and b) the mean catch per trip, both measured in kilograms.



Hunting Technique Variable	Component 1 Loadings	Component 2 Loadings
Trap	-0.318	0.578
Trips	-0.314	0.538
Distance	-0.481	
Density	0.22	0.488
Forest	-0.514	-0.265
Type	-0.506	-0.177
Cable		-0.189

Figure 7. 1: Biplot and loadings produced from a Principal Components Analysis of hunting techniques. Individual hunters can be seen in light grey. Arrow length shows the importance of each component. Loadings values for each component denote the weight of each variable, and its direction.

Principal components can be used to find structuring, or clusters in data (and is related to kmeans cluster analysis). A first look at the distribution of the hunters in the biplot does not suggest a rigid clustering of hunters into groups with specific techniques, and is better interpreted as a range of techniques, with incremental differences.

Predictors of hunting components

To further look at patterns in the hunting techniques used, socio-economic data for individual hunters and their households were used to find the best predictors of hunting technique, by using Component 1 and Component 2 as response variables. When looking at household predictors, a subset of hunters was used, with one hunter from each household, to prevent pseudoreplication. The same subset was used as was in Section 4.3.2.2, Chapter 4 (Table 4.4). For both components, the only significant predictor of hunting technique was the age of the hunter, and Figure 7. 2 shows the PCA biplot by age group and these significant correlations.

Having identified age as the only predictor of hunting technique, the relationship between the age of the hunter and each of the technique variables was investigated individually. The mean distance that hunters trapped from the village was highest for middle-aged hunters, between 40 and 50, with the oldest hunters (60+) trapping closest to the village (distance = 2.809 + 0.02887 age - 0.000355 age^2, $p < 0.001$, $r^2 = 18.8$). Age also had a quadratic correlation with the number of traps that a hunter had out at one time (the average number of traps laid for 40 to 60 year olds being 7 times higher than for the youngest hunters under 20 years old, Figure 7. 3), and the number of trapping trips that he undertook over the year ($\sqrt{}$number of trips = - 1.417 + 0.3617 age - 0.004132 age^2, $p < 0.001$, $r^2 = 17.2$).

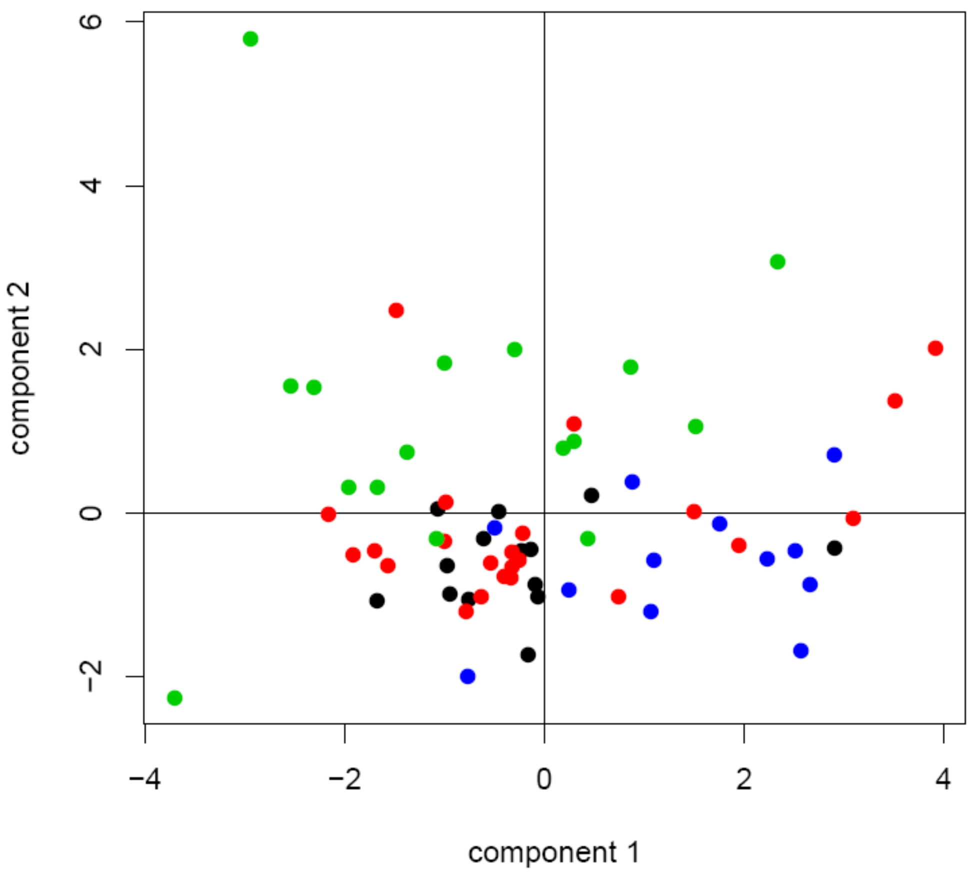


Figure 7. 2: PCA biplot of hunting strategy, showing the distribution of hunting techniques by age. Hunters have been assigned to 4 age classes for illustrative purposes: Black = 0 – 20 years old, blue = 21 – 40, green = 41 – 60, red = 61+.

Age is a significant predictor of both components:
Component 1 = 2.68 - 0.1963 age + 0.002514 age^2. $F_{2, 35} = 6.69$, $p = 0.003$, Component 2 = -3.81+ 0.2007 age – 0.002105 age^2. $F_{2, 35} = 6.03$, $p = 0.006$.

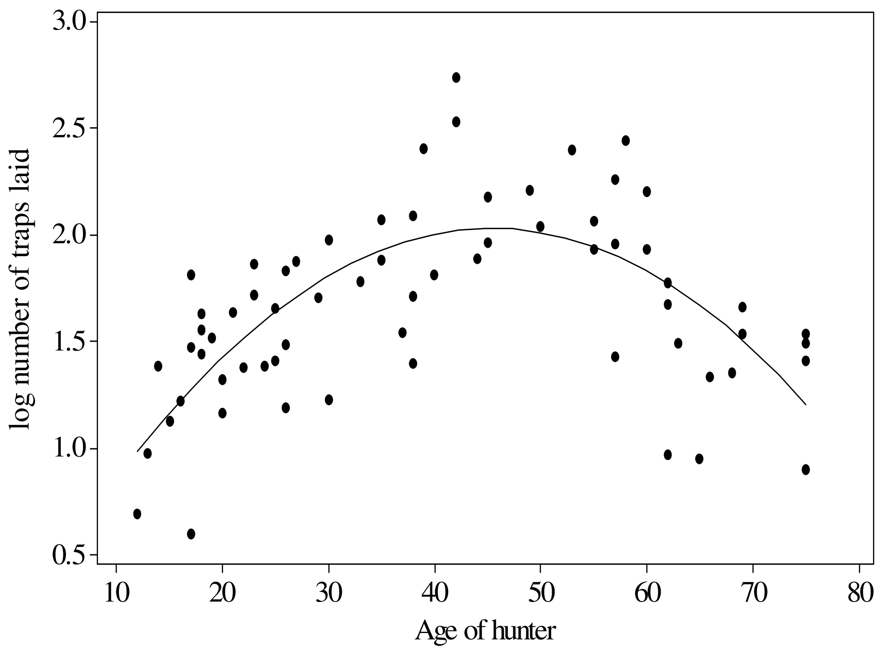


Figure 7. 3: The quadratic correlation between age and the number of traps laid per hunter (log trap number = 0.0970 + 0.08525 age - 0.000939 age^2, $p<0.001$, $r^2 = 0.47$).

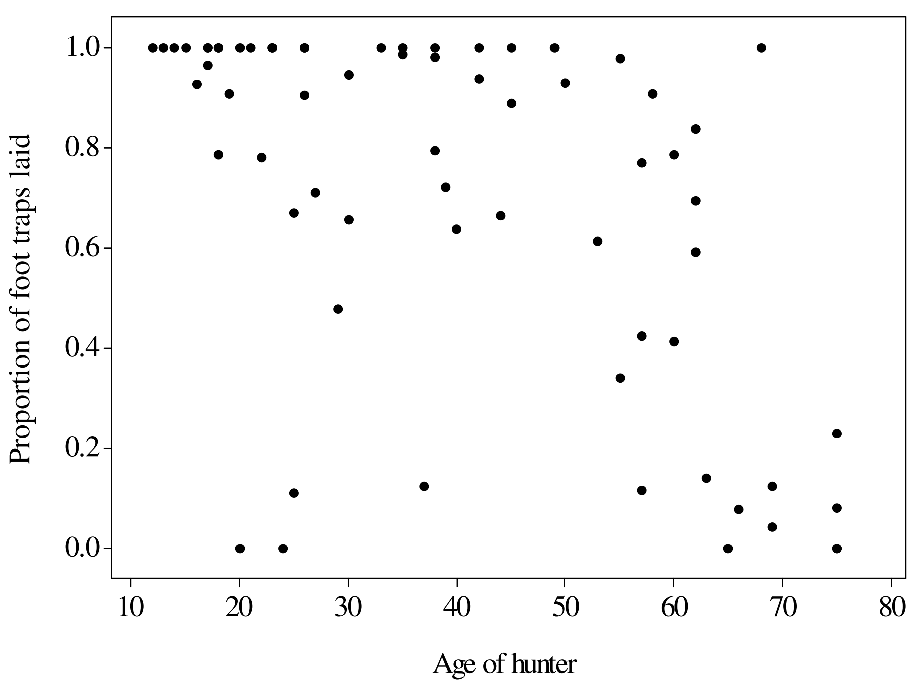


Figure 7. 4: The proportion of foot traps laid with age of hunter. $p < 0.001$ $r_s = -0.558$.

Although young and old hunters both put fewer traps down and trap closer to the village than hunters of middle age, they do not share other hunting characteristics. Older hunters (from around 55 years) were more likely to put their traps in degraded forest, whereas all other hunters generally had a high proportion of traps in mature forest ($p < 0.001$ $r_s = -0.473$). Similarly, hunters over the age of 55 were more likely to lay neck traps rather then foot traps (Figure 7. 4), and used more cable on each of their traps ($p = 0.014$, $r_s = 0.304$). There was no difference in the density at which traps were laid with age.

The trapping characteristics of each of the four age groups are summarized in Table 7. 4

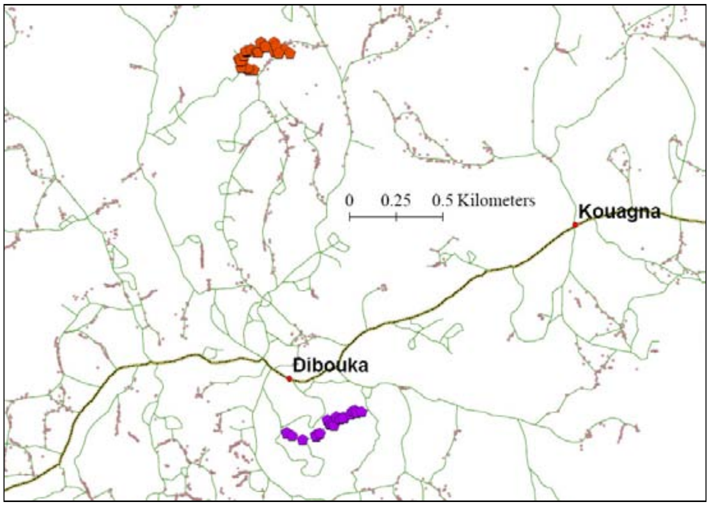
7.3.2 Landscape use

7.3.2.1 Trapping areas: Spatial distribution, duration and laying dates

Figure 7. 5 a – d illustrates the spatial distribution of hunting areas for hunters of different ages; hunters are divided into four age groups as previously. Looking at these maps is easy to see the differences in trapping characteristics between age groups, with young hunters laying few traps close to the village. The number of traps and their distance from the village increases with age, and hunters of 40 to 60 (Figure 7.5 c) have the most traps at greatest distances. Trapping trails tend to be elongated outwards from the village – possibly so that maximum distances from the village can be achieved. Some hunters also create ‘loops’ of traps (see Figure 7.5 b and c, Hunter 53, Hunter 6 and Hunter 8), in order that as many traps as possible can be reached in a one-day trip and traps are not unnecessarily checked twice. From the larger map of trap placements (Figure 6.1, Chapter 6) it is also clear that hunters tend to trap along rivers, probably for ease of travel.

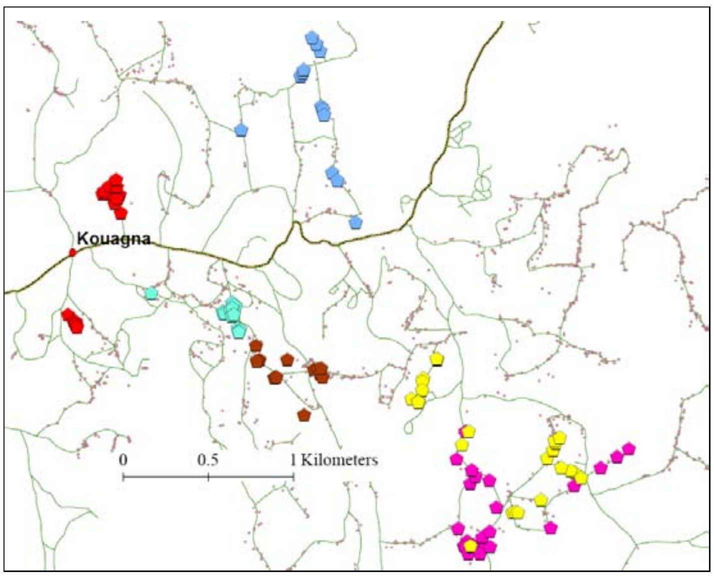
	All hunters (n = 58)	< 20 (n = 14)	21 – 40 (n = 23)	41 – 60 (n = 16)	61 – 80 (n = 13)
Hunting technique:					
Trips (year)	32.2 (4.08)	21.14 (6.08)	30.13 (5.7)	58.9 (10.7)	14.85 (4.7)
Traps (once)	75.1 (11.2)	24.6 (4.44)	63.4 (10.8)	173.1 (32.5)	29.4 (4.37)
Distance (km)	2.20 (0.19)	1.92 (0.20)	2.14 (0.25)	3.11 (0.60)	1.50 (0.27)
Density (250m)	52.25 (3.37)	45.76 (3.94)	54.19 (7.2)	58.98 (6.61)	47.53 (6.92)
Forest Type	0.67 (0.05)	0.85 (0.08)	0.71 (0.08)	0.70 (0.08)	0.36 (0.01)
Trap Type	0.69 (0.04)	0.90 (0.07)	0.76 (0.07)	0.74 (0.07)	0.29 (0.10)
Cable	1.38 (0.04)	1.32 (0.07)	1.32 (0.05)	1.37 (0.05)	1.58 (0.13)
Trapping area:					
Number of areas	1.79 (0.14)	1.91 (0.42)	2.00 (0.22)	1.80 (0.28)	1.39 (0.24)
Duration of area (months)	8.59 (0.70)	3.10 (0.55)	8.59 (1.18)	11.84 (1.15)	9.08 (0.99)
Total trapping duration	10.04 (0.67)	5.55 (1.39)	11.16 (0.98)	12.27 (1.24)	9.44 (1.12)

Table 7. 4: Hunting characteristics by age group. Displays the mean values for each age group, with standard errors in brackets.



Hunter 37 (red): Dibouka
19 years old, with no other job. Set a barrage of 33 neck traps in November 2003. He did not visit his barrage during the study, and his only catch was a red duiker, found by another hunter, which was too rotten to eat. He was teased by the bigger hunters for his incompetence, and his older brother removed his traps in January.

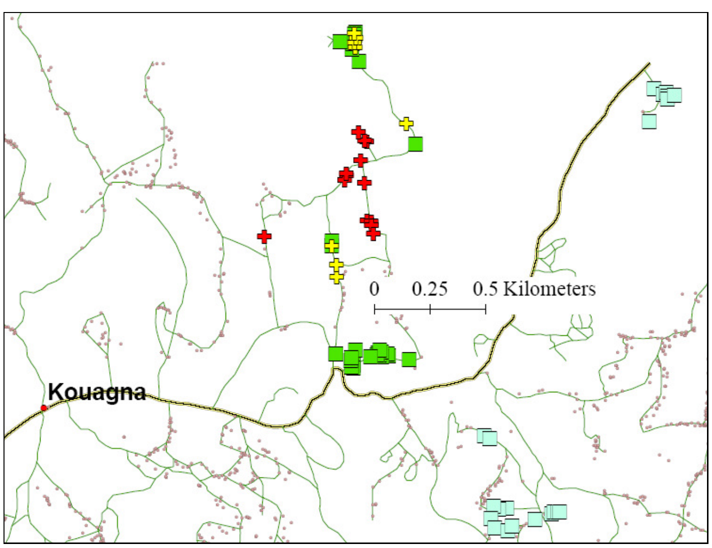
Hunter 67 (purple): Dibouka
14 years old. Started trapping in December 2004, and set 23 foot traps, and 2 neck traps. I have only 1 record of him visiting his traps.



Hunter 36: Kouagna (different colours show his different hunting areas.)

16 years old. Six consecutive hunting areas, all used for three to four months, from December 2003 to Jan 2005, without a break in hunting activity. He laid 129 traps in total, 92% of them being foot traps, and caught 33 animals over the study period. I perceived him to be one of the young men more serious about hunting.

Hunter 37 trapped with 6 other young hunters: 4 others aged 13 – 18, and Hunters 2 and 26 (below).

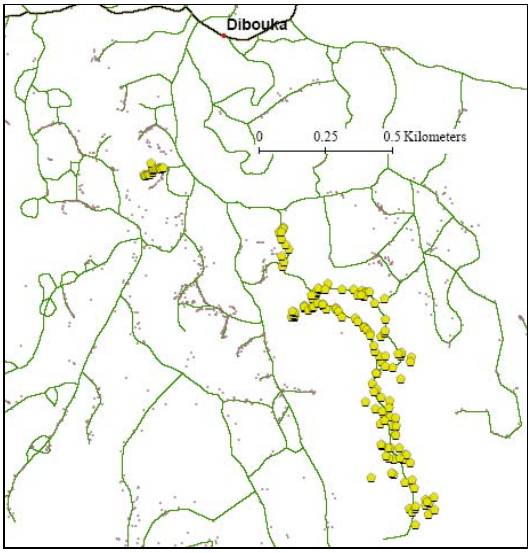


Hunter 2 and Hunter 26:
Kouagna (Hunter 2's areas depicted by crosses, and Hunter 26's by squares)

Hunter 2 (aged 15) had 2 trapping areas: 1 from March – July 2004 (red), and one that was laid November 2004 (yellow). He laid 30 traps, all foot traps, which caught 18 animals. Hunter 26 (14) had 1 trapping area in Aug – Sept (blue), and then moved to trap with Hunter 2 in November 2004 (green). He laid 52 traps in total, all foot traps and caught 21 animals

Both boys always trapped with other member of the young hunter group, who all had similar trapping characteristics.

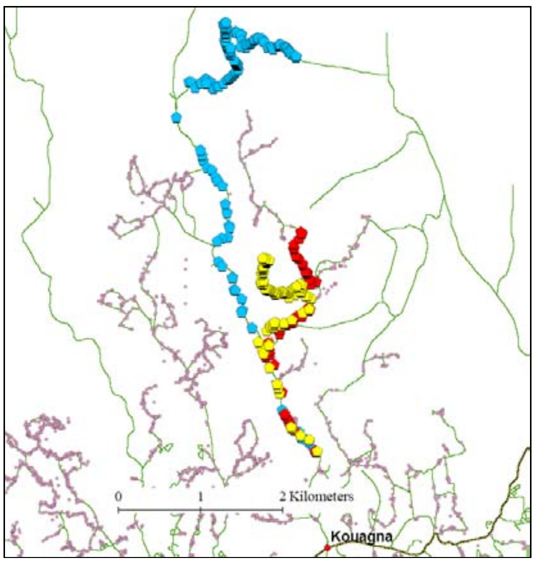
Figure 7. 5 a: Examples of trapping areas for four young hunters (under 20) from Dibouka and Kouagna.



Hunter 65:

27 years old. First set his traps in this area in June 2003, and kept the same area for the whole study period. He complained that the area was not productive, and in Nov 2004 removed a lot of the old traps and added new ones, but in the same hunting area. He laid 170 traps in total, 71% foot traps, and caught 37 animals.

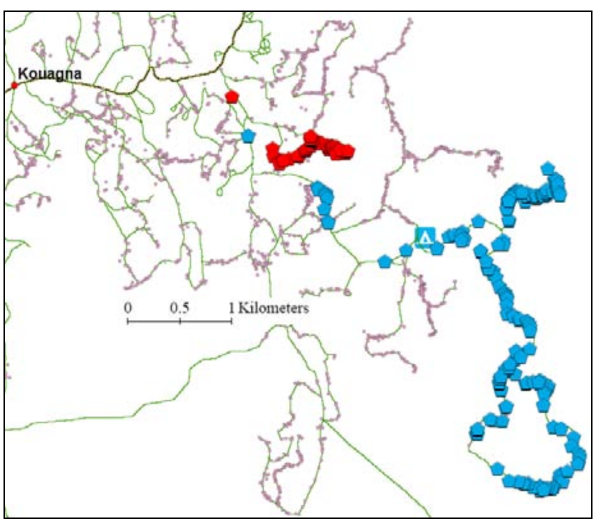
Hunter 65 had a few plantations of his own (not his wife's), where he grew and sold pineapples and palm wine. He only learnt how to trap a few years previously, since returning from employment town.



Hunter 56:

35 years old. First area (blue) laid in Dec 03, and kept there until May. He then laid a new area (red) in May, but removed it by the end of June. Once the plantation season finished he set a new area (yellow) in November. He was the most productive hunter in the two villages, catching 265 animals. He set 335 traps, all of them foot traps, and also did a lot of gun hunting.

Hunter 56 was the entrepreneur of Kouagna. As well as the most productive plantations in the village, he and his wife ran the village shop, and he had a good palm wine business. Hunter 56 also built his family a new house during the study period. He moved to the village after doing well at secondary school in Libreville to look after his family (parent, grandparents).



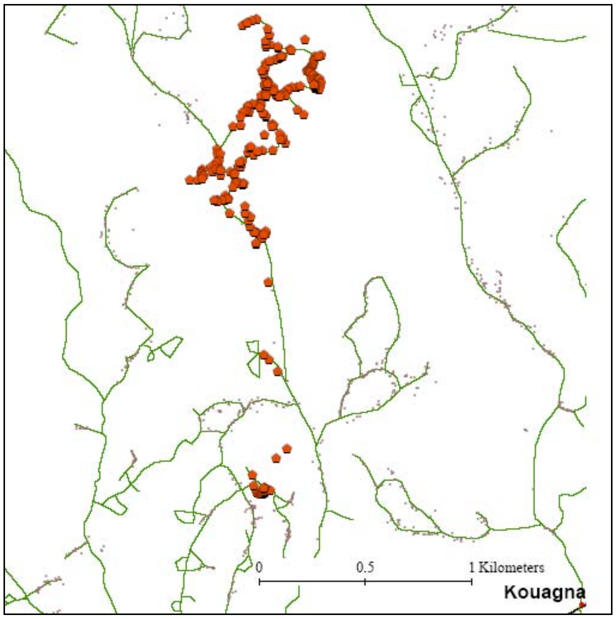
Hunter 6:

38 years old. Hunter 6 first laid his traps in December 2003, based from a hunting camp (blue and white triangle), which he shared with 3 other hunters. They all left this camp in June, for the dry season. In November 2004 Hunter 6 started a new hunting area much nearer to the village.

The reason he gave for this was that he had burnt and planted his own plantations (he did not have a wife or any family in the village) and wanted to be near to these, as he thought the plantations would make him more money than the hunting camp.

Hunter 6 had 242 traps, all foot traps, and caught 121 animals.

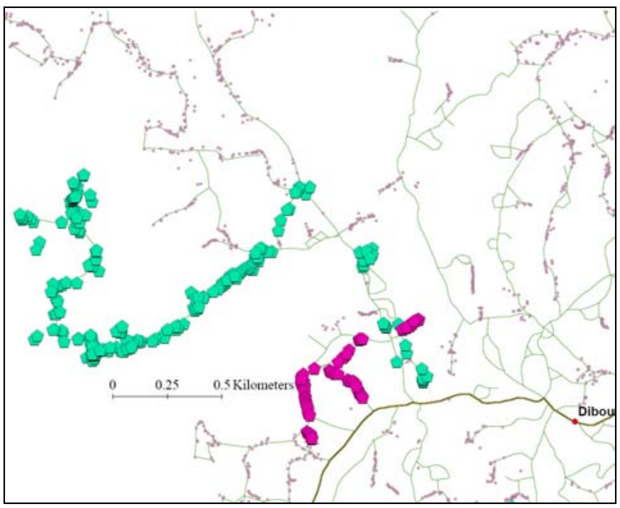
Figure 7.5 b: Examples of trapping areas for three hunters aged 21 – 40 from Dibouka and Kouagna.



Hunter 53:

57 years old. He trapped in 1 area, which he started in October 2003, and continued to trap all through the study period. He had 333 traps; 77 % foot traps with 2 small barrages of neck traps close to the village that were checked at the same time as all of the other. He was also a gun hunter. He caught 96 animals during the study period.

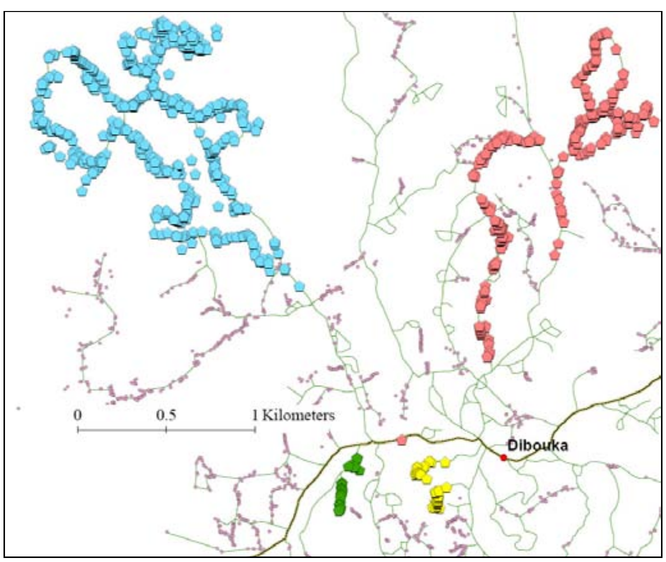
Hunter 53 had a large family, with a large number of plantations, and had no other jobs. Previously he had worked in the manganese mines, and came back to the village to retire.



Hunter 16:

53 years old. Hunter 16 had two hunting areas laid in October 2003; one main area (green) and a large barrage of neck traps, which he visited more infrequently (pink). He kept these areas active through the dry season and moved areas in December 2004, when he moved to trap with another hunter in a hunting camp in Kouagna (not pictured), where he would stay for a week before returning to the village. He had 543 traps, 61% foot traps, and also gun hunted. He caught 105 animals.

Hunter 16 had a large family and many plantations. Previously he had worked as a driver and moved back to the village when this job ended.



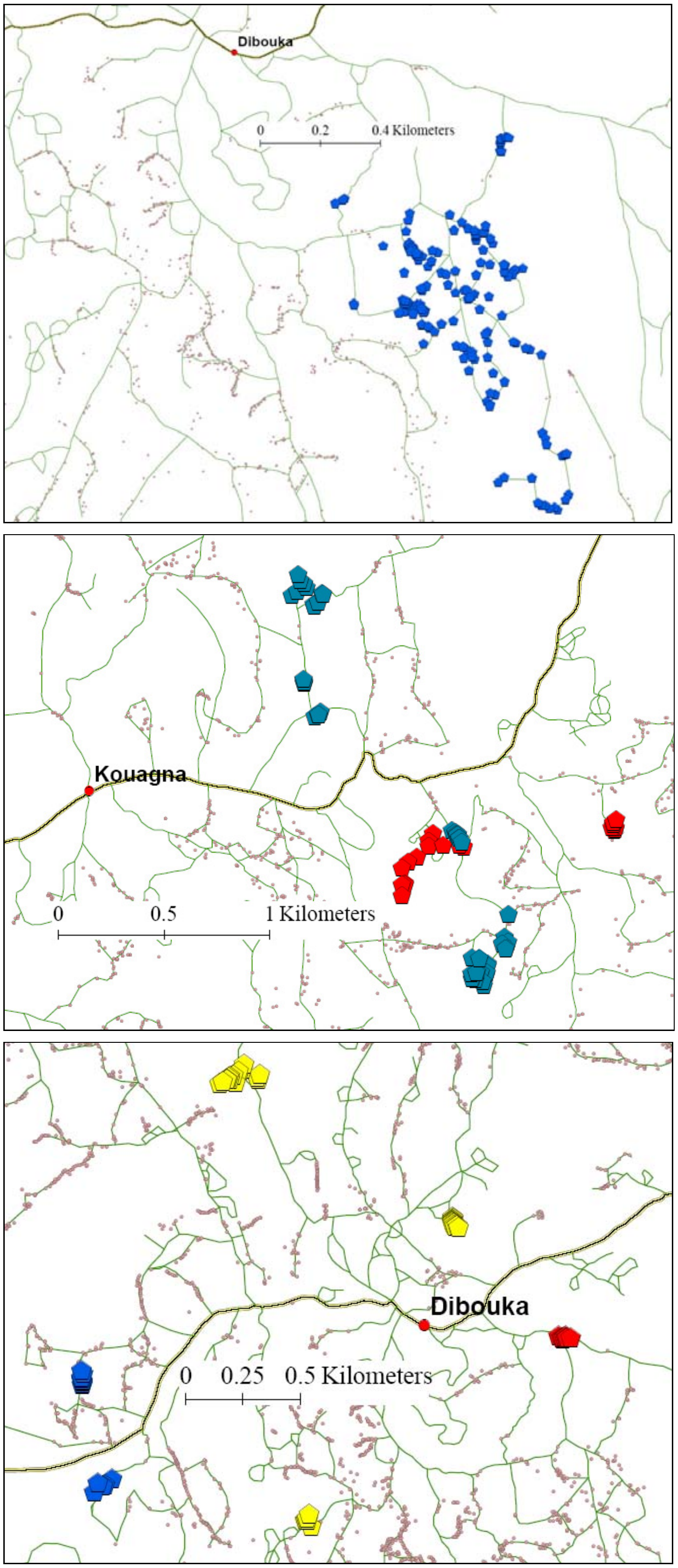
Hunter 8:

42 years old. Hunter 8 had the most traps of all hunters: 1067 traps, 93% of which were foot traps. He was also a gun hunter and caught 265 animals over the study period in total.

He used three areas, the main two (blue and red) being visited at least once a week, with two small barrages (yellow and green) generally checked by his wife on the way to their plantations. All of these areas were laid between Sept and Dec 2003, and were used through to the end of the study.

Hunter 8 returned to the village after working as a driver. He also sold palm wine in the village, usually after visits to his main traps.

Figure 7.5 c: Examples of trapping areas for three hunters aged 41 – 60 from Dibouka and Kouagna.



Hunter 28:

62 years old. Laid traps in November 2003 and trapped continually in this area throughout the study period. He laid 173 traps, 69% of which were foot traps, and also did some gun hunting. Overall he caught 24 animals.

Hunter 28 was retired, and had no other jobs. His wife maintained plantations for the two of them, and he was waiting for a pension to start.

Hunter 62 (red, 62 years old)

Chief of the village, Kouagna. Retired with a pension, he laid 24 traps (59% foot) on the tracks to his plantation. He laid two barrages, one in Dec 2003 (left), which he removed in May 2004, and then another in Oct 2004 (right). He also did some gun hunting, and caught a total of 28 animals.

Hunter 60 (blue, 68 years old).
Hunter 60 set traps to the South of Kouagna in Dec 2003, which were left in place until May 2004. In Oct 2004 he set a new area to the North. In total he set 51 traps (all foot) and also went net hunting around porcupine holes. He caught 25 animals.

Hunter 48 (yellow, 75), **Hunter 68** (blue, over 70) and **Hunter 59** (red, over 70):

These three older hunters typify the trapping behaviour of the over 70's: all three put small barrages of neck traps on the tracks close to the village leading to the plantations, or around the plantations themselves. Hunter 48 owned 37 traps, Hunter 68 owed 8 and Hunter 59 owned 25. These were laid in late 2003, and removed during the dry season, but were never recorded as being checked, possibly as they were laid for plantation defence rather than for hunting directly.

Figure 7.5 d: Examples of trapping areas for six hunters over 60, from Dibouka and Kouagna.

Figure 7. 6 provides a timeline for each trapping area, organised by hunter, in order of their age. The mean number of trapping areas used by a hunter over the study period of 16 months was 1.7 areas. Forty seven percent of hunters used more than one area over the study period, with one hunter (Hunter 36) using five areas consecutively. For those hunters that used more than one hunting area, use was generally consecutive, with one area being used, removed and then replaced with a new area. There was no correlation between the number of consecutive hunting areas used and the age of the hunter (Kruskall Wallis, $p > 0.2$). However, eight hunters used more than 1 hunting area at the same time, and these were hunters of middle age (mean age of 48 +/- 4.5) with a large number of traps.

The mean duration of a hunting area was correlated with the age of the hunter (Figure 7. 7), with hunters of middle age keeping their trapping areas active for longer. The total amount of time spent with traps laid during the study period showed the same correlation, with hunters of middle age having traps down for the longest time ($\sqrt{\text{trapping duration}} = 0.7089 + 0.1174\ \text{age} + -0.001211\ \text{age}^2$).

The time of year that hunting areas were created (i.e. when the first traps were laid for a new area) varied significantly for old and young hunters (Fisher's exact test, $p<0.001$). Twenty seven percent of the hunting areas laid for hunters of age 25 and under were laid during the dry season months of July to September. As the dry season covers ¼ of the year, this suggests that young hunters did not differentiate between the dry and wet season when starting new zones. In comparison older hunters almost entirely chose to start new areas in the wet season (98% of hunting areas).

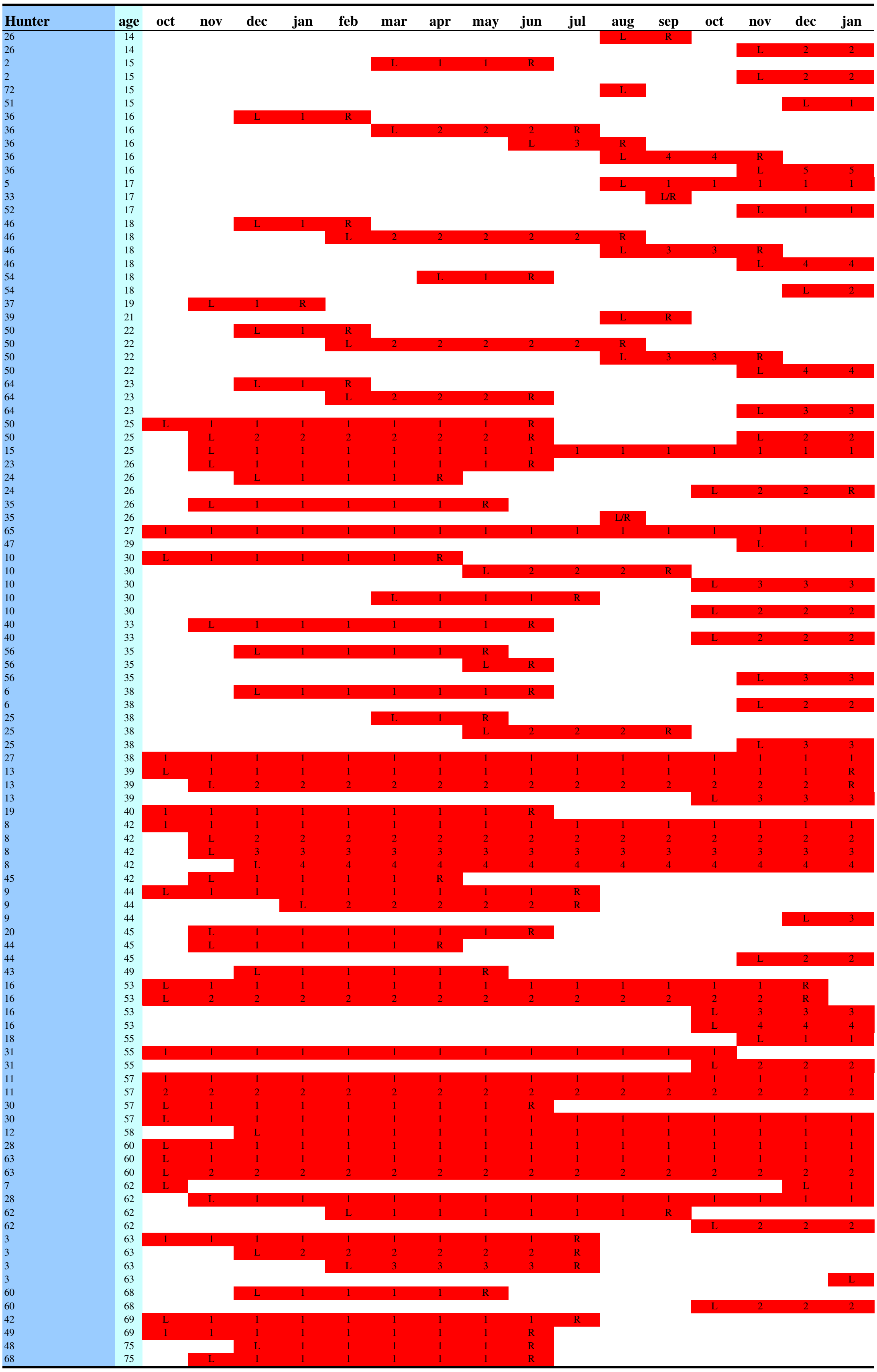


Figure 7.6: Timeline of hunting area movements, organised by hunter and hunter age.
L = The month that the hunting area was laid, R = the month that it was removed.
Areas are labelled 1,2,3,4 etc to denote how many hunting areas each hunter owns.

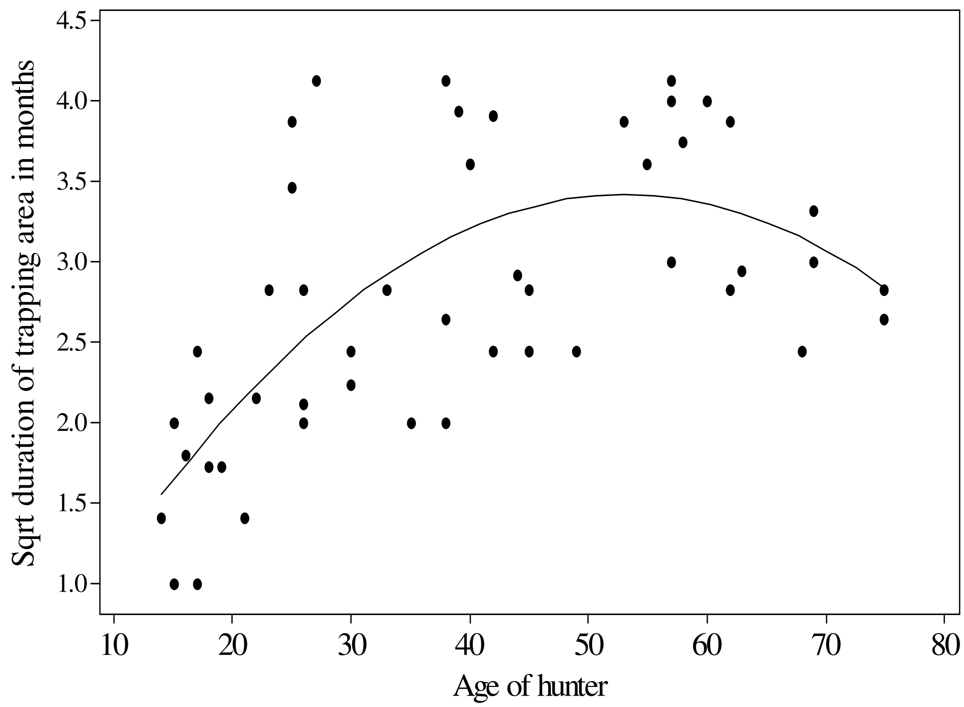
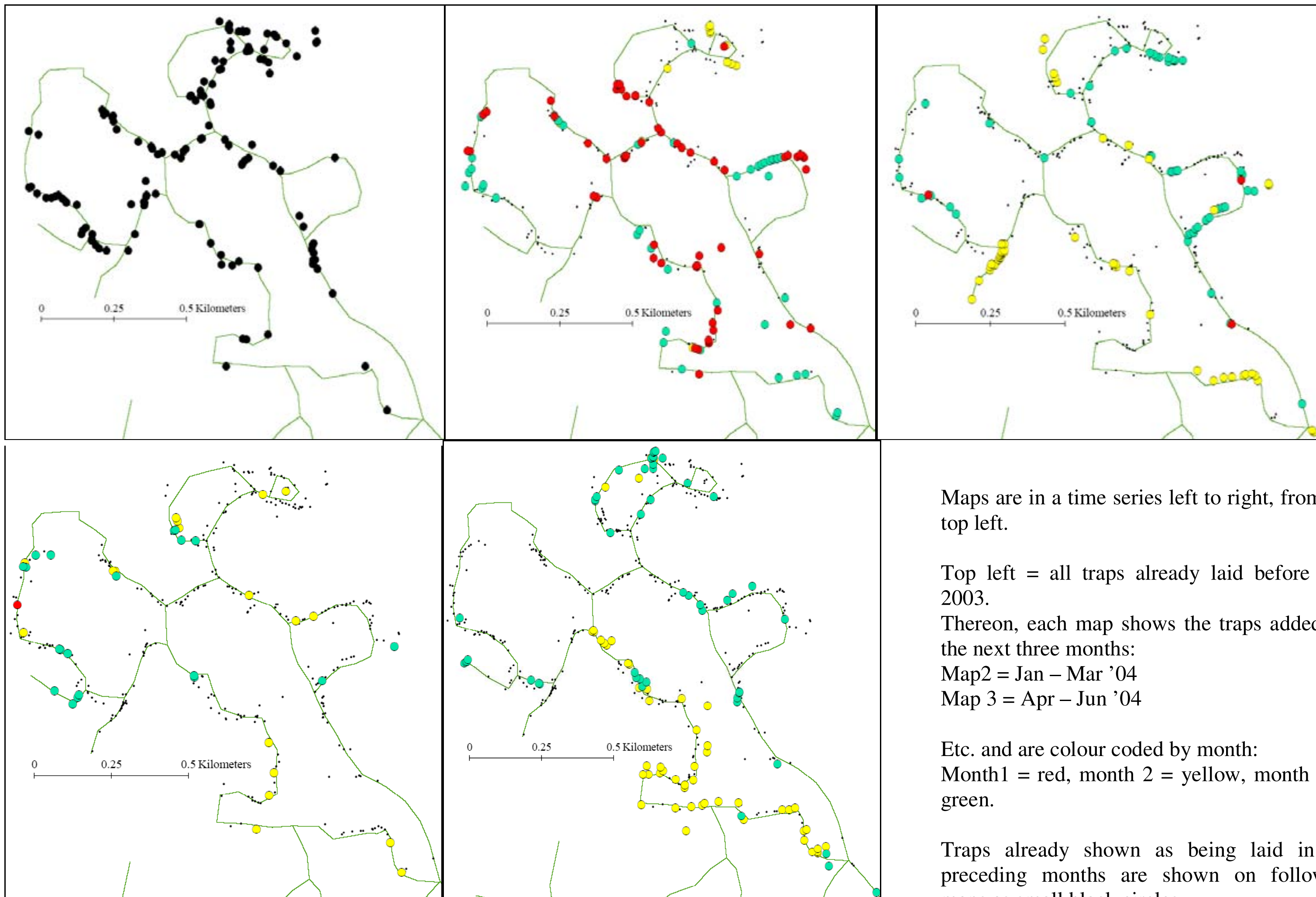


Figure 7. 7: The quadratic correlation between hunter age and the mean duration of his trapping areas. √trapping area duration = -0.0177 + 0.1292 age – 0.001215 age^2, $p < 0.001$, $r2 = 0.46$.

7.3.2.2 Trap additions within trapping areas

Figure 7. 8 provides an example from the most productive trapper in Dibouka of how traps within one trapping area are laid over time. The traps that are added each month are not all laid together in one area, but instead the gaps within the trapping area are steadily filled in with new traps. This method of trap additions was observed for hunters who laid large numbers of traps (mean of 276 traps, range = 82 - 1067), whereas hunters with fewer traps (mean of 41 traps, range of 5 - 129) tended to lay all their traps for one trapping area in one go, and rarely added more (ANOVA, hunters grouped by whether they exhibited a "filling in of gaps" behaviour, or put all traps down in one go. $F_{63} = 45.52$ $p < 0.001$).



Maps are in a time series left to right, from the top left.

Top left = all traps already laid before Dec 2003.
Thereon, each map shows the traps added for the next three months:
Map2 = Jan – Mar '04
Map 3 = Apr – Jun '04

Etc. and are colour coded by month:
Month1 = red, month 2 = yellow, month 3 = green.

Traps already shown as being laid in the preceding months are shown on following maps as small black circles.

Figure 7. 8: Trap additions of Hunter 8 over one year, for his area of traps in Loba (hunting area).

7.3.2.3 Seasonal changes in trap positions

A selection of 16 hunters who trapped in both seasons was used to test whether there were any differences in hunting technique between seasons, using paired t-tests. There was little evidence to suggest that hunters modified their trapping behaviour between seasons. There was a non-significant trend towards hunters laying a larger proportion of their traps near rivers in the dry season (wet season = mean of 17.3% of traps near a river, dry season = 26.5% of traps near to a river, $n = 16$, $p = 0.07$) and no significant differences in the distance from the village that traps were laid, or the type of trap that was used ($p > 0.5$).

7.3.3 Hunter behaviour and decision-making

7.3.3.1 Trap location: Animal paths

Hunters made decisions on where to lay their traps based in part on information from tracks and signs in the understorey and forest floor. Animal trails were plainly visible, and were identified by the shape of the path, the displacement of the undergrowth by the animal, and any tracks; the categories of trail described by hunters are shown in Table 7. 5 a. In general it was easiest to tell when a large animal was not using a small animal trail, rather than the other way round. Porcupine trails were low to the ground and showed a characteristic tail pattern; if this trail was enlarged it meant that red or blue duikers were using the same path, but this did not rule out the use of it by smaller animals.

During each hunter follow, hunters were asked at each new trap the type of animal trail that the trap was placed on. When the trail type was compared to the final catch of the trap, it seems that hunters can influence the species caught by a trap through their choice of animal trail (Table 7. 5 a). Hunters also appear to be choosing the type of trap and the amount of cable to lay and the type of trap to use based on their assessment of animal trails (Table 7. 5 b). Interestingly, the distance from the village that animal trails are found mirrors the results on how the body size of the catch increases with distance, as found in Chapter 3. This again suggests that larger-bodied species are being found further from the village.

	Animal Caught						
Animal Path	Small/ Cane rat	Porcupine	Blue duiker	Red duiker	Sitatunga	Red river hog	Mean Catch weight (kg)
Small/Cane rat	74	17	2	1	0	0	2.41
Porcupine	230	411	88	40	5	0	3.52
Blue duiker	2	5	3	0	2	0	3.01
Red duiker	17	45	24	31	2	5	6.77
Sitatunga	1	1	0	3	2	0	15.29
Red river hog	1	2	1	10	0	3	12.03

Table 7. 5 a: The number of individual animals of each species category captured by traps laid on each type of animal path, as recorded from hunter follows data.

Mean catch weight describes the mean weight of animals (using mean species weights from the study) caught in traps laid on each animal path. Catch weight varies significant with hunting path: Kruskal Wallis: $H_{971} = 104.32$, df = 5, $p < 0.001$

Animal Path	Mean Cable	Proportion foot traps	Mean Distance from village (km)
Small/Cane rat	1.17	0.08	1.11
Porcupine	1.20	0.89	2.82
Blue duiker	1.31	0.97	3.29
Red duiker	2.12	0.99	3.71
Sitatunga	2.66	1	1.30
Red river hog	3.26	1	4.46

Table 7.5 b: How hunting technique correlates with the type of animal path the hunter identified as the trap being placed on, and the mean distance from the village that traps placed on each animal path are found at.

Statistical tests, correlation with animal path:

- Cable: Chi-squared. Path categories porcupine and blue duiker merged, and sitatunga and red duiker hog merged, due to low expected values. 4 categories for cable: 1,2,3, and 4+ wires. Chi squared = 4846.9, df = 9, n = 8050 $p < 0.001$.
- Trap type: Chi squared, all path categories used, trap type neck or foot. Chi-squared = 3807, df = 5, n = 8050 $p < 0.001$.
- Distance from village: ANOVA: $F_{7176} = 323.12$, $r^2 = 18.3$, $p < 0.001$

7.3.3.2 Trap life

Figure 6.9 (Chapter 6), shows that trap success increases linearly until traps are approximately 5 months old, at which point they are unlikely to make further catches. To examine whether hunters were leaving their traps out for the ideal time period of less than 5 months, 7 cohorts of traps (from 7 hunters) were followed for up to 15 months, using information on trap presence/absence from hunter follows. For each hunter, the fate of the traps recorded on the first hunter follow was tracked over subsequent follows, which provided the percentage of original traps still present over time (Figure 7. 9). The point at which 50% of traps were removed was then estimated for each hunter, and an average trap life expectancy calculated from the 7 hunters. This mean life expectancy of a trap was 9 – 10 months, which suggests that hunters are leaving their traps set for much longer than their optimum.

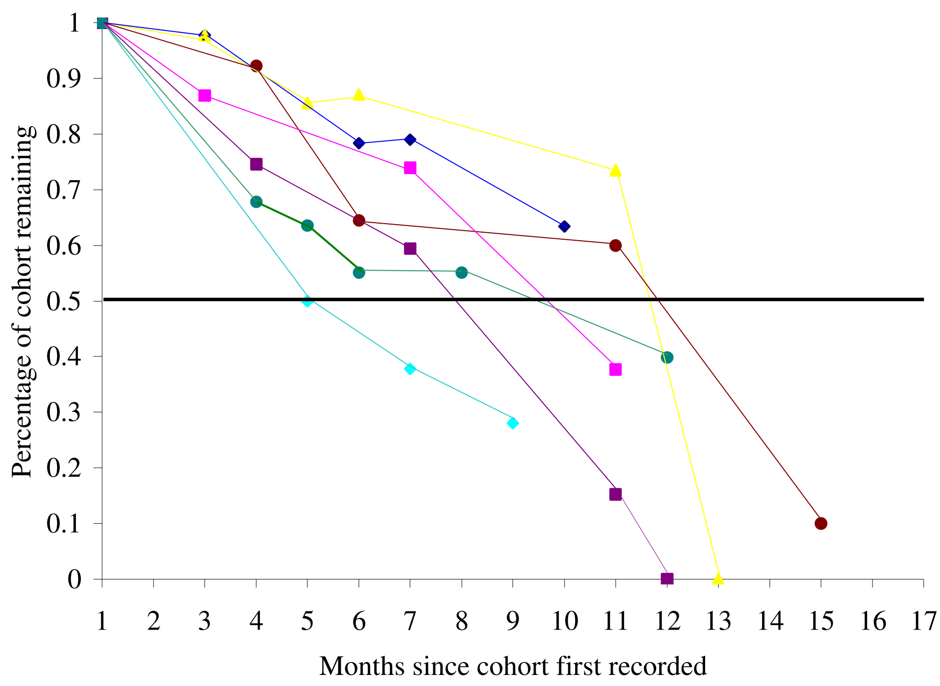


Figure 7. 9: The percentage of the original traps remaining over time, for seven hunters.

7.3.3.3 Time between trapping trips

The mean number of days left between trapping trips by hunters was 4.0 (s.e +/- 0.09, for 45 hunters where over 5 trap trips were recorded), and repeating this for just the ten most productive hunters gave the same result; there was no correlation between the average time left between trips with age or the number of traps owned. The effect of time since the last trapping trip on trap dormancy (a trap is described as 'dormant' when it is correctly set, not sprung, and ready to catch; see Section 3.4.2.2 for complete description) and catch rates was ascertained using a Generalised Linear Mixed Model to control for pseudoreplication (hunter included as a random factor). As the time since the traps were last seen increased, the number of traps which were recorded as dormant (correctly set) during a hunter follow decreased (response = proportion of dormant traps, predictor = days since last follow: estimate = -0.0111, se +/- 0.0027, $t = -4.025$, $p < 0.001$, $n = 256$ trap follows, 66 hunters) but even in situations where traps were left for over a week, the mean percentage of traps still set was 86%, suggesting that time between hunting trips does not greatly reduce the trapping effort available. The catch per hunting trip did not increase if traps were left for longer, and this may be due to the low catch rates (GLMM, response = catch for the trip (number of animals), predictor = days since traps last visited, random effect = hunter, $p > 0.2$, $n = 934$ trips, 31 hunters). However, the time left between trips did greatly influence the state, and therefore the saleability, of the meat caught (GLMM, response = state (0 or 1, fresh or decomposed), predictor = days, random effect = hunter. Estimate = 0.0639, se = 0.0178, $z = 3.587$, $p < 0.001$, $n = 578$ catches, 30 hunters).

During the study period, 30% of the total catch had reached a state of decomposition before it was found (Figure 5.3, Chapter 5). As Figure 7. 10 shows, a reduction in the days between trapping trips produces a sharp decrease in the number of decomposed animals found in traps, which would increase the profitability of hunting trips.

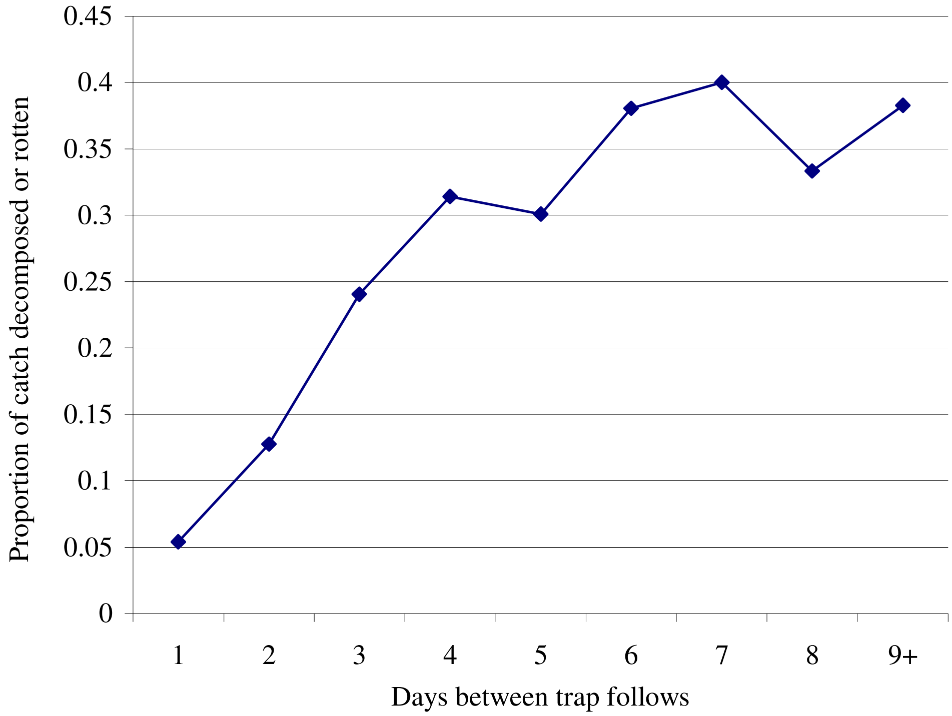


Figure 7. 10: How the proportion of the catch that is found in a decomposed or rotten state increases as the number of days that a hunter leaves his traps unseen for increases.

7.3.4 Decision-making for hunting areas: Changes in CPUE and trap additions

For all nine hunters (who had high enough numbers of hunter follows throughout the year to enable the change in traps over time to be analysed) the cumulative number of traps added over time shows quite a smooth increase (Figure 7. 11), but the total number of traps present over time seems to differ depending on the hunter. Some, like Hunter 8 (Figure 7. 11 a), kept most of their old traps in place, which resulted in an increase in the number of traps in the trapping area over time. Others, such as Hunter 27, despite trap additions during the year kept quite a constant number out at one time, suggesting replacement of traps over time. In one case (Hunter 65, Figure 7. 11 d) there is actually a decline in the number of traps out over time, where this hunter decided to remove a large number of old traps and replace them with new traps in the same area, rather than changing hunting areas.

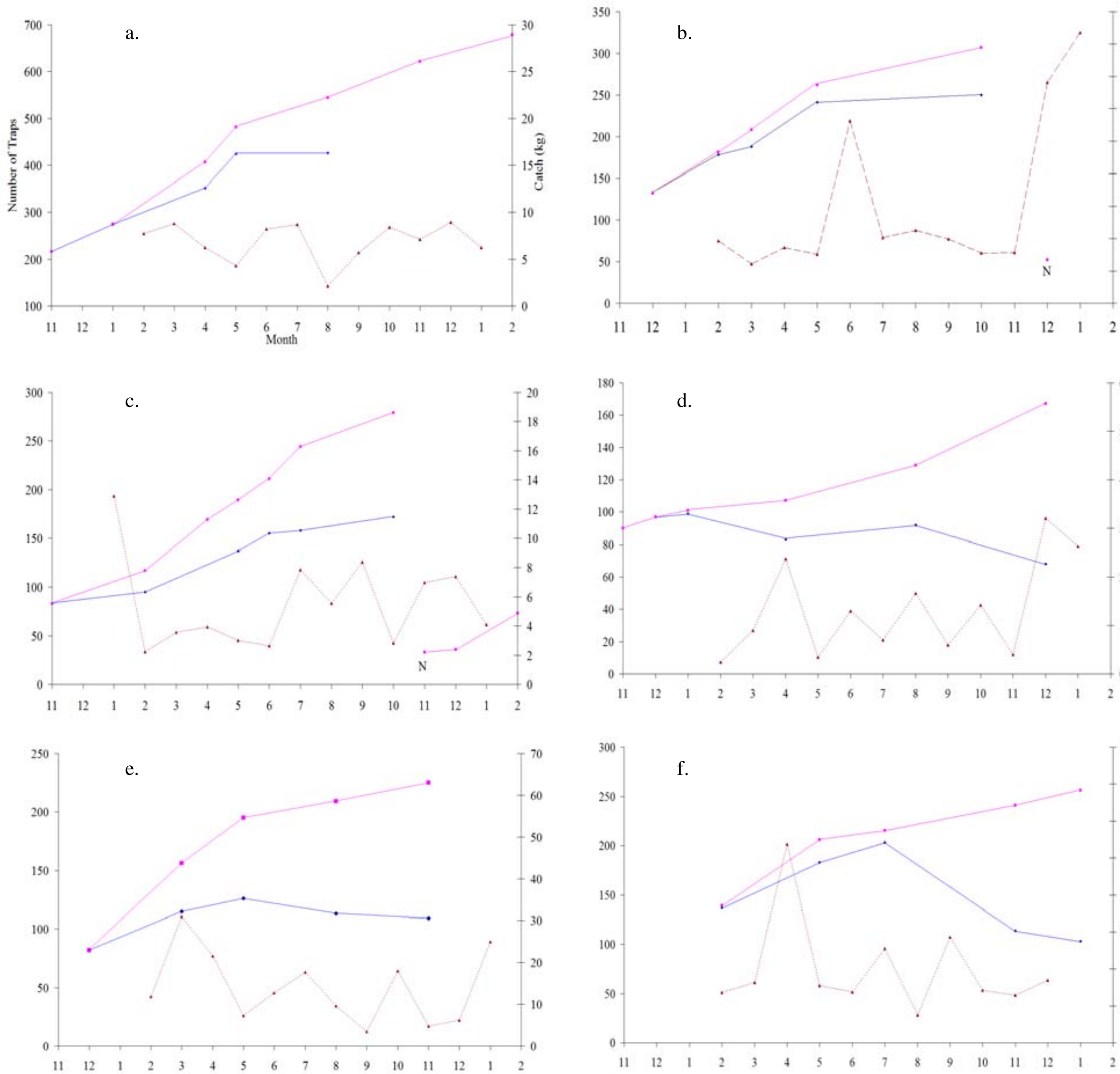


Figure 7. 11: Changes in trapping effort and monthly catch for 6 hunters, between November 2003 and February 2005.

Red line: Cumulative number of traps that have been added by the hunter since November 2003
Blue Line: Number of active traps present at each hunter follow
Purple dotted line: Catch/ month, in kilograms (secondary y axis)

The catch per trip for each hunter is also displayed in Figure 7. 11, and suggests that there does not seem to be a decline in catch per trip over the life of the hunting area. A Linear Mixed Effects Model, with hunter as a random factor, was used to investigate the relationship between the catch per trip, the trapping effort, and the time since the hunting area was established, and the output from this model are shown in Table 7. 6. The catch for a certain month increased with the number of hunting trips that a hunter carried out, and the number of new traps that had been laid in the last two months. As the time that the hunting area had been in use for increased there was a significant decline in the catch rate. The total number of traps present that month did not significantly predict the catch rate.

Model Comparisons, Fixed Effects:

Predictor	d.f	AIC	Likelihood ratio	P value
Trips/month	5	99.444 - 91.416	10.028	0.0015
New traps (last 2 months)	5	96.812 - 91.416	7.396	0.0065
Age of hunting area (months)	5	93.339 - 91.416	3.923	0.0476
Total traps set that month	7	92.650 - 91.416	0.766	0.3816

Minimal Model (AIC 91.416)

Random Effect: Formula: 1|Hunter

	Intercept	Residual
Standard deviation	0.3714	0.5523

Fixed Effects:

	Estimate	Standard Error
Intercept	2.162	0.399
Trips/month	0.126	0.0392
New traps	0.00948	0.00349
Age of hunting area	-0.0539	0.0267

Number of observations = 42, number of groups = 9

Table 7. 6: Linear Mixed Effects model, showing the best predictors of the catch rate for a specific month. Hunter is included as a random factor in the model, and the AIC method was used to test significance for fixed effects.

7.3.5 The influence of traditions and laws on the choice of hunting areas

7.3.5.1 Village hunting laws in the past

Among the 13 hunters who had knowledge of the village hunting laws that were used before 1960 (independence), either from personal experience or from what their fathers had told them, there was complete agreement on what these laws were. Before the *regroupements* of Kouagna and Dibouka were formed, the land use of each old village, or clan (one clan per village) had strict rules governing where each man could hunt, and where each woman could put their plantations. Each clan could hunt in a named piece of forest, often delimited by rivers, and could not hunt in a neighbouring clan's area. Within each clan there were also areas for each family, and hunting areas passed down from father to son.

"Before, people couldn't just go where they liked, because each part was divided. When your dad had for example trapped in Bileba [name of forest], you must also trap in Bileba. You cannot leave Bileba to go and trap on the other side, for example in Loba, because your dad had not trapped there. It was [divided] by clan. If you are from another clan and you put your traps in the place of another clan, you will have problems. It was the same with the plantations".
Interview #22, Hunter 69, aged aprox. 75

7.3.5.2 Law enforcement in the past

Five hunters provided information on the penalties for breaking the law, and these penalties were strict. Four hunters said that if you were caught in the area of another clan, they were within their rights to take you as a slave, to do their plantation work for them, one saying that in addition to this the rape of the offender's wife by the landowner could be used as a punishment. Another hunter said that if you were caught hunting in another man's forest it could lead to fights to the death. One hunter also talked about being able to buy back your freedom with precious stones. An older hunter, Hunter 69, said that these laws were in place to prevent fights between clans breaking out in the forest, as if everyone keeps to their own piece of forest, their can be no territory disputes.

7.3.5.3 Current village hunting laws and reason for change

Of the 28 hunters that were asked, 21 said that at present, there was complete freedom for hunters in where they could put their traps or go hunting. When those hunters who knew about the old practices were asked why this change had occurred, a number of factors were identified, the main one being the changes that came with the *regroupement*, and independence. The chief of Kouagna, (interview #31) stated that when the old villages were regrouped, each old village kept its hunting areas, and even the village housing was divided by clan. The two villages now have '*quartiers*', which hold their roots in these old village divisions, but now show little division by clan. Hunting areas are passed down from father to son, but a man inherits his clan maternally. In the past marriages would have been within the same clan, and so the formation of the regroupement, and the resulting inter-clan marriages have gone some way to dissolving the old rules. Of the eight hunters who gave reasons for the change, seven said that it was introduced by the state, or the French, and was the result of the new state-ownership of the forest.

"Now, since the whites have come to organise the country, we have changed. The forest is partitioned by the whites, from when they came to organise the country. We have left for the moment the rule that not everyone can go in certain areas of the forest. Now there is no problem. It's the state that benefits from the forest. It's the state that eats there now."
Interview #22, Hunter 69, aged approx. 75

"The life of yesterday is not the same as the life of today. What we had before, like fetishes [witch doctors magic], they no longer exist. The old [men] took them all with them. Now we have simple liberty."
Interview #11, Hunter 30, aged 57

"There are no interdictions now. They have left the things from before. Since the Eaux et Foret [Gabonese authority for forest use] arrived. They said you shouldn't be discussing the forest. The forest does not belong to you, if anyone goes into the forest he can go where he wants."
Interview #25, Hunter 66, aged 66

One hunter said that it was not the state, but a well-known Gabonese witch doctor, who demanded the change in forest use, and as the interview with Hunter 30 implies, there has been a loss of the old traditions of black magic over the generations, which may have reduced the fear of the consequences of breaking the laws.

Interestingly an older hunter, Hunter 41, suggested that the migration of more and more young people out of villages, into the towns to find employment, might also be helping to break down old rules:

"… Some feel that they [young hunters] should feel the same rules as their grandparents. There are some that do this, but now it is rare that the young can live well in the village. So there may not be anyone who [is available to] hunt where his grandparents hunted. So one young man who is free might go there, without respecting the old rules. Also they don't know the forest and you must know the forest and the zones that it is divided up into."
Interview #17, Hunter 41, aged 60

7.3.5.4 Current reasons for choosing hunting areas

The majority of hunters, when asked how they chose which are of the forest to trap in, said that they chose it because it had the most animal tracks. During extended interviews, nine hunters were asked why they had chosen to change from one trapping area to another during the study period. All of these hunters said that it was because the place where they had previously been trapping had stopped producing, as shown by the following examples:

"Now for the moment, I am going to change my traps soon, because the animals are already difficult [to find]. They are pregnant already. There are some that already start to produce young, the young start to walk, so that there will soon be many [animals] again. Then we trap."
Interview #36, Hunter 70, aged 33

"*You also ask the question, why one year do you trap over there and then the next year you change the place? It is normal. One year I will trap where I was trapping at Bapeka, over there. If this year I stop trapping there, it is so that the animals can multiply. They grow as well. Maybe the young, I have killed their mother and their father, and the young have stayed, it is necessary that the young grow. They also have children. And then two/three years later I can go back to that area."*
Interview #32, Hunter 45, aged 42

However, listening further to the descriptions of hunting practices, it seems that old traditions have not entirely vanished. Three of the hunters who did not feel that hunting laws were no longer operational were two Ndzebi (Gabonese tribe) men, and one Congolese man had come to the village through marriage. In all three cases they had been shown where they could hunt by other Ndzebi, or in-laws, and said that they would have to ask the chief of the village or a member of the family if they wished to change.

"When I arrived [in the village], I went to see Mr X, who steered me, he said 'look there is where you can go and hunt', the areas of Kanda and Nzinga-Massindzi, Bamboro, those are our areas, so you can go and hunt, and you won't have any problems [with other hunters]. Since that time until now, I hunt there…
… there are the areas that I can't enter, because I have to follow the direction of Ndzengue. Mr X is Ndzebi (Gabonese tribe), even though until now he lives with the Pouvi.... When I arrived, you see the parental line, I approached him, and he said 'I am from your family'. That area of the forest is an Ndzebi area of the forest, Ndzebi that came from Popa…
…Before arriving in a [hunting] area you must make yourself known in front of the people in the village, and the Chief of the village… because it is he who will give you

the instructions… Now for the moment I can put my traps where I want, but always after asking the chief. If he says, you must go there, I go there….”
Interview #1, Hunter 71, aged 39

Several hunters mentioned that some of the older hunters still act is if the old laws are in place, and object when younger hunters disregard the old forest divisions:

“… the old guy Y, he defends his area by the Yahoo [river] here… now, that area of the forest is going to be free [access], because he [Mr Y] is dying, and it’s him that has been creating the disorder. When I trap, he asks ‘who has been trapping over there’ I say ‘me!’ he says ‘Why!’ I say ‘The forest is not defended for one person; the forest is for all of us. Why are you defending the forest?’ That’s how we discuss how the forest is defended. And when I saw that, that is why I took up my traps there [by the Yahoo], and went to trap at Mounganga.”
Interview #35, Hunter 21, aged 12

“The rules still exist, because there are some people who still talk of them, For example, that area of the forest [pointing], there is the old man in Mambouete. Because that is their zone, someone from Kouagna cannot go to cut wood over there, because if they find you, they will always ask, ‘Why did you go over there?’ That is their area. Because for each one of us, there are always the areas that our grandparents left us. For the moment, there are certain people who don’t like it if someone goes and traps in their area.”
Interview #36, Hunter 70, aged 33

And this was confirmed by many of the older hunters, who mentioned that they hunt in the same area that their fathers did, even though there are no longer any rules to this effect.

“The forest is divided by the clans. Now it’s [divided by] the whites and the state, but it was by clan, so the [forest] area over there is the area of my dad. Now that I am retired [from work in town] I also use the area of my dad, I saw the area where he trapped.”
Interview #17, Hunter 41 aged 60

When hunters placed their traps in the same place as their fathers, it was not always due to old laws; some hunters said that they had to wait for other people to show them new areas of the forest, because they didn't know the forest well enough, and that it was generally their dad or another family member that showed them:

"[You cannot hunt anywhere], because the forest… if someone brings you with them, like Mr Z [brother-in-law] brought me here [a hunting camp], he brought me here, he knows the trails, and he showed me. If I want to trap here next year I already know the areas, I know the routes, and I can go in this way."
Interview #21, Hunter 16, aged 53

All of the hunters interviewed agreed that if someone already has their traps down in an area, you must not start to lay your own traps in the same area. Areas of the forest in Dibouka and Kouagna are also still named, and have known limits (generally rivers or hills). During the study period we identified 56 named forest areas in Kouagna (or 0.9 /km^2) and 58 in Dibouka (1.2 /km^2). The size of named hunting areas increased with distance from the village; the forest was more tightly divided close to the village.

The extent to which old hunting laws are still followed, or known about, depended on the age of the hunter. Five hunters under the age of 25 were interviewed; of which two could not say whether there had been any hunting restrictions in the past, and two said that there definitely were none, and the forest had always been free. One young hunter even said that in the past the forest had been free, and it was only today that there were restrictions, as he found that some of the old hunters were intolerant of where he put his traps (see Hunter 21 interview, above). Of the five young hunters, three did not even know which clan they belonged to.

7.4 Discussion

7.4.1 Individual hunter success

An individual hunter's success, measured as biomass (kg) caught over the study period, is best predicted by the effort he puts into hunting. This comprises the number of traps laid and the number of trapping trips that he carries out, and the distance from the village that he travels when trapping. Distance from the village was also seen to be a predictor of success at the individual trap level (Section 6.3.3.2, Chapter 6); however other predictors of individual trap success do not have a significant effect on success at the level of the individual hunter (such as the type of trap laid, the forest type and the trapping density). One possible explanation for this difference is that hunters may be making optimal decision about the type of trap, and the position of trap within their hunting area, which would result in there being no difference between hunters in trapping success based on these variables. However, it may also be that with the considerably smaller sample size of hunters compared with traps, the effects of trap type, forest type, trap density, partly due to co-variance with distance, are not individually discernable, instead all being described by the change in distance, the only significant predictor.

These results show that the best predictors of hunting success can vary depending on the scale at which hunting success is being observed: in this case, hunter or trap? This provides us with a methodological warning. As the results of Chapter 6 have shown, the forest type, trap density and trap type all influence the catch rate, and the type of animal caught. However, this information would have been lost if the study had been only carried out at the hunter level.

7.4.2 Social determinants of hunting behaviour

Hunting strategies are predominantly characterised by age, with none of the other social characteristics collected during the survey, such as income, family size, ethnicity or other employment found to be significant. Middle-aged hunters (who have the highest hunting offtakes, Section 4.3.3.2, Chapter 4) invest the most effort into hunting, walking further from the village than younger and older hunters, leaving their trapping areas active for longer, and carrying out a higher number of trap visits. They also employ trapping techniques that best reflect the predictors of individual trap success (trapping far from the village, a high percentage of foot traps, using old secondary forest areas).

These differences in behaviour by age are probably partly due to differences in strength, as demonstrated by Walker et al (2001) among the Ache hunters of Paraguay. However, this study has shown that hunters aged 40 – 60 are those hunting in the most strenuous (and productive) way, and this age bracket is probably past the peak of physical fitness for most men. Similar results were found by Kaplan et al (2000), who found that offtake rates on difficult foraging tasks for Hiwi hunters, peaked at older ages (around 35) than would be expected from strength and endurance alone. For Machiguenga and Piro hunters (Gurven and Kaplan, unpublished data cited in Walker, 2001) peak hunting offtakes were at 40, for the Etolo it was the mid-50's (Dwyer, 1983), for the Hazda 45 – 50 (Marlowe, 2000), and 37 – 42 for the Ache (Walker et al 2001). The peak hunting offtakes for this study were between 35 and 45, agreeing closely with these previous studies.

Another effect of age on behaviour might therefore be due to skill acquisition. As Walker et al (2001) demonstrate, acquiring the skills needed to be a good hunter can mean that hunting returns peak later than a hunter's physical peak. Different stages in skill acquisition were observed in the young hunters of Dibouka and Kouagna. Many were learning the skills of trapping for the first time in their 20's and were hesitant of how best to trap, often asking for help from their older brothers. They tried to mimic the middle-aged hunters, by trapping at similar distances into the forest, and using foot traps. Young hunters were also seen to lack patience (which could be interpreted as a skill to be acquired); they often began a small trapping area, but did not tend or add to their traps in the same way as older hunters. When realising that the area was not producing, rather than increasing their trapping effort they were more likely to abandon the area and start in a different place. Gun hunting seemed to be a skill which was learnt much later than trapping, with the general progression of skills being: bird trapping (under 20 years old), trapping, dog hunting and finally gun hunting. There were few hunters in their twenties who were proficient gun hunters. Observations of hunters during the study suggest that the effects of alternative employment may also produce a delay in skills acquisition. From semi-structured interviews I found that in Dibouka and Kouagna, hunters often moved away from the village in their 20’s to seek employment with logging companies, as taxi drivers, or other enterprises in town. Men often returned from the town to the village and became hunters after this employment was terminated, hence men could be in their late 20’s or 30’s before deciding that the village, and hunting, offered a more stable livelihood. Because of this, many men have to relearn their hunting skills late in life, which may be another reason for the late peak in hunting returns with age.

Younger hunters (under 20) and the much older hunters (60 or 70+) also have different motives for hunting, which may influence their behaviour. Young hunters often go hunting in groups, and hunting is seen to a certain extent as a social activity; the hunting offtakes in this case can be seen as a secondary, or of equal concern compared with the social reasons for hunting. The higher proportion of young hunters starting hunting areas during the dry season may be partly due to their lack of other responsibilities (although young hunters do help clear and burn the plantations), and partly due to the break-up of school in the dry season (which is designed so that children can help in the plantations), providing them with free time. Older hunters, to some extent, see their continued hunting as a sign of their continued vigour. It has been the habit and activity of a large portion of their life, which they do not want to give up (just as many men reaching retirement in the UK prefer to keep active in their work), and it also provides a reason to go into the forest every day, rather than staying in the village which at midday is hot and uncomfortable. For these reasons, hunting for young and old hunters is often not about maximising catch. Middle-aged hunters, who have families to provide for, are more likely to view hunting as a strict livelihood activity, and therefore exhibit behaviour that maximises catch.

7.4.3 Prey selectivity by trap hunters

Trap hunting as a technique is generally thought to be non-selective; however this study shows that a certain level of prey selection is possible. Hunters always laid their traps on animal paths, and during hunter follows I observed that hunters choose the location of traps based on the type of prey they believe is using the path, but also on the frequency that they estimate each particular path is used, determined by the number of tracks seen and their estimated age. They then decide on the type of trap to use and the amount of cable that is needed for each trap, depending on the type of animal they think is likely to be caught. This choice of trap position by animal path has also been described by Kumpel (2006). The results of Section 7.3.3.1 suggest that they are quite skilled at identifying paths, and that catch could therefore be partly determined by prey choice.

This decision-making by hunters can cause problems with using catch data to look at hunting sustainability. Using catch data in this way assumes that there is no selectivity by hunters, and that, taking into account the effects of trap type, forest type etc, any differences in catch rate or size are therefore due to prey depletion. However, if hunters are able to select, to a certain extent, the prey that they target, catch data may overestimate depletion. The increased catch rate of larger-bodied species with distance from the village is in accordance both with central place foraging and depletion. An increase in the catch of large species with distance from the village could be due to local depletion around the central place (in this case the village), and this is the interpretation given to the results in Chapter 6. However, also in agreement with central place foraging, hunters may be selecting the paths of larger animals over those of smaller animals the further out from the village they go, in order to balance transport costs and maximise returns. This prey-choice by hunters is an issue for studies that aim to measure landscape depletion through hunting offtakes (e.g. Ngnegueu and Fotso, 1996), and these finding highlight the importance of understanding hunter behaviour. An interesting follow-up to this study would be to compare catch rates with estimates of species abundance within the same landscape, to measure the accuracy of hunting offtakes in reflecting the depletion of the prey base.

7.4.4 Decision-making by hunters: Trap life and trap visits

Hunters in this study left their traps out for much longer than their useful life; traps were unlikely to catch much after 5 months, but hunters left them out for an average of 9 or 10 months. In this case, hunters are not exhibiting optimal behaviour, and there may be several reasons for this. Firstly, productive hunters generally have more than 100 (often nearer 200 – 300) traps out at once. Traps are not added in groups, instead being interspersed between existing traps. It may be very difficult therefore for hunters to remember when each individual trap was laid. In fact, it was observed at the beginning of the study that after a few (2 – 3) months of a trap being laid, hunters began to forget the month that they had laid it. This information was used in the study design to make sure that estimates of trap life were as accurate as possible. In comparison, hunters were very good at remembering what animal a trap had caught. This may be that information on catches is more useful to them than the trap longevity, and consequently they retain it. This explanation assumes that hunters know the optimum time to remove a trap, but that logistically it is too difficult to remember trap placements and durations. Another explanation is that hunters do not have perfect knowledge about when to remove a trap. This is quite probable due to the low catch rates; if traps caught more than one animal it would be much easier to see a decline in catch rate over time and learn when to remove traps. However in this study catch rates per trap were well below 1 animal/trap lifetime, and this would make it extremely hard for a hunter to judge when to remove traps.

Hunters also leave too long between trap visits, resulting in a significant proportion of catches reaching a state of decomposition before being found; during the study period, 30% of the total catch had reached a state of decomposition before it was found (see Figure 5.3, Chapter 5). As Figure 7.10 shows, a reduction in the days between trapping trips produces a sharp decrease in the number of decomposed animals found in traps, which would increase the profitability of hunting trips. The behaviour of hunters in this case is therefore reducing the money that can be made from their catch and, where the animal is completely rotten, removing any benefit to the catch at all. As the losses produced by leaving traps for too long are obvious, it is unlikely that hunters are leaving too long between trapping visits due to imperfect knowledge of the system. The time between trapping visits may be due to the demands of other livelihood activities (but see Chapter 4, Section 4.3.1.1). Physical fatigue may prevent further hunting trips, and this was certainly true of some of the more productive hunters, where one hunting trip could take up to 12 hours, and was very physically demanding. It may simply be that hunters do not aim to maximise their catch. This has been shown previously in the studies of pursuits hunting (Mithen, 1989), where hunters were seen to be aiming to improve their catch from the previous hunting trip, rather than maximise their catch. The idea that fishermen catch maximise has been debated in the fishing literature, and Salas and Gaerther (2004) suggest that it may be true for large scale rather than small-scale fisheries, who may take other considerations into account such as covering costs (Cabrera and Defeo, 2001) or minimising risk (Salas, 2000, Gillis, 2003).

7.4.5 Patch dynamics: Choice of hunting areas and reasons for leaving

Hunter interviews highlight the rapid change in village land use rules that has occurred since the 1960's. Past village rules provided each family with their own hunting area, and imposed strict penalties on those who disregarded the boundaries. However, *regroupement*, and changes in government forest policy, have made these laws impotent and untenable, and today a range of behaviours, largely dictated by age (or generation) can be observed. The vast majority of hunters perceive the forest to be open-access. However, older hunters still use the old hunting areas that would have been assigned to their family under the old laws, and young hunters often learn to hunt in the hunting areas of their fathers, which means that a vestige of the old system is still visible. Today, however, many hunters choose their hunting areas by the number of animal paths that are visible in the area. The difference in land use can be summarised as moving from one of closed access to open access. This is likely to be having a major effect on the way that the forest is exploited. Hardin's (1968) 'tragedy of the commons' suggests that open access systems are must more likely to be degraded, as every hunter seeks to maximise his gain, in competition to exploit the resource before it is used by others. The closed access system of individual hunter ownership of particular hunting areas is more likely to result in sustainable practice. An open access system is also more likely to display the patch dynamics and ideal free distribution models introduced in Section 7.1.1, as it leaves hunters free to choose their hunting area on the basis of catch, allowing at least the potential for profit maximisation.

Many hunters chose to stop trapping during the plantation season, and changed their hunting area in the new wet season, in November/December. When asked about why this was, one of the most productive hunters, Hunter 45, gave a detailed explanation:

"We trap a lot in the month of November, because in the wet season, the animals move around easily, and we easily see their tracks, the passages where the animals pass. That is why we trap from the month of November and in May/June we stop. If it is necessary to continue to trap, others trap along the rivers, during the dry season – it's not forbidden to trap during the dry season. On the big mountains, the animals no longer stay there, because the soil is hard, and also you can't easily see the trails where the animals pass. The dead leaves fall and you can't see the trails. In the dry season you are obliged to trap along the edge of the rivers, because on the riverbank you can see where the animals are passing, and when they come from time to time to get water, you will get them in your trap."

Other hunters chose to continue trapping in the same are during the dry season, but again, the change in seasons was influential in their trapping behaviour, and these hunters often changed their hunting area at the beginning of the new wet season. It seems that this seasonal change in trapping areas is partly due to the plantation season, as hunters have less time and energy to devote to hunting, spending more time clearing and burning the plantations (see Chapter 4, Section 4.3.1.1), and partly due to a perceived drop in catch per unit effort over the dry season, due to changes in the visibility of animal tracks due to the hardening of the soil (which also makes trap pits harder to dig) and changes in animal behaviour. Muchaal & Ngandjui (1999) report similar decreases in snaring in the dry season for hunters bordering the Dja reserve, Cameroon. As in this study, hunters cited time constraints during the dry season due to agricultural needs, and the hardening of the soil as the reasons for a switch to gun hunting. Similarly, King (1994) reports that the wet season was the hunting season for both guns and snares in Western Bakossiland, Cameroon, due to seasonal abundance of game and the wet ground.

Section 7.3.4 shows that without detailed examination of trap movements within a hunting area, catch per month obtained from a hunting area, appears not to significantly decline over time (at least for the 9 hunters studied). However, this measure of CPUE does not take into account the addition of more new traps by hunters as the hunting season progresses. In addition, traps are added on new animal trails, and so for each trap, the probability of catching an animal, or the depletion of the area from the point of view of this single trap location, does not depend entirely on the previous catches of surrounding traps. This means that at the end of a year, although there may be fewer animals in the hunting area than there were at the beginning, the catch per trap in these areas is not a good indicator of this depletion. When the number of new traps added to an area each month was accounted for, a decline in the CPUE was detectable (Table 7.6). Due to the intensive nature of the fieldwork required to get these data, the sample size is small, and a further, more focussed study on the changes in CPUE over time in hunting areas is needed to fully understand these patch dynamics. Hunters have suggested that catch declines during the dry season. With the sample size in this study, and the correlation between the age of a hunting area and the season, it is not possible to decouple these effects, and so what seems to be a decline in CPUE over time may be an effect of season.

When hunters were asked why they changed their trapping areas, many referred to a change in hunting success, rather than a change in the season, suggesting that hunters are responding to a decline in CPUE, as predicted by the patch choice model. However, the timing of hunting area changes is strongly correlated with the plantation season. It seems that the patch dynamics of hunters in this system may be governed by both catch (possibly catch-maximisation), the influence of other livelihood activities, and habit. Patches are nearly always changed with season, but the choice of new hunting area (whether in the same general area, or a totally new area) may depend on changes in catch.

Observed hunter behaviour in the real world is therefore likely to be a combination of those behaviours that we might expect from optimal foraging theory, such as central place foraging and prey choice, together with socio-economic influences on behaviour such as skill, strength, social dictate and alternative income opportunities. Ignoring these socio-economic influences would result in a poor representation of ‘real world’ behaviours. Bioeconomic models, incorporating real world hunter behaviour, have a great deal of potential to inform on the outcomes of changes in hunting systems, such as changes in the prey base, livelihood opportunities, etc. However, the current paucity of empirical data available for bioeconomic models the current time limits their practical use. Substituting real world hunter behaviour with optimal foraging rules would result in poor explanatory power.

This study also highlights the problems of using catch data as a proxy for prey depletion; if studies are conducted at the level of hunter, or hunting area, a change in CPUE for each area may not be visible. Even looking at the individual trap level can be misleading, due to a level of prey-selection (by animal trail) by hunters. This suggest that hunting offtake may not be the best way of measuring sustainability, and a review of the relative merits of abundance data versus offtake data for monitoring of hunting sustainability is required.

Chapter 8: Discussion

'*Ignoring the human factor in the sustainable management of bushmeat is a clear recipe for failure*'

Stevenson and Newby, 1997

The overharvesting of bushmeat hunting is one example among many of the unsustainable use of natural resources by human populations, with immediate needs competing against those of future users. Although the need for sustainable resource use is now being recognised by the international community (such as through the Convention on Biological Diversity; CBD, 1993), research effort has often focussed on *how much* of a certain resource is currently being used, comparing this with how much can be used sustainably (Fa et al 2002; Refisch and Kone, 2005b). While an important first step, this does not address why the resource is under pressure, and from whom. Without this information, sustainable use is unlikely to be achieved (Salas and Gaertner, 2004).

Research to estimate the maximum sustainable yield of tropical forest shows that the productivity of forests is too low to support their current (rising) human populations, and its use must be drastically cut to ensure the survival of many species and ecosystem function (Milner-Gulland and Bennett, 2003; Beckman and Muller-Landau, 2007). At the same time many people depend on wildlife for their basic, essential protein needs. Where might resource-use cutbacks be achieved in order that those with the most dependence on the resource are the least affected? Research effort now needs to concentrate on identifying the different groups of people who use bushmeat, understanding why and how they use it, and predicting how their resource use will change under different social, economic and ecological scenarios.

The aim of this thesis was to place hunting in the context of village livelihoods, focussing on the factors that influence hunter behaviour. The specific objectives were to:

1. Investigate the socio-economic characteristics of hunters and hunting households, the use of hunting incomes and the availability of alternative livelihoods.

2. Examine the characteristics of the trade in bushmeat from forest to market, and the economic decision-making of hunters.

3. Study the predictors of individual trap success, investigating the impact of hunting and landscape variables on catch rates.

4. Describe the hunting strategies of village hunters, and the social, cultural and economic factors that influence their behaviour and decision-making.

In this discussion I summarise the results of the thesis, from the perspective of its findings on hunter behaviour, and the social, cultural and economic factors that influence it. I then discuss how these results might be used to inform further research and monitoring of the bushmeat trade, and implications for bushmeat policy.

8.1 Hunting behaviour and optimal foraging strategies

8.1.1 Hunting behaviour and age: strength, skill and motivation

The success of an individual trap was predicted by trap type, the density of trapping, distance from the village and forest cover, and an individual hunter's success was predicted by hunting effort (distance from the village, number of traps and number of trapping trips). However, the trapping strategy that a hunter decided to employ depended on his age, and the reasons for this were probably a combination of fitness, hunting skill and motivation. The hunters with the higher offtakes were middle-aged;

although moving past their physical prime their trapping characteristics were the closest match to the best predictors of individual trap success, possibly due to a combination of maintained fitness, skill and knowledge, and the need to provide for their households. For younger hunters in their peak fitness, who laid few traps for short periods, the motivation for hunting may have been more social, learning new skills and interacting with peers. For old hunters with declining fitness, who kept their barrages of neck traps close to the village, hunting may have provided them with a reason to go into the forest every day, and maintained their status as a household provider.

8.1.2 Spatial hunting behaviours

The observed hunting patch dynamics in Dibouka and Kouagna provide an example of how other livelihood activities can influence hunter decision-making. Optimal foraging behaviour predicts that hunters should change their hunting area when catch per unit effort declines to the point at which the change to a new area would increase catch (Charnov, 1976); however in these villages changes in hunting areas are ruled by the agricultural calendar. Hunting activity decreased during the dry season, when men were needed to clear and burn the plantations in time for October planting, and hunters often chose to use this break in hunting activity to change their hunting areas, regardless of changes in catch.

Old hunting rules also affect spatial hunting behaviour. The influence of traditional rules has deteriorated under the influence of French colonial rule, the *regroupements* and the government ownership of the forest, resulting in changes in hunting behaviour down the generations, with older hunters still observing traditional land-use rules, but younger hunters moving their hunting areas freely, allowing for patch choice. It remains to be seen whether this more open-access situation will result in behaviour more closely resembling optimal foraging.

8.1.3 Hunter skills

This study was able to compare some actual hunter behaviours with predicted optimal behaviours, to measure how well they matched. Although hunters were shown to be skilled at choosing trap positions from animal paths, there were other areas in which they showed either imperfect knowledge of the system or an unwillingness/inability to hunt optimally; hunters generally left their traps set for twice as long as than their predicted useful life, and the time between trapping visits was sufficiently long to result in 8% of the animals caught in the study period being thrown away. These behaviours may have been due to hunters not having perfect knowledge of the system, but could also be because of limited time in the forest to change trap positions or energy for increased numbers of trips. It may also be the case that hunters are not attempting to maximise their catch, as discussed by Alvard (1995).

8.2 Economic hunter behaviour

8.2.1 Livelihood options for village men

There are few alternatives to hunting available to village men; less than 1% of men's time during the study period was spent in paid employment, and as a result 74% of village men were hunters. However, hunting offtakes were unevenly distributed within the study villages, with the wealthiest households capturing the most bushmeat and making the most money.

The other main livelihood activity in these villages, producing 75% of household incomes was agriculture (Starkey, 2005). Although men were involved in plantation clearing and burning, women were the main agricultural workers. Agriculture is currently seen as a women's activity, and therefore is not often perceived by men to be a promising alternative to hunting. Other activities, such as wood-cutting, logging company employment and house-building, were generally transient, lasting from a couple of days up to six months, and hunters would temporarily leave the village, or leave their traps only to return and resume trapping shortly afterwards.

Hunter interviews and personal observations suggest that the role of hunting may vary from man to man; for teenagers it can be a coming-of-age ritual and method of social interaction, for young men it can provide a stopgap income between periods of more formal, but less stable, employment in town. For men who have chosen to stay in the village it can be their only form of stable employment. For old men it is an activity to be taken up during their retirement.

8.2.2 The commercial trade in bushmeat

This study has provided an in depth look at commercial trade from a bottom up perspective, including the trading behaviour of hunters, their commercial hunting behaviours, and their decisions on how to spend commercial incomes.

Dibouka and Kouagna are situated on the old *route economique*, a well-maintained road that is the alternative route to Libreville when the current main road is impassable. Trade in bushmeat along this road is brisk; half of the total biomass caught by hunters was sold, and 62% of this was bought by traders, or people travelling to Koulamoutou. Other studies in Gabon and Central Africa suggest that this is a representative amount, with an average 54% of offtakes sold over 12 studies (Table 5.1, Chapter 5). The prices of animals sold from Dibouka and Kouagna depended predominantly on their weight and the state of the meat, and larger-bodied species that were freshly caught therefore gained the highest prices. Porcupines, the most preferred species in Libreville taste tests (Schenck, 2006), had higher increases in price with a unit increase in weight than other species, which may be an example of urban preferences influencing village prices.

8.2.3 Trading behaviour

The characteristics of eaten and sold animals in Dibouka and Kouagna suggest that urban demand had an effect on the species and state of the animals that hunters chose to sell. Larger bodied species, and larger individuals within species were sold more often than small species/individuals, and red duikers and porcupines were the species most preferentially sold within the village and to town. Fresh animals were also sold in preference to decomposed animals. This suggests that hunters chose to sell the most profitable animals from their catch in order to maximise profits, and casual observations of the animals that hunters chose to display for sale support this. However, urban demand and profit maximisation were probably not the only factors influencing a hunter's decision to sell; household livelihood needs may also have been influential. The proportion of a hunter's offtake that was sold over the study period increased with his total catch. This may be due to a baseline requirement for protein, which once satisfied allows for any further meat to be sold as desired. Further studies into the decision-making of hunters on whether to sell or whether to eat their catch are needed to test this hypothesis.

8.2.4 Hunting behaviour

Some hunters may also have altered their hunting techniques in favour of gun hunting, in order to catch species of high demand for the commercial trade; hunters that carried out proportionally more gun hunting over the study period sold more of their catch, and individual gun hunted animals were more likely to be sold than trap hunted animals. The reasons given for gun hunting trips suggested that gun hunting was often undertaken when a hunter wished to make money immediately, for a specific need, compared with trapping, where the timing and type of catches could not be predicted, and the use of the meat was decided on after, rather than before, it was caught.

More commercially orientated hunters also travelled further into the forest. The percentage of animals sold increased from 15% in the 1 km radius surrounding the village, to over 40% at 5 km from the village, due to a combination of the depletion of larger-bodied animals close to the village, and decision-making by hunters to target these species by hunting far from the village.

8.2.5 Spending behaviour

The use of hunting incomes, and the impact of hunting offtakes on household spending in Dibouka and Kouagna suggest that whilst bushmeat was an important provider of protein for the household, hunters chose to spend a large proportion of their incomes on more luxury items, such as cigarettes and alcohol, and the proportion of their spending that went on these luxury goods increased with their hunting incomes. In comparison, women were more likely to spend their plantation incomes on food, and these plantation incomes were perceived by the community to be a better indicator of household wealth than hunting incomes.

These gender differences in spending behaviour, which have also been observed in rural communities in Guatemala (Katz, 1995), and Cameroon (Solly, 2002), may be due to underlying differences in priorities between men and women. The FAO (1996) has suggested that household food security and nutrition is best helped by increasing women's access to incomes, and their role in household decisions on expenditure. Alternatively, it may be due to the perception by men of hunting incomes as 'free money', a windfall, to be spent quickly and freely. Hunting is often treated as a temporary income provider by men that live in the village during times of unemployment (Solly, 2004; pers. obs.). Men may not perceive more formal employment opportunities in the same way, and the incomes may be treated differently.

8.3 Indicators of depletion and sustainability in the hunted landscape

The impact of hunting on prey population has generally been assessed through the comparison of hunted and unhunted prey populations (Lahm, 1994a; Hart, 2000, Peres, 2000). While providing a direct measurement of impacts, this method does not provide information on the distribution of these impacts over the forest landscape, and cannot distinguish between the effects of different variables (such as forest cover, hunting densities and distance from settlements or roads) on prey abundance. Studying the landscape use of hunters, and measuring the effect of different landscape and hunting variables on individual trap catches can overcome these problems; although without a direct measure of prey abundance the real effects of hunting on prey abundance cannot be measured.

This study is the first to have measured individual trap success over a hunted landscape, and has found that forest cover, trap density and distance from the village were all significant predictors of catches. The effects of hunting on trapping success varied depending on the prey species, with the catch of small bodied species responding negatively to distance from the village while large bodied species were likely to be caught much further out from the village.

The increase in catch of large-bodied species with distance from these two villages is typical of central place foraging, with hunters moving further from the village as prey declines; yet according to camera trapping rates (P.Henschel, unpublished data) the prey base in this area is very low, even at the limits of hunting activity (Section 6.4, Chapter 6). However, hunters are not continuing to travel outwards to areas which may be less depleted, possibly due to physical barriers (in this case the Lolo river), economic barriers (travel costs) and/or social barriers (hunting territories of other villages, livelihood requirements of staying in the village, social perceptions of hunters who stay in the forest).

The gradient of depletion seen here represents the differences in hunting pressure and depletion over the landscape, but on its own holds no information on the overall magnitude of the reduction in prey populations, or the sustainability of the current offtake. Local hunters report that these village landscapes have been hunted intensively for over 20 years, and this gradient of depletion could quite possibly represent a post-depletion equilibrium. The only way to determine this would be through a follow-up study a few years on, measuring trap returns in the same forest areas, with the same trapping techniques to study whether catch rates were declining in time as well as space.

A landscape assessment of hunting pressure (Section 6.3.2, Chapter 6), using data from the distribution of hunting pressure over the hunted landscape found in this and other studies in Central Africa, suggests that the impact of village hunting in Gabon could be extensive. High trapping densities, and the resulting reductions in large-bodied prey populations are likely to be occurring over at least 26% of the country.

8.4 Lessons for further study of the bushmeat trade

8.4.1 Predicting impacts

Recently the emphasis of bushmeat research has moved from documenting impacts to predicting the future impacts of changes in the hunting system (e.g. social, economic and demographic and prey base changes), and the impacts of bushmeat policy (Starkey, 2005; Kumpel, 2006; Brown and Fa, 2007). Models of the hunting system such as those of Rowcliffe et al (2003) and Damania et al (2005) provide a tool for measuring these impacts, but their use is currently restricted by a lack of empirical understanding of the hunters and prey behaviour. Hunter behaviour has been found to be crucial for the predictive ability of fisheries models (Gillis, 2003; Salas, 2004; Abernethy et al, in press), yet it is rarely considered in hunting models, partly because there are very few data on hunter behaviour and decision-making, especially for trap hunting. Where behaviour is incorporated it is generally assumed that hunters will behave according to optimal foraging rules.

This study has provided the first detailed analysis of hunter trapping behaviour, and suggests that hunter behaviour is driven not only by catch, but also by social, cultural and economic factors, including the time and effort requirements of other livelihood activities, the skills and strength of hunters, the motivation to hunt, and traditional laws constraining hunting behaviour. The result is that the real behaviour of hunters in this case would have been poorly represented by an optimal foraging strategy, and models that used an optimally foraging hunter in place of actual data on hunter behaviour may have predicted very different reactions to changes in the system. For example, a model with optimally foraging hunters would predict that with a decline in the prey base, hunters would move further from the village in search of larger-bodied prey, only constrained by travel costs. However, our data suggest that only a few middle-aged hunters would consider hunting at more than 5 km from the village. Changes in prey numbers would probably not affect young and old hunters due to their current trapping behaviour and motivation for hunting, and social constraints on staying in the forest for long periods of time would probably mean that few hunters would move any further into the forest than currently observed. This study suggests that unless further data are collected detailing hunting behaviour and decision-making, under current conditions of uncertainty these models are likely to perform poorly, and their predictions should be treated with caution.

8.4.2 Monitoring impacts

Market data are often used as a tool for monitoring the bushmeat trade because markets provide a bottleneck in the trade from which to observe a large quantity of meat and can represent the regional trade. Markets have previously been used to directly measure hunting sustainability (Fa et al, 1995; Refisch, 2005), and it has been suggested that the ratio of large to small-bodied species present in the market could be used as an indicator of hunting sustainability in the market catchment area (Rowcliffe et al, 2003; Jerozolimski and Perez, 2003). This study shows that the biased sale of larger-bodied species in villages means that small-bodied species are greatly under-represented in markets. If large-bodied species continue to be preferentially sent to market as their populations are locally depleted, the ratio of large to small-bodied species in the market is likely to change more slowly than that of the original catch, and so unsustainable use is likely to be observed in the species compositions of markets only after heavy depletion has already occurred in the prey base.

This use of market data also fails to take into account the spatial movements of hunters (Milner-Gulland and Clayton, 2002; Crookes et al, 2005). In this study, animals caught for the commercial trade were caught further from the village than those that were eaten, and the resulting market prey profiles therefore do not reflect the depletion of larger-bodied species seen close to the village. On the other hand, hunters from Dibouka and Kouagna seem unlikely to move much further into the forest in search of larger animals, which may limit this effect. Village hunters such as those observed in Dibouka and Kouagna are likely to be constrained by their central place foraging behaviour, returning to the village every night. However, commercial hunters are not so constrained, and more likely to move into less depleted areas in search of larger-bodied commercial prey. In this case landscape-level depletion will certainly not be observed in market prey profiles until all areas are depleted.

The alternative to market monitoring is monitoring at the village level, which has traditionally been used for much more short-term studies of hunting offtakes and prey abundance, where hunting sustainability is generally assessed using space as a proxy for time (Ngnegueu and Fotso, 1996; Muchaal and Nganjui, 1999; Fimbel and Curran, 2000) Collecting the required amount of data for useful estimates of prey population densities requires a great deal of fieldwork effort. These village studies are often not conducive to long term monitoring due to the high amount of cooperation required from the hunters, and the need for a researcher to be continually based in the village. Village studies are also case studies by nature, and alone cannot provide information on regional trends.

Measures of CPUE have been suggested as a quicker and easier alternative for assessing hunting sustainability at the village level. This requires data on hunter catch and effort, and can even be recorded by the hunters themselves, allowing many more villages to be monitored consecutively and over longer time periods (Noss et al, 2005). However, by collecting data at the individual trap level, this study has demonstrated that there may also be problems with the use of CPUE in detecting changes in prey abundance. New traps added to hunting areas are placed on different animal paths, which means that the catch of individual traps is not dependent on the prey availability in the surrounding area. This can result in declining prey populations while a hunter’s CPUE stays stable, due to his ability to target specific animal trails. CPUE will eventually decline once the number of animal trails becomes limiting, but, as with market data, reductions in prey abundance will only be detected long after they originally began to fall.

Offtake data can also be used to determine the influence of different trap and landscape variables on trapping success. However, the effect of the scale at which offtakes are measured matters; testing predictors of trapping success at the level of the individual hunter masked the effects of forest type, trap density and trap type seen at the more detailed level of individual trap catches, which might have led to the assumption that these variables have no effect on catch. This study has also found that hunter decision making about where to lay traps means that the some of the variables affecting trap success cannot be measured effectively. Hunters chose their trap type depending on the type of animal trail that the trap was to be set on, and this makes it impossible to determine the extent to which the species caught was a function of animal path that the hunter laid the trap on, rather than the type of trap used.

These problems with the efficacy of CPUE as a proxy for depletion suggest that, although there are problems with the precision of prey abundance estimates, these errors may be preferable to the biases of CPUE data. A review of the merits of both strategies, including rapid assessment methods, is essential.

8.5 Implications for current policy to tackle the bushmeat crisis

Current policy to reduce hunting pressure and produce a sustainable hunting trade in Gabon focuses on the reduction of urban consumption; there is elastic demand for bushmeat in Libreville, and a possible generational change in preference for bushmeat, that can be capitalised upon (Schenck et al, 2007). Targeting urban consumption rather than rural consumption has generally been considered the best strategy, partly because of the bottleneck in trade that markets produce, which makes enforcement easier, but also because it avoids targeting the bushmeat consumption of the rural poor, for whom bushmeat provides most of the protein requirements. Gabon's human population is currently growing at just under 3% a year, putting more pressure on its natural resources. The nature of this growth however, suggests that it may impact the commercial trade rather than the rural need for protein, as while urban populations are growing, rural ones are currently staying stable. However, reductions in the urban trade will affect rural economies, reducing hunting incomes in rural areas where they can represent up to 72% of overall household incomes (Starkey, 2005).

8.5.1 Targeting urban demand

This research provides more evidence to suggest that urban demand is probably the best place to affect reductions. From an ecological standpoint, the commercial trade appears to be targeting the larger-bodied, less sustainable species. From a socio-economic standpoint, this study suggests that hunting incomes provide less benefit to rural households than other sources of income, such as those from agriculture. In addition to this, a small proportion of predominantly wealthier households would see the largest reduction in hunting incomes. However, in the same villages, Starkey

(2005) noted that while wealthy households made more money from bushmeat than poor households, bushmeat accounted for a larger (but not statistically significant), proportion of household incomes for the poorer households in this village. If this is the case then a small reduction in incomes may have a larger impact on poorer households, and the impact of bushmeat incomes on different sections of the community is a priority for further research.

Even under the assumption that household livelihood budgets would not suffer directly from a reduction in hunting incomes, the impact on the income options for rural men remains. Although these incomes are spent more on luxury items than the incomes generated by women, this does not mean that their reduction is unproblematic. The lack of alternative livelihood opportunities shown in this study mean that incomes lost through the reduction of commercial hunting may not be replaceable through other forms of employment, and this may lead to agricultural incomes being used for the purchase of goods originally bought with hunting incomes, reducing the income available to the household for subsistence goods. However, if bushmeat incomes are perceived as a ‘windfall’ income, and are therefore spent in a short-term manner, these spending habits may not be transferred to other sources of long-term income, such as agriculture.

To understand the effect of reducing the urban demand for bushmeat, more information on hunter decision-making is also necessary. Although currently larger-bodied species are predominantly sold rather than consumed by the hunting household, it does not necessarily follow that a reduction in urban demand will reduce pressure on these species; hunters may continue to hunt a range of species but switch their consumption patterns to the larger species that would previously have been sold. An alternative outcome of reduced urban demand might be a reduction in hunting pressure, and/or the distance from the village at which hunters set their traps.

8.5.2 Targeting rural use

Bushmeat in rural communities is often the main (sometimes only) source of protein, and reducing rural consumption requires protein alternatives, be they reared bushmeat and livestock within the village, or imported frozen produce. Although this project did not measure the availability of alternative protein sources within these villages, personal experience of living in the village suggested that there are few. Tinned sardines imported from France (due to Gabon's oil-induced food production crash) were one of the only substitutes, but are perceived as a luxury rather than a necessity. Livestock in these villages are used as a way of saving money rather than producing protein, acting as a safety net for future emergencies. Cane rat and porcupine-rearing projects, such as those currently seen in Franceville (Jori et al, 1998) are long-term projects requiring heavy investment. Introducing similar projects into the 2000-plus villages in Gabon would require serious time, effort and capital, and any current bushmeat policy should avoid reducing rural consumption until alternatives are available.

The results from this study suggest that in theory restricting the use of guns and foot traps would ease pressure on larger-bodied species, shifting hunting effort onto smaller-bodied, more sustainable species. However, the reality of the enforcement situation in Gabon makes these ideas impractical. Current regulations ban the use of non-licensed firearms and all trapping, and penalties are strict, with illegal hunting of protected species affording the hunter up to six months in prison (Christy, 2006). However, these fines and prison sentences are rarely given out. In the province where this study was carried out there were 10 agents, with only 4 vehicles, patrolling an area of 25,200 km^2, and no arrests or fines were delivered in the study villages in the two years that I was there, or the 18 months that Malcolm Starkey was based in Dibouka. Changing the current hunting regulations is unlikely to have any impact without changes in enforcement. In addition to this, strict regulations breed resentment among poor village communities, where fines are often greater than a household's annual income. Less 'stick' and more 'carrot' (such as conservation education programmes, coupled with a form of direct payment scheme for local conservation) may be more appropriate for rural communities, although these can be just as hard to regulate as traditional enforcement. However, strict penalties may still be appropriate for bands of commercial hunters (often moving across the border from the Congo; F. Maisels, pers. comm.), who are hunting solely to supply urban markets and not rural protein needs.

Current hunting practices, which appear to be removing larger-bodied species and allowing only small-bodied species to persist, may be sustainable for human consumption purposes, but do not fulfil many conservation needs, having severely altered the species composition, and therefore probably the ecosystem structure and function of the area. Although village hunting is likely to continue to have large impacts within the village landscape, with a reduction of the commercial trade this landscape use may be sustainable for small-bodied species, which would prevent further encroachment into areas of undisturbed forest.

8.5.3 Bushmeat and poverty alleviation

Bushmeat hunting is often described as a crucial resource for the poorest rural households in Central Africa (DFID, 2002), and has even been suggested as a tool for poverty alleviation (Brown and Williams, 2003). However, the use of bushmeat as a livelihood activity of the rural poor has generally been studied in isolation from other available livelihood activities. This study has shown that the incomes from agriculture are much more likely to influence household wealth and food security than the incomes from bushmeat sales. These results highlight that the role of other household incomes, especially those from women, is not being given enough consideration in the debate over the role of bushmeat in poverty alleviation. With other poverty alleviation strategies in South America citing the increased power of female heads of households as one of the most effective strategies for bringing communities out of poverty (Nigenda and Gonzalez-Robledo 2005; Hoddinott and Skoufias, 2000), a broader perspective on the drivers of poverty and poverty alleviation in these rural communities, including all livelihood activities and actors, is required.

8.6 Further study

This study has provided a valuable study of hunting in an ‘ordinary’ village – one which is not on the border of a national park. The decision to use a case study has allowed for an unusually detailed study on hunting behaviours and the role of hunting in village livelihoods, which would not have been possible with a larger sample size of villages. However, as a case study it is limited in its ability to inform us on regional or national realities, and questions have arisen from the results of the study that could not be tested with the available data. In this section I outline some of the questions that I feel have a high research priority, and some of the methods that could be used to answer them.

8.6.1 The use of CPUE as a tool for monitoring sustainability

A number of problems with the use of CPUE as an indicator of prey abundance, or prey depletion were highlighted by this study (Section 8.4.2). However, prey abundance data were not collected due to resource limitations, and it was therefore not possible to quantify the impact that these problems may have on the use of CPUE data. A useful follow-up to these results would be to collect CPUE data and prey abundance data in the same areas (possibly radiating outwards from a village) to evaluate how well measures of CPUE reflect changes in prey abundance. This work has been started by researchers in Equatorial Guinea (Janna Rist, pers. comm.) and the results should be illuminating.

8.6.2 The contribution of all livelihood activities to rural livelihoods

This study has provided the first look at the use of hunting incomes, using village shop purchases as an indicator of overall trends in spending. This used the direct monitoring of purchases, rather than the use of a recall survey to ask people about their spending habits. The reason for this was that previous researchers had noted a reluctance of hunters to give accurate details of their spending, often leaving out purchases of luxury goods (M. Starkey, pers comm.) However, the method used in this study also has limitations. By monitoring purchases in the shop alone, purchases between households (which are more likely to be agricultural and forest foodstuffs and home-made alcohol) are ignored, and the contribution of these purchases to overall spending was unknown. An interesting follow-up to this study would be to use recall surveys alongside the monitoring of shop-purchases, thereby gaining a fuller picture. This would be a useful addition to studies such as that carried out by de

Merode et al (2004) and Starkey (2005), which used recall to measure household incomes from different livelihood activities. By incorporating information on incomes from different livelihood activities with a record of purchases by individuals in each household, the contribution of different livelihood activities, including bushmeat and agriculture, could be accurately quantified. This is crucial to inform the ongoing (but data-poor) debate on the use of bushmeat by the rural poor.

8.6.3 Impacts of a reduction in the urban trade on rural livelihoods and prey populations

The targeting of larger bodied species by the commercial trade suggests that hunting for incomes may be having a greater impact on less robust species than hunting for food. However, although larger-bodied species are more likely to be sold it does not follow than a reduction in the commercial trade will necessarily reduce hunting pressure on larger-bodied species. It may be that species are equally valuable and targeted as a food-source within the village, but that current commercial needs result in their sale. Studies of rural prey preferences for consumption would help our understanding of the impacts of a reduction in urban market demand, as would a comparison of hunter prey profiles and hunting offtakes before and after a market closure or increased enforcement, although this type of study is much harder to achieve.

8.6.4 The ecological footprint: regional and national landscape use

The current lack of information on hunting distributions in village landscapes means that any regional and national estimates of landscape effects of hunting are very imprecise. Similar village landscape surveys are required, but could be collected at a much coarser scale. Rapid Rural Appraisal mapping exercises in a good sample of villages (possibly 20 – 30) around the country could provide estimates of territory use, which can then be compared with a few detailed case studies such as this one, to estimate the proportion of the village landscape likely to be under high hunting pressure, or the ‘ecological footprint’. These Rapid Rural Appraisal studies are already underway in Gabon in this way, set up to assess the impacts of hunting on the new national parks (M. Starkey, pers comm). Similar studies on the landscape use of hunters in forestry concessions would help to complete the picture. The Global Forest Watch published a report in 2002 on the number of large access tracts that were left in Central Africa, with information on logging company roads. With further information on prey populations, such as dispersal and ranging behaviour, a similar type of analysis could be employed to determine the size of forest areas in Gabon that are likely to be free of hunting pressure, and which species these are likely to conserve.

This thesis has highlighted the importance of a full empirical understanding of resource users and their behaviour, for an analysis of the sustainability of harvesting systems. More generally, it demonstrates the use of case studies in providing detailed information, without which important trends may go unnoticed, or even be misinterpreted.

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Appendices

Appendix 1: Species list for Gabon

Protected and Partially Protected Species in Gabon: (Figure reproduced from http://www.wcsgabon.org/gibier)

ANIMAUX INTEGRALEMENT PROTEGES

Noms communs	Noms scientifiques
a) Mammifères	
Gorille	Gorilla gorilla gorilla
Chimpanzé	Pan troglodytes
Hippopotame	Hippopotamus amphibius
Lion	Panthera leo
Panthère	Panthera pardus
Chat doré	Felis aurata
Serval	Felis serval
Lamantin	Trichechus senegalensis
Chevrotain aquatique	Hyemochus aquaticus
Pangolin géant	Manis gigantea
Cobe onctueux	Kobus ellipsiprymnus defassa
Cobe des roseaux	Kobus redunca arundinum
Daman des arbres	Dendrohyrax arboreus
Galago de Demidoff	Galago demidovii
Galago élégant	Galago elegantulus
Galago d'Allen	Galago alleni
Potto de Bosman	Perodicticus potto
Potto de Calabar	Artocebus calabarensis
Oryctérope	Orycteropus afer
Céphalophe de Grimm	Sylvicapra grimmia
Céphalophe à pattes blanches	Cephalophus ogilbyi
Cercopithèque à queue de soleil	Cercopithecus solatus
Potamogale	Potamogale velox
Baleine à bosse	Megaptera novaeangliae
Baleine de bryde	Balaenoptera edeni
Rorqual boréal	Balaenoptera borealis
Rorqual Commun	Balaenoptera physulus
Cachalot	Physeter macrocephalus
Orque	Orcinus orca
Dauphin à bosse d'Atlantique	Sausa teuszii
Dauphin commun	Delphinus delphis
Faux orque	Pseudorca crassidens
Steno	Steno bredanensis
Dauphin Sp	Stenella sp
Dauphin Sp	Tursiops sp
b) Oiseaux	
Aigle couronné	Stephanoaetus coronatus
Aigle pêcheur	Haliactus vocifer
Aigrette garzette	Aigretta garzetta
Anhinga d'Afrique	Anhinga rufa
Cormoran africain	Phalacrocorax africanus
Ibis sacré	Threskiornis aethiopica
Jabiru du Sénégal	Ephippiorynchus senegalensi
Grande aigrette	Aigretta alba
Héron goliath	Ardea goliath
Héron à tête noire	Ardea melanocephalus
Héron cendré	Ardea cinerea
Marabout	Leptoptilos crumeniferus
Pélican blanc	Pelecanus onocrotalus
Pélican gris	Pelecanus rufescens
Picatharte à cou gris	Picathartes oreas
Spatule d'Afrique	Platalea alba
Tantal ibis	Ibis ibis
Vautour palmiste	Gypohierax angolensis
c) Reptiles	
Crocodile du Nil	Crocodylus niloticus
Tortue luth	Demothelus coriacea
Tortue verte	Chelonya mydas
Tortue olivâtre	Lepidechelys olivacea
Tortue imbriquée	Erethmochelys imbricata

ANIMAUX PARTIELLEMENT PROTEGES

a) Mammifères	
Eléphant	Loxodonta africana
Buffle	Syncerus cafer nanus
Bongo	Tragelaphus euryceros
Sitalunga	Tragelaphus spekei
Céphalophe à dos jaune	Cephalopus sylvicultor
Guib harnaché	Tragelaphus scriptus
Potamochère	Potamochoerus porcus
Hylochère	Hylochoerus meinertzhageni
Mandrill	Papio sphinx
Drill	Popio leucophaeus
Colobe guereza	Colobus guereza
Colobe noir	Colobus satanas
b) Oiseaux	
Perroquet gris	Psittacus erithacus
Inséparable	Agapornis pullaria
Canard de hartlaud	Pteronetta hartlaubii
c) Reptiles	
Crocodile nain d'Afrique	Osteolaemus tetraspis tetraspis
Faux gavial	Crocodylus cataphractus
Python de Seba	Python sebae

Appendix 2: Data collection sheets (*dummy data entered in italics to demonstrate use)*

A2.1: Census data for each household

FIELD ASSISTANT: *Lauren* DATE: *22/6/5* HOUSEHOLD NUMBER: *32*
CARTIER: *Makene* HEAD OF HOUSEHOLD: *Ngouabenga Ettienne* WAYPOINT NUMBER: *09*

Family name	*Mbombe*	*Continued for rest of family….*			
First name	*Wilson*				
Age	*28*				
Sex	*Male*				
Place of birth and ethnic group	*Dibouka, Pouvi*				
Relationship to head of household	*Son*				
Livelihood activity (1)*	*Trapper*				
Livelihood activity (2)	*Gun hunter*				
Livelihood activity (3)	*Agriculture*				
Education**	*CM2*				

Family name					
First name					
Age					
Sex					
Place of birth and ethnic group					
Relationship to head of household					
Livelihood activity (1)*					
Livelihood activity (2)					
Livelihood activity (3)					
Education**					

* In order of time spent at each activity
** By class: infant 1,2, primary 1,2 secondary 1 – 6, and university.

A2.2: Household Wealth.
Salaries, Pensions, Commerce, Agriculture, Housing and Basket of Goods

Household Datasheet				
Household Number:				
PRIMARY REVENUE	The primary source(s) of revenue in the household in the last month			
Salaries:	**Name**	**Salary (CFA)**	**Bonuses (CFA)**	**Employer**
	Mbombe Wilson	*90,000*	-	*CEB*
Pensions:	**Name**	**Pension (CFA)**	**Ex Employer**	
	Mbombe Pierre	*30,0000*	*CEB*	
Commerce:	**Name**	**Commerce (CFA)**	**Large/med/small commerce**	
	All household	*Beer, tomato tins*	Small	
Presents:	**Name**	**Value (CFA)**	**Provenance**	
	All household	*30,000/ year*	*Family in K/M*	
Agriculture:				
Item		**Quantity**	**Total Price**	
Peanut sacs sold this year		*6*	*12,000 x 6*	
Coffee sacs sold this year		*0*		
Cocoa sacs sold this year		*0*		
Tarot sacs sold this year		*4*	*15,000 x 6*	
Others				
Others				
Others				
Peanut sacs sold last week		*1*	*12,00 x 1*	
Bananas sold last week		*2 regimes*	*2,500*	
Tarot sold last week		*0*		
Tubercule sold last week		*0*		
Other		*2 manioc*	*400*	
Other				
Other				

Appendix 2.2 cont.

BASKET OF GOODS:			
Items Owned	**Quantity**	**Unit Price (CFA)**	**Total Price**
Goats	*0*		
Sheep	*0*		
Pigs	*0*		
Chickens	*0*		
Cows	*0*		
Gas Cooker	*0*		
Mattress	*1*	*30,000*	*30,000*
Oil lamp	*2*	*2,600*2*	*5,200*
Watch/ Clock	*0*		
Refrigerator	*0*		
Freezer	*0*		
Radio/cassette/cd player	*0*		
Television	*0*		
Mobile phone	*0*		
Electric fan	*0*		
Cooking pot	*9*	*Estimate of total*	*4,900*
Headtorch	*0*		
Generator	*0*		
Chainsaw	*0*		
Axe	*1*	*12,000*	*12,000*
Wheelbarrow	*0*		
Machete	*1*	*3,500*	*3,500*
Cane sugar press	*0*		
Gun	*0*		
Total value			

TYPE OF HOUSE (circle those that apply)				
Walls	Leaves/bark	*Mud*	Wood (branches)	Cement covered mud
	Mud bricks	Wood (planks)	Corrugated iron	Half cement
	Cement			
Floor	*Mud*	Concrete		
Roof	Leaves	*Corrugated Iron*	Flat sheet iron	
Number of bedrooms:		*3*		

A2.3: Hunter follows

Data on each trap collected during a hunter follow: (3/4 normal size, in order to fit within page margins)

FIELD ASSISTANT: *Lauren* HUNTER NAME: *Mbombe Wilson* TIME STARTED: 08.30
GPS NUMBER: *GPS 2* DATE: *18/02/04* TIME ENDED: 16.50
HOW MANY TRAP HUNTER SAYS HE HAS: *30* VILLAGE: *Dibouka*

Line number	Trap no.	Way Point No.	Time	Last time hunter saw trap	Type of Trap	Type of forest	Name of forest	Trap placement				Type of human path (principle, private, plantation, other	Type of animal path, if present
								1 flat 2 gentle 3 mod. 4 steep	Near (10m river	On river bank	On piece of wood		
1	*3*	*46*	*8.51*	*tuesday*	*to*	*n*	*batsengui*	*2*	*y*	*n*	*n*	*pv*	*Ngom*
2													
3													
4													
5													
6													
7													
8													
9													
10													
11													
12													
13													
14													
15													
16													
17													
18													
19													
20													

Line number	Barrage or single?	Date trap laid	No. Pieces of cable	State of trap: Dormant (d) Sprung (f) Got away (e) Caught (a) Cut (co) Broken (ca)	If 'Got Away' was there anything that the animal left in the trap to identify the species?	If 'Caught', which species?	State of animal: Alive (v) Fresh (f) Decomposed (d) Rotten (p)
1	*s*	*Jan*	*1*	*a*		*porcupine*	*v*
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							

A2.4: Animals found in each trap:
Datasheet used to ask each hunter what he had caught previously in each trap, during a hunter follow.

Trap number	Species	Date (nearest month)
8	*Porcupine*	*Dec 03*
13	*Gambian rat*	*Unknown*

A2.5: Trap hunting returns

Data collected in village each time a hunter returns from a hunting trip (2 sheets, normally printed on 1 A4 sheet, back and front)

Trapper Name: Was there someone else who accompanied him?	NAME: *Mbombe Wilson* OTHER PERSON: *none*		
Porter Name (if any):	NAME: *none*		
Start of Trapping tour	TIME: *8.50*	DATE: *22/2/4*	MONTH: *feb*
End of Trapping Tour:	TIME: *14.10*	DATE: *22/2/4*	MONTH: *feb*
Did he bring a gun with him:	YES/NO *no*		
If yes, did he kill anything with the gun? (If 'yes' then fill in a gun-hunting sheet)	YES/NO *no*	SPECIES:	
When was the last time he saw his traps?	DATE: *19/2/4*	MONTH: *feb*	
Had he added/taken up/ changed the place of any traps on his last visit?	YES/NO *yes*	DETAILS: *added 2*	

Reason for the trap visit:	*Just checking the traps*
Division of meat between hunters (if any):	*none*
Profit for the porter(s) (if any):	*none*

ID	Species	Sex	Age	State of meat	Trap details		Old animal wounds? Give details	Name of forest	Type of forest	Type of human path	Any other information
					Trap Number	Type of trap					
1	*Porcupine*	*F*	*Adult*	*Fresh*	*19*	*to*	*none*	*Batsengui*	*K*	*Pv*	
2											
3											
4											
5											
6											

If the animal is whole (not cut into 'gigots')

ID	Mass (kg)	Eaten or Sold?	Price (CFA)	Sold to who, and destination
1	*3.4kg*	*Sold*	*4,000*	*Commercant going into koulamoutou*
2				
3				
4				
5				
6				

If the animal is cut into gigots:

ID	Head		Front left leg		Front right leg		Back left leg		Back right leg	
	Mass (kg)	Eaten/sold (Price)	Mass (kg)	Eaten/sold (Price)	Mass (kg)	Eaten/sold (Price)	Mass (kg)	Eaten/sold (Price)	Mass (kg)	Eaten/sold (Price)
1										
2										
3										
4										
5										
6										

ID	Other:		Other:		Other:		Other:		Other:	
	Mass (kg)	Eaten/sold (Price)	Mass (kg)	Eaten/sold (Price)	Mass (kg)	Eaten/sold (Price)	Mass (kg)	Eaten/sold (Price)	Mass (kg)	Eaten/sold (Price)
1										
2										
3										
4										
5										
6										

A2.6: Gun hunting returns

Data collected in village each time a hunter returns from a hunting trip (2 sheets, normally printed on 1 A4 sheet, back and front)

Trapper Name: Was there someone else who accompanied him?	NAME: *Mbombe Wilson* OTHER PERSON: *Ngouabenga Alain*		
Porter Name (if any):	NAME:		
Start of Gun Tour	TIME: *17.50*	DATE: *22/2/5*	MONTH: *feb*
End of Gun Tour:	TIME: *09.30*	DATE: *23/2/5*	MONTH: *feb*
How many cartridges did he bring with him?	NUMBER: *12*		
How many did he use?	NUMBER: *2*		

Reason for the trap visit:	*Something to eat*
Division of meat between hunters (if any):	*Yes, Alain got the back legs*
Profit for the porter(s) (if any):	

ID	Species	Sex	Age	State of meat: fresh or smoked	Old animal wounds? Give details	Name of forest	Type of forest	Type of human path	Any other information
1	*Bay duiker*	*f*	*a*	*f*		*batsengui*	*e*	*pp*	
2									
3									
4									
5									
6									

If the animal is whole (not cut into 'gigots')

ID	Mass (kg)	Eaten or Sold?	Price (CFA)	Sold to who, and destination
1				
2				
3				
4				
5				
6				

If the animal is cut into gigots:

ID	Head		Front left leg		Front right leg		Back left leg		Back right leg	
	Mass (kg)	Eaten/sold (Price)	Mass (kg)	Eaten/sold (Price)	Mass (kg)	Eaten/sold (Price)	Mass (kg)	Eaten/sold (Price)	Mass (kg)	Eaten/sold (Price)
1	*2.1*	*Eaten*	*2.2*	*S, 1,500 KM*	*2.1*	*Eaten*	*1.9*	*Eaten*	*1.8*	*Sold, 1,500 Ndzengue Pierre*
2										
3										
4										
5										
6										

ID	Other:		Other:		Other:		Other:		Other:	
	Mass (kg)	Eaten/sold (Price)	Mass (kg)	Eaten/sold (Price)	Mass (kg)	Eaten/sold (Price)	Mass (kg)	Eaten/sold (Price)	Mass (kg)	Eaten/sold (Price)
1										
2										
3										
4										
5										
6										

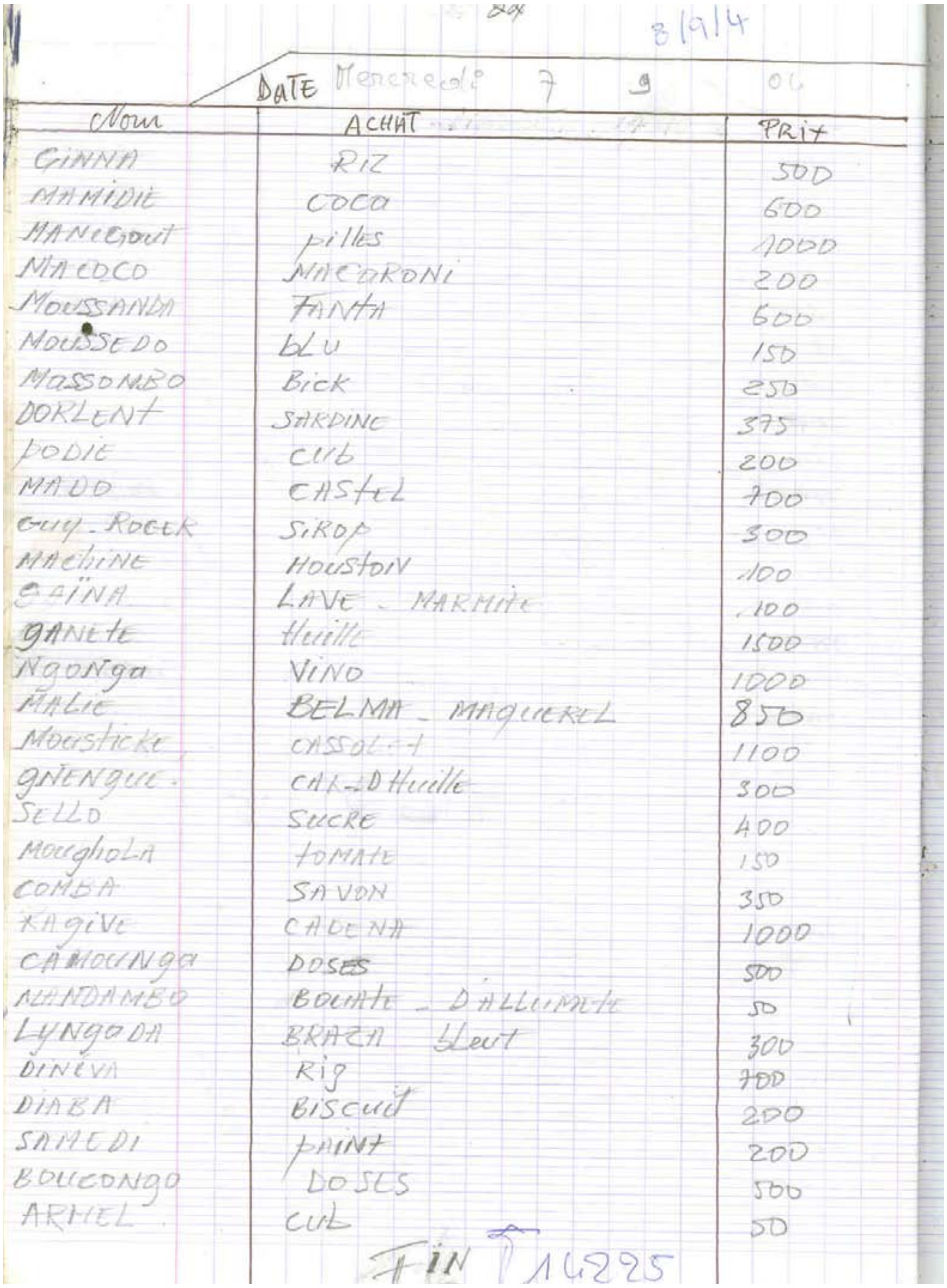
A2.7: Male Livelihood Activities:

Main daily activity, recorded for a subset of 30 men from Kouagna. Hunter names are usually pre-typed on the form, but for the purposes of illustration, only a few have been added.

Hunter Name	Activity	Time started	Time Finished	What did he bring back home with him? (If anything)	Quantity
Mbombe Wilson	*Trap hunting*	*8.40*	*16.00*	*Cola nuts* *Porcupine*	*Handful of nuts, 1 pp*
Boumbanga Edward	*Went to help his cousin build a house in Mouila*	*10.40*	*17.30*	*A Panier of cane sugar*	*1 panier*

A2.8: Bar returns datasheet

Example of the book used to record purchase information



8/9/4

DATE Mercredi 7 9 06

Nom	ACHAT	PRIX
GINNA	RIZ	500
MAMIDIE	COCA	600
MANIGOUT	pilles	1000
MACOCO	MACARONI	200
MOUSSANDA	FANTA	600
MOUSSEDO	bLU	150
MASSOMBO	Bick	250
DORLENT	SARDINE	375
DODIE	club	200
MADO	CASTEL	700
Guy-ROCK	SIROP	300
MACHINE	HOUSTON	100
GAINA	LAVE - MARMITE	100
GANETE	Huille	1500
NGONGA	VINO	1000
MALIE	BELMA - MAQUEREL	850
MOUSTICKE	CASSOLET	1100
GNENGUE	CAKED Huille	300
SELLO	SUCRE	400
MOUGHOLA	TOMATE	150
COMBA	SAVON	350
KAGIVE	CADENA	1000
CAMOUNGA	DOSES	500
NZANDAMBO	BOUATE - D'ALLUMETE	50
LYNGODA	BRAZA Lait	300
DINEVA	RIZ	700
DIABA	BISCUIT	200
SAMEDI	PAINT	200
BOUCONGO	DOSES	500
ARMEL	CUB	50

FIN 14225

A2.9 Items sold in the local shop, Dibouka.

Items on sale during the study period, and their displayed prices.

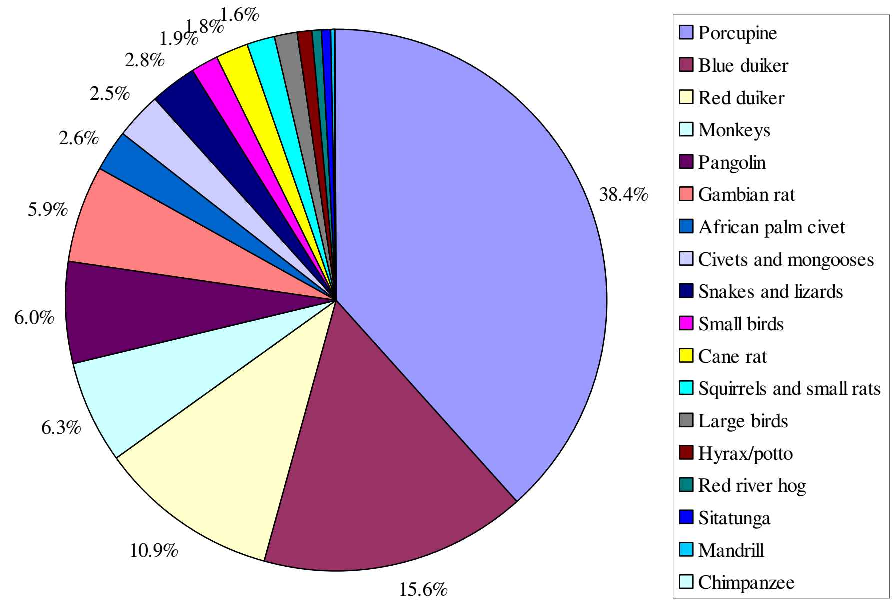
Category	Item	Price (CFA)
Alcohol:		
	Beer: Regab (65cl)	500
	Beer: Castel (65cl)	700
	Beer: Castel (33cl)	500
	Royal Dutch Lager (50cl)	1000
	Guinness (33cl)	900
	Gin and Tonic (33cl)	600
	Whisky Black (33cl)	600
	Wine (1litre)	1350
	Wine (33cl)	550
	Liquor (1 shot)	100
	Rum (1 shot)	100
	Whisky (1 shot)	100
	Menthe (1 shot)	100
Cigarettes:		
	Brazza Blu (20)	500
	Houston (20)	500
	Houston (1)	25
	Dunhill (20)	1500
	Dunhill (1)	75
	Gabonaise (20)	500
	Marlborough (20)	1000
	Marlborough (1)	50
Soft drinks (categorised as food for analysis):		
	Coca Cola (1 litre)	1000
	Coca Cola (50cl)	500
	Andza water (1 litre)	1000
Food:		
	Palm Oil (50cl)	750
	Palm Oil (1 litre)	1350
	Bread (1 roll)	100
	Bread (with butter)	150
	Bread (with chocolate)	150
	Tin Sardines (125ml)	300
	Sardines in Tomato Sauce (425g)	700
	Salt (907g)	500
	Concentrated Tomato Paste (70g)	150
	Concentrated Sugared Milk (78g)	250
	Concentrated Sugared Milk (397)	750
	Handful Pasta (~50g)	100
	Packet Pasta (500g)	750
	Cassolet (Beans, tomatoes, meat: 425g)	1000
	Cassolet (Beans, tomatoes, meat: 875g)	2200
	Nescafe (tin, 25g)	1000
	Nescafe (1 cup’s worth)	100
	Sugar (1kg)	1000
	Onion	100
	Garlic bulb	300
	Rice (1 cup)	100
	Sweets (1)	25
	Stock cube	25

Household:		
	Small soap	350
	Large soap	500
	Pen	250
	Matches (10 packets)	50 per pack 250 for 10 packets
	Batteries (1 headtorch)	225
	Batteries (1 AA)	200
	Cleaning Sponge (1)	200
	Metal wool cleaning sponge (1)	200
	Sewing needle (1)	100 – 150
	Bedsheets (1)	6000
	Hair trussing cotton (1 packet)	900
	Razor blades	50 for 1 500 for 10
	Mosquito coil	100 for 1 500 for 5
	Sanitary towel (1)	100
	Bic razors	200 for 1 1000 for 5
	Lightbulb (1)	350
	Paracetamol (1 pill)	50
	Toothbrush (1)	500
	Underwear (1)	600
Hunting equipment:		
	Cable	500 per metre 7500 per 25m roll
	00 Shotgun Cartridges (only sold in town, not included in analysis)	600 single 15,000 for 25
	Chevrotine Shogun Cartridge (capable of killing buffalo)	700 – 800 single 15,000 for 25
	“4” shotgun cartridge (for birds)	600 single 13,000 for 25
	“6” shotgun cartridge (for birds)	600 single 13,000 for 25

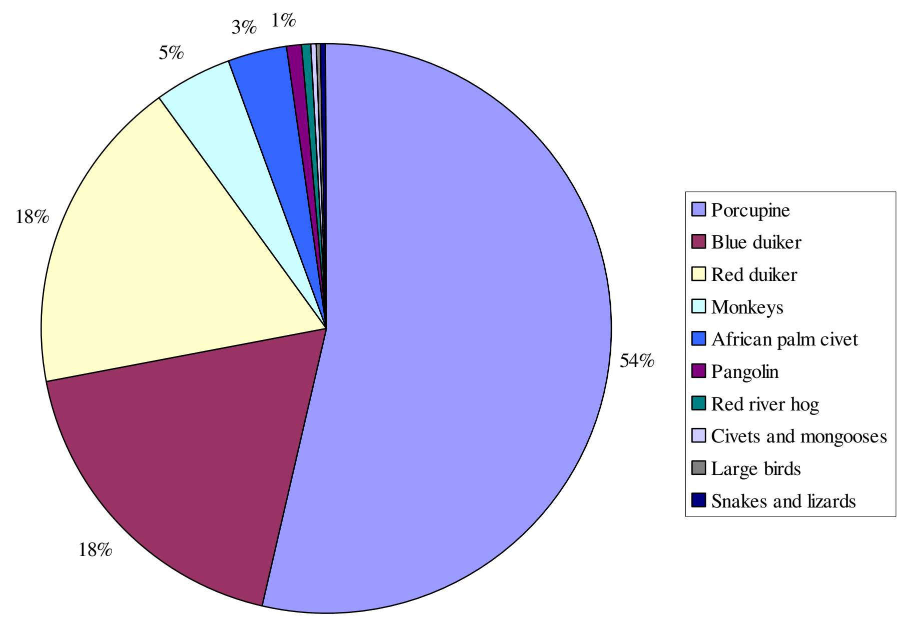
Appendix 3: Data outputs

A3.1: Species composition of (a) original catch and (b) catch sold to town.

a.



b.



A3.2: Mean species weights and prices (*only adult, and fresh or decomposed, animals used to calculate mean values:*

Species (only those animals where species id known)	Species (latin name)	Number recorded in village surveys	Number weighed (adult fresh or decomposed only)	Mean Weight (kg)	Number sold where price known (adult fresh or decomposed only)	Mean Price (CFA)	Mean Price per kg
African Civet	Civettictus civetta	6	1	5.1			
African Palm Civet	Nandinia binotata	69	40	2.7	14	3286	1114
African Python	Python sebae	1					
Bay duiker	Cephalophus dorsalis	220	134	16.2	58	10573	651
Black Colobus	Colobus satanas	6	4	11.7	2	6000	
Black-fronted duiker	Cepholophus nigrifrons	3	2	19.0			
Black-Legged Mongoose	Bdeogale nigripes	3	1	3.0			
Blue duiker	Cephalophus monticola	410	250	4.2	102	3295	806
Great Blue Turaco	Corythaeola cristana	1	1	1.0			
Brush-tailed Porcupine	Atherurus africanus	1010	478	3.4	254	4160	1199
Cane Rat	Thryonomys swinderianus	48	29	4.2	2	4500	833
Chimpanzee	Pan t. troglodytes	1	1				
Crab	unknown	1	1	0.5			
Crowned Guenon	Cercopithecus pogonias	7	5	4.2	2	3750	940
Beecroft's anomalure	Anomalurus beecrofti	1	1	0.7			
Gaboon Viper	Bitis gabonica	14	4	2.3			
Giant Pounched Rat	Cricetomys emini	155	77	1.3	2	1000	718
Green Touraco	Turaco persa persa	4	2	1.3	1	1500	938
Grey-cheeked Mangabey	Lophocebus albigena	4	3	7.2	3	5000	762
Guinea Fowl	Possibly Guttera sp.	7	6	1.1			
Hornbill	Tocus spp, Ceratogyamne spp	33	27	1.5	1	1500	1000
Mandrill	Mandillus sphinx	8	2	20.1			
Long-snouted Mongoose/Marsh Mongoose	Herpestes naso/ Atilax paludinosus	28	13	2.3	1	3500	778
Monitor Lizard	Varanus niloticus	31	8	4.5	1	4000	
Moustached Guenon	Cercopithecus cephus	118	65	4.0	24	3630	854
Ogilby's Duiker	Cephalophus ogilbyi	12	7	16.6	2	12000	619
Otter Shrew	Potamogogale velox	1	1	1.4			
Long-tailed Pangolin/Tree Pangolin	Uromanis tectradactlya/Phataginus tricuspis	157	69	2.0	13	2056	1087
Potto	Perodicticus potto	3	2	1.2			
Putty-nosed Guenon	Cercopithecus nictitans	20	14	4.8	6	4375	758
Red River Hog	Potamochoerus porcus	18	11				
Rope Squirrel (red cheeked?)	Funisciurus leucogenys	12	7	0.5			
Scaly Francolin	Francolinus squamatus	23	11	0.7			
Servaline Genet	Genetta servalina	29	16	1.9			
Sitatunga	Tragelaphus spekii	13	5	42.0			
Small Rat	unknown	1	1	0.1			
Rope Squirrel spp	Funisciurus spp	10	6	0.2			
Forest Tortoise	Kinixys erosa	12	4	1.6			
Tree Hyrax	Dendrohyrax arboreus	15	11	3.5			
Water Chevrotain	Hyemoschus aquaticus	14	7	11.0	2	9000	823
White-Bellied Duiker	Cephalophus leucogaster	20	10	14.2			

A3.3: Summary of village territory data, from a review of the literature

(Further information on trap line distances available: contact lmc35@cam.ac.uk for Excel spreadsheet)

Village	Study ref	Length of study (time researchers spent in village)	Size of village	No. of trappers	No. trappers surveyed	Estimated territory size (km)	Method	No. traps	Density of traps Traps/km	Distance of traps from village (km)	No. hunting camps	Distance (km) of camp from village
Kanare, CAR	Dethier 1996	29 days	89 (117 total)	14		120	Community mapping, GPS principal paths	1105	9.208333333	Under 1 hours walk		
Bakota, CAR	Dethier 1996	52 days	397		12	450	Community mapping, GPS principal paths				7	Mean 25 km, taken from map
Ngoundi, CAR	Dethier 1996	9 days				90	Community mapping, GPS principal paths					
Kanare, CAR	Dethier and Ghurghi, 1999	3 months, spent between 4 villages	62	15		146	Community mapping, GPS principal paths					
Kopou, CAR	Dethier and Ghurghi, 1999	3 months, spent between 4 villages	52	20		102	Community mapping, GPS principal paths					
Gbaza, CAR	Dethier and Ghurghi, 1999	3 months, spent between 4 villages	114	26 + 44 pygmy		184 (205 with pygmy)	Community mapping, GPS principal paths					
Mouele, CAR	Dethier and Ghurghi, 1999	3 months, spent between 4 villages	117	34+ 16 pygmy		99	Community mapping, GPS principal paths					
Dambadjodjo, CAR	Dethier and Ghurghi, 1999		119	31		130						
Ekom (actually 6 villages)	Dethier 1995	8 months	360	135	37	270 forest, 37 village	Community mapping, GPS principal paths	538 village, 1013 forest	14.5 village, 3.8 village	2.17 estimated distance taken from maps	8	14,15,16,13,18,12,14,10
Ekom, Cameroon	Jeanmart 1998		360		36	270 forest, 37 village		1248 village, 841 forest	33.8 village, 3.1 forest			
Kompia, Cameroon	Jeanmart 1997		317			170						
Malen, Cameroon	Debroux and Dethier, in Delvingt 1997		156			125 forest, 40 village						
Oleme, Congo	Vanwinjnsberghe, 1996		142			81	PRM and GPS		0.67	4.1 - 4.9 mean	3	Mean 4 km
Diba, Congo	Vanwinjnsberghe, 1996		52			55	PRM and GPS		1.18	2.4 - 3.5 mean		
Sendje - Equ Guinea	Kumpel 2006	18 months	317	55	48	142 (buffer traps), 307 (buffer btw camps), 600 (comp)	3 different ways, page 202	5060 per month (mean)	8.43	13.1 (use hunting camps)	10	Mean 16.8 km
S. Ituri settled	Hart 2000	330 days		48		188	convex polygon - 3.5 km buffer				16	

S. Ituri remote	Hart 2000	90 days		46		475	convex polygon - 3.5 km buffer				13	
C. Ituri	Hart 2000	106 days		325		571	convex polygon - 3.5 km buffer				31	
Nkonzuh, cam	Auzel and Hardin, 2001	unknown	469			187						
Mboumo, cam	Auzel and Hardin, 2001	unknown	248			196						
Bossouaka, congo	Lia and Gami, 1995		187			277						
Essiengbot, cam	Vermeulen, 1997		308			52						
Ekomo, cam	Vermeulen, 1997		214			77						
Kompia, cam	Vermeulen, 1997		316			87						
Kompia collective	Vermeulen, 1997		838			211						
Etol, cam	Fankap, 1997		130			82						
Ntsina, cam	Fankap, 1997		130			69						
Maleu'leu, cam	Fankap, 1997		171			75						
Etol collective	Fankap, 1997		431			160						
Banyanga, CAR	Noss, 1998b		2500			1000						
Kouagna and Dibouka, Gabon	This study		386			100						
Djaposten, cam	Delvingt et al, 2001		600			518						
Ekom (3 villages)	Nngnegueu and Fotso,1996				11	600		1285				
Bomassa, Congo	Eves and Rodrigues, 2000		159			300						
Mekas, Cam	Muchaal and Nganjui, 1999		368			247						
BMWS, cameroon	Wilcox and Nambu, 2006		8533			750						

Appendix A3.4: GLM outputs- Predictors of trapping success

A3.4.1: Predictor of whether a trap catches something (1) or not (0): detailed forest:

General model:		**d.f (change, residual)**	**Deviance**	**p (chi square)**
Date since Trap Laid (months)		1,1774	73.874	<0.001
Trap Type (Neck/Foot)		1,1774	63.558	<0.001
Density of traps (250m radius)		1, 1771	16.809	<0.001
Understorey Density (1 – 4)		3, 1773	4.182	0.006
Distance from Village*Forest Type		1, 1774	9.707	<0.001
Forest Type		4,1775	5.05	<0.001
Distance		1,1775	0.678	0.410
River (yes/no)		1,1770	2.402	0.121
Human Track (principal/private)		1,1696	1.735	0.176
Hill (1 – 4)		3,1629	0.127	0.722
Minimal model:		**Estimate**	**s.e**	**p (chi square)**
Constant		-2.344	0.587	0.001
Date since Trap Laid (months)		0.1108	0.0128	0.001
Trap Type (Neck)		1.211	0.160	0.001
Density of traps (250m radius)		-0.00879	0.00216	0.001
Understorey Density: 2		-0.538	0.243	0.027
	3	-0.559	0.246	0.023
	4	-0.049	0.285	0.864
Forest Type:	Young Sec/Old Plantation	0.375	0.709	0.204
	Young Secondary	0.501	0.529	0.597
	Old Secondary	1.115	0.538	0.334
	Young Primary	2.354	0.552	0.038
Distance from Village (Km)		0.455	0.358	0.204
Distance to village (m)*Forest Type:				
	Young Sec/Old Plantation	-0.018	0.513	0.971
	Young Secondary	-0.026	0.366	0.943
	Old Secondary	-0.351	0.361	0.331
	Young Primary	-0.557	0.359	0.221

Reference levels:

Forest Type: Old Plantation
Understorey Density: 1
Trap Type: Foot

A3.4.2: Predictor of whether a trap catches something (1) or not (0): 'Pouvi' forest:

General model:		**d.f (Change, residual)**	**Deviance**	**p (chi square)**
Date since Trap Laid (months)		1,4058	156.57	<0.001
Trap Type (Neck/Foot)		1,4053	77.68	<0.001
Density of traps (250m radius)		1,4053	39.61	<0.001
Forest Type		1,4054	10.35	<0.001
River (yes/no)		1,4053	8.884	0.003
Human Track (principal/private)		1,3958	6.025	0.014
Hill (1 – 4)		3,3466	0.870	0.456
Distance		1,4052	0.12	0.734
Minimal model:		**Estimate**	**s.e.**	
Constant		-1.536	0.243	
Date since Trap Laid (months)		0.1059	0.0013	
Trap Type (Neck)		1.061	0.115	
Density of traps (250m radius)		-0.0075	0.0013	
Forest Type:	Ngoma	0.542	0.219	
	Evosso	-0.188	0.393	
River (yes)		-0.277	0.101	
Human Track (private)		-0.212	0.086	
Reference levels:				
Forest Type: Kange				
River: No				
Trap Type: Foot				
Human Track: Principal				

A3.4.3: Predictor of whether a trap catches a small-bodied animal (1) or not (0): Detailed forest:

General model:		**d.f (Change, residual)**	**Deviance**	**p (chi square)**
Date since Trap Laid (months)		1,1332	1.68	0.195
Trap Type (Neck/Foot)		1,1370	127.05	<0.001
Trap Density (250m radius)		1,1361	1.79	0.180
Understorey Density (1 – 4)		3,1362	3.3	0.020
Distance*Trap Density		1,1360	4.79	0.029
Forest Type		1,1370	5.26	<0.001
Distance		1,1370	5.5	0.019
River (yes/no)		1,1359	0.0182	0.893
Human Track (principal/private)		1,1291	1.64	0.201
Hill (1 – 4)		3,1323	1.78	0.148
Minimal model:		**Estimate**	**s.e**	
Constant		-3.991	0.745	
Trap Density (250m)		-0.01515	0.00616	
Distance from Village (km)		-0.276	0.10	
Distance*Density		0.00596	0.00273	
Forest Type:	Young Sec/Old Plantation	1.261	0.360	
	Young Secondary	1.516	0.398	
	Old Secondary	1.788	0.476	
	Young Primary	2.396	0.609	
Trap Type (neck)		2.655	0.248	
Understorey Density: 2		-0.378	0.494	
	3	0.228	0.495	
	4	0.602	0.538	

A3.4.4: Predictor of whether a trap catches a small-bodied animal (1) or not (0): 'Pouvi' forest:

General model:		**d.f (Change, residual)**	**Deviance**	**p (chi square)**
Date since Trap Laid (months)		1,3315	9.51	0.002
Trap Type (Neck/Foot)		1,3315	163.19	<0.001
Trap Density (250m radius)		1,3315	3.83	0.050
Forest Type		2,3316	12.93	<0.001
Distance		1,3315	7.90	0.005
River (yes/no)		1,3314	0.76	0.383
Human Track (principal/private)		1,3315	5.14	0.023
Hill (1 – 4)		3,2899	0.58	0.631
Minimal model:		**Estimate**	**s.e**	
Constant		-3.193	0.460	
Forest Type:	Ngoma	1.420	0.371	
	Evosso	0.474	0.357	
Trap Type (neck)		2.354	0.183	
Trap Life		0.0463	0.0149	
Distance from village (km)		-0.1271	0.0482	
Trap Density (250m)		-0.00495	0.00256	
Human Path (Private)		-0.380	0.165	

A3.4.5: Predictor of whether a trap catches a medium-bodied animal (1) or not (0): 'Detailed' forest:

General model:		**d.f (Change, residual)**	**Deviance**	**p (chi square)**
Date since Trap Laid (months)		1,1570	45.34	<0.001
Trap Type (Neck/Foot)		1,1571	0.0025	0.960
Trap Density (250m radius)		1,1399	0.0613	0.804
Forest Type		4,1573	5.01	<0.001
Distance		1,1399	1.24	0.266
Forest Type*Distance		1, 1399	8.54	<0.001
River (yes/no)		1,1575	4.68	0.031
Human Track (principal/private)		1,1487	3.33	0.068
Hill (1 – 4)		3,1500	0.63	0.593
Minimal model:		**Estimate**	**s.e**	
Constant		-2.193	0.211	
Forest Type:	Young Sec/Old Plantation	-2.27	01.14	
	Young Secondary	0.194	0.548	
	Old Secondary	0.664	0.516	
	Young Primary	2.811	0.608	
Distance to village*Forest Type:				
	Young Sec/Old Plantation	0.816	0.698	
	Young Secondary	-0.322	0.387	
	Old Secondary	-0.609	0.378	
	Young Primary	-0.859	0.375	
Distance		0.650	0.370	
Trap Life		0.0889	0.0132	
River (Yes)		-0.349	0.165	

A3.4.6: Predictor of whether a trap catches a medium-bodied animal (1) or not (0): 'Pouvi' forest:

General model:	d.f (Change, residual)	Deviance	p (chi square)
Date since Trap Laid (months)	1, 3964	78.21	<0.001
Trap Type (Neck/Foot)	1, 3963	0.78	0.378
Trap Density (250m radius)	1, 3406	3.68	0.055
Forest Type	2, 3965	3.39	0.034
Distance	1, 3406	0.26	0.612
River (yes/no)	1, 3964	9.70	0.002
Human Track (principal/private)	1, 3821	0.74	0.478
Hill (1 – 4)	3, 3530	0.002	0.961

Minimal model:	Estimate	s.e
Constant	-2.275	0.154
Forest Type:		
Ngoma	0.333	0.136
Evosso	0.117	0.271
Trap Life	0.0834	0.0093
River (Yes)	-0.363	0.119

A3.4.7: Predictor of whether a trap catches a large-bodied animal (1) or not (0):
'Detailed' forest: (same results as for 'pouvi' forest)

General model:	**d.f (Change, residual)**	**Deviance**	**p (chi square)**
Date since Trap Laid (months)	1, 3824	25.62	<0.001
Trap Type (Neck/Foot)	1, 3824	14.37	<0.001
Trap Density (250m radius)	1, 3824	5.01	<0.025
Forest Type	3, 1671	0.42	0.793
Distance	1, 3824	14.55	<0.001
River (yes/no)	1, 3824	7.87	0.005
Human Track (principal/private)	1, 3693	0.34	0.562
Hill (1 – 4)	3, 3372	0.06	0.983
Minimal model:	**Estimate**	**s.e**	
Constant	-4.282	0.360	
Trap Density	-0.00916	0.00418	
Distance From Village	0.1483	0.0374	
Type of Trap	-1.593	0.515	
Trap Life	0.1105	0.0210	
River (Yes)	0.664	0.228	

Appendix A3.5: Individual hunter trapping characteristics, and sampling effort

Hunter ID	Age	Number of hunter follows during study period	Number of trips over 1 year	Mean biomass (kg) per hunting trip	Mean distance (km) of traps from village	Mean density of traps	Number of traps laid over 1 year	% trap in 'ngoma' forest	% traps next to river	% traps on private path	% Foot traps	Mean hill category	Mean pieces of cable on each trap	Mean trap number present at one time	Number of months with active traps	Mean trips per month	Animals 1 year	Biomass (kg) 1 year	Mean new traps laid per month
21	12	2	3	0	1375.95	53.67	5	1	0	1	1	3	1	5	1	3.00	1	0.9	0
38	13	4	7	0	1731.43	27.11	10	1	0.11	0.78	1	2	1.33	9.5	2	3.50	0	0	0
26	14	5	26	0.808	2001.1	29.6	52	1	0.02	0.63	1	2.19	1.49	24.33	6	3.86	7	9.5	12.25
2	15	4	39	0.359	1785.94	21.68	30	1	0.09	0.36	1	1.75	1.2	13.5	7	4.88	14	67.76	2.17
36	16	11	71	0.4507	1837.99	46.7	129	0.82	0.18	0.82	0.93	2.02	1.22	16.71	12	5.46	33	120.14	9.1
5	17	2	1	0	1436.98	64	5	1	0	1	1	2	2	4	1	1.00	0	0	NA
33	17	1	3	0.667	2026.8	54.61	31	0.87	0.35	0.97	1	2	1.1	30	2	1.00	2	6.01	0
52	17	6	35	0.6	2683.78	46.6	128	0.96	0.12	0.77	0.96	2.09	1.26	65.5	7	5.00	21	142.26	20.8
46	18	9	59	0.949	1393.76	38.25	132	0.95	0.18	0.73	1	1.65	1.15	36.17	13	4.21	56	143.24	9.6
51	18	2	20	0.4	4139.89	28.33	43	1	0	0	1	1.42	1.56	43	4	4.00	8	19.16	0
54	18	4	23	0.783	2011.69	44.83	74	0.79	0.09	0.71	0.79	1.54	1.36	28	5	3.83	18	65.33	0
37	19	2	1	0	1751.92	65.12	33	1	0.12	1	0.91	1.61	1.45	33	0	1.00	0	0	0
29	20	3	1	0	1270.93	57.8	15	0	0	NA	0	1.8	1.36	14.67	1	1.00	13	29.12	0
39	20	2	7	0.714	1463.1	62.33	21	0.48	0.71	0.95	1	1.9	1	21	3	3.66	9	30.95	4.67
32	21	3	3	1	1749.1	57.33	46	1	0.24	1	1	2.69	1	43.33	2	1.50	3	5.3	0
50	22	8	43	0.512	2536.38	30.86	90	0.77	0.06	0.76	0.78	1.37	1.1	24	10	3.91	26	65.19	4.86
1	23	6	9	0.889	1972.57	56.93	97	0.97	0.13	0.77	1	2.4	1.24	52.8	7	1.29	8	46.12	0
64	23	10	46	0.63	4077.82	39.03	279	1	0.04	0.76	1	1.55	1.48	74	10	4.60	29	101.37	20.71
58	24	6	3	0.667	764.41	54.68	40	0	0.1	1	0	3.25	1	24.5	3	1.00	2	11	2.67
4	25	3	24	0.1667	1168.78	53.61	88	0.09	0.33	0.91	0.67	1.25	1.25	45.5	9	2.67	4	12.29	5.14
15	25	3	7	0.714	443.92	120.44	28	0	0.11	1	0.11	NA	NA	26	3	2.33	5	27.68	0
23	26	4	10	0.2	2942.3	73.23	31	1	0.19	1	1	2.28	1.29	31	4	2.00	2	16.86	0
24	26	6	34	0.2647	1042.82	49.76	55	0.86	0.04	0.8	1	2.62	1.24	15.5	8	4.25	9	26.71	1.5
35	26	8	14	0.357	1386.96	40.99	108	0.96	0.22	0.57	0.91	2.39	1.41	68.25	6	2.33	5	12.48	5.5
65	27	8	76	0.4868	1228.71	76.94	170	0.67	0.15	0.83	0.71	1.42	1.31	76.14	13	5.85	37	122.39	4.82
10	30	9	36	1.389	2595.64	38.72	256	0.92	0.06	0.96	0.95	1.53	1.37	95	9	3.60	50	157.19	12
34	30	2	13	0.308	1385.96	42.2	35	0.54	0	1	0.66	1.6	1.6	17	6	2.17	4	25.7	4.33
40	33	11	54	1.019	2818.62	61.35	193	1	0.06	0.65	1	2.39	1.2	60.71	11	4.50	55	188.21	11.2
14	35	4	35	0.6	3785.14	17.7	78	1	0.13	0.14	0.99	1.51	1.01	76.5	10	3.50	21	112.46	4.38
56	35	11	50	1.94	4190.78	41.75	337	0.97	0.07	0.57	1	1.64	1.89	119.2	11	4.55	97	329.09	24.7

61	37	4	1	0	1034.18	176.2	75	0	0.03	0.73	0.13	1.53	1.08	35	9	1.56	22	56.6	0
Hunter ID	**Age**	**Number of hunter follows during study period**	**Number of trips over 1 year**	**Mean biomass (kg) per hunting trip**	**Mean distance (km) of traps from village**	**Mean density of traps**	**Number of traps laid over 1 year**	**% traps in 'ngoma' forest**	**% traps next to river**	**% traps on private path**	**% Foot traps**	**Mean hill category**	**Mean pieces of cable on each trap**	**Mean trap number present at one time**	**Number of months with active traps**	**Mean trips per month**	**Animals 1 year**	**Biomass (kg) 1 year**	**Mean new traps laid per month**
6	38	16	56	1.857	4755.62	28.13	242	1	0.09	0.92	1	1.77	1.24	124	11	5.09	105	521.51	16
22	38	2	14	0.571	1863.25	17.65	52	1	0	0.71	0.98	1.79	1.17	52	7	2.00	8	24.01	0
25	38	5	27	0.2593	1899.19	31.27	63	1	0.49	0.94	0.79	1.79	1.62	25	7	3.86	3	7.86	8.17
13	39	10	113	0.7434	2334.28	55.22	457	0.77	0.36	0.96	0.72	1.59	1.55	256.8	12	9.42	84	653.89	17.4
19	40	4	21	0.429	2433.98	29.55	82	0.8	0	0.77	0.64	1.79	1.49	65	6	3.50	9	30	3
8	42	23	171	1.20	2276.7	72.27	1067	0.76	0.24	0.95	0.94	2.03	1.29	550.83	13	13.15	206	808.51	50.5
45	42	5	17	3.53	3922.6	50.82	385	0.99	0.03	1	1	1.87	1.26	339	4	4.25	60	186.23	88.5
9	44	5	50	0.68	1655.2	74.79	172	0.68	0.08	0.94	0.66	1.49	1.5	78.33	9	5.56	34	240.47	9.88
20	45	5	24	0.99	2784.1	31.40	112	0.93	0.14	0.15	0.89	1.45	1.3	93	6	4.00	23	163.61	10.33
44	45	6	37	1.32	4309.3	37.71	303	1	0.03	0.49	1	1.77	1.13	152	7	4.63	49	166.53	16.6
43	49	3	12	2.33	4466.7	82.74	162	1	0.01	0.67	1	1.9	1.06	162	4	3.00	28	79.19	10
27	50	5	78	0.67	3483.8	33.49	231	0.97	0.24	0.8	0.93	2.09	1.27	110.6	13	6.00	19	68	8.42
16	53	13	79	1.23	2179.7	70.74	543	0.49	0.12	0.82	0.61	1.8	1.55	252.6	13	6.08	97	406.32	24.2
18	55	2	22	0.68	1223.1	68.06	110	0.13	0.05	0.3	0.34	1.47	1.55	86.5	4	5.50	15	36.56	64
31	55	2	12	4.17	10727.3	15.99	235	1	0.03	0.14	0.98	1.87	1.9	117.5	9	1.33	50	389.04	20.75
11	57	9	104	0.35	1228.3	119.87	120	0	0	0.92	0.12	1.13	1.16	91.67	13	8.00	36	85.83	5.2
30	57	2	25	0.16	1729.7	31.67	34	0.61	0	1	0.42	NA	1.52	27	5	5.00	4	10.5	0
53	57	10	88	0.96	2748.0	72.94	333	0.88	0.37	0.91	0.77	2.56	1.18	182.33	13	6.77	84	220.76	12
12	58	5	83	1.12	4757.9	45.17	614	0.91	0.12	0.97	0.91	1.95	1.5	280	12	6.92	93	605.98	32.3
41	60	7	69	0.88	1433.9	83.74	395	0.39	0.29	0.75	0.41	1.49	1.45	160.4	12	5.75	61	207.19	22.9
63	60	12	72	0.21	821.1	52.31	189	0.48	0.43	0.71	0.79	1.26	1.33	86.2	12	6.00	15	138.08	9
7	62	3	2	1.5	4244.7	59.32	96	0.81	0.15	0.72	0.84	1.98	2.46	47.5	2	1.00	3	35.71	0
28	62	4	37	0.35	1124.1	71.15	173	0.525	0.16	0.78	0.7	1.55	1.25	59.67	10	3.36	52	175.61	11.88
62	62	4	48	0.46	1951.9	29.5	24	0.54	0.08	0.38	0.59	1.79	1.83	9.33	11	4.36	9	28.47	1.67
3	63	6	24	0.54	1311.7	53.17	64	0	0.21	0.94	0.14	1.36	1.98	31.5	9	2.67	13	45.08	2.5
17	65	3	3	0	1634.1	26.5	11	0.75	0.13	1	0	1.38	1.75	9	1	3.00	0	0	0
66	66	6	2	0.5	1686.7	72.81	26	0.65	0.15	0.35	0.08	1	1.22	21.75	1	2.00	1	15.36	0
60	68	4	38	0.45	1713.5	37.06	51	0.7	0.06	0.78	1	2.28	1.36	22.67	7	5.43	17	62.21	6.4
42	69	4	12	0.67	1206.1	90.88	54	0	0.02	0	0.13	1.27	1.17	46.25	6	2.00	8	15.15	1
49	69	3	3	0.33	719.6	48.46	35	0	0.17	0.67	0.04	NA	NA	34.5	2	1.50	1	3	0
47	75	2	4	1	913.0	52.93	52	0.09	0.14	0.98	0.48	1.55	1.43	51	3	1.33	4	42.7	23
48	75	3	1	0	982.4	41.13	37	0.14	0	0.16	0.08	1	1.14	31.33	0	1.00	NA	NA	0
55	75	3	21	0.43	1898.5	68.64	61	0.69	0.11	0.69	0.23	1.33	1.84	34.67	7	2.63	9	74.21	4.43
57	75	1	1	0	388.1	9	8	0	0	0	0	1.25	1.88	8	1	1.00	1	2.1	NA
59	75	3	1	0	616.0	10.33	25	0	0	0	0	NA	1.11	26	0	1.00	NA	NA	NA