Incentives for sustainable hunting of bushmeat in Río Muni, Equatorial Guinea

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ABSTRACT

Bushmeat hunting is thought to be becoming increasingly unsustainable in west and central Africa, but true assessment of sustainability, and consequently appropriate management, is constrained by poor understanding of cause and effect. This cross-disciplinary study considers the complex and dynamic interactions between market, hunter and prey along an entire bushmeat chain in continental Equatorial Guinea, thus enabling evaluation of the sustainability of the system under different policy scenarios. Fieldwork was undertaken over a period of 18 months from 2002-2004. Market surveys and consumer interviews in Bata, the regional capital, were used to evaluate the determinants of urban bushmeat consumption: people preferred fresh meat and fish, including bushmeat, but tended to consume cheaper frozen foods more often. Bushmeat consumption increased with income. 1607 household and 72 hunter interviews were conducted in the village of Sendje, gateway to the forested Monte Alén National Park and major source of bushmeat to Bata. Men hunt for income because there are few other livelihood options. A village offtake survey estimated over 10,000 animals hunted per year (90% by trapping), hunted using a long-term rotation of camps up to 30 km from the village. Hunter behaviour, prey choice and animal encounter rates were recorded during 77 trapper and 48 gun-hunter follows. Trapping is currently preferred to gun-hunting due to lower costs and relatively high returns. However, as the availability and affordability of guns and cartridges increases, and trapping success decreases, hunters are switching to shooting arboreal prey. Population densities of key primate prey species were estimated in two sites with differing gun-hunting histories, using 408 km of line transects. Whereas some of the guenon monkey species were still numerous in the heavily hunted village site, the absence of *Colobus satanus* suggests they are more vulnerable to hunting pressure. Extremely high densities of *Colobus satanus* were found inside the park, suggesting it should be an urgent conservation priority. The current oil boom in Equatorial Guinea is increasing urban wealth and subsequent demand for bushmeat. In the absence of alternative foods and rural livelihoods, and proper enforcement of protected areas, people will continue to hunt for the commercial bushmeat trade until many vulnerable species become at least locally extinct.

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Chapter 1

Introduction

1.1 'THE BUSHMEAT CRISIS'

Asibey (1974) stated over three decades ago that, 'the wildlife which used to provide large quantities of protein is now in short supply', in Africa south of the Sahara. He cited the rapid expansion in human population, loss of forest to alternative land-use such as agriculture, new roads opening up previously inaccessible areas and overexploitation of wildlife as reasons for this shortfall. He went on to report that, 'domestic livestock is not produced in large enough quantities to fill the gap created by diminishing wildlife resources'.

Asibey was wrong perhaps in one respect. Far from being in short supply, large quantities of bushmeat (meat from wild animals) are still flooding out of the forests of west and central Africa, and a trip to any market in the region might suggest that the bushmeat trade is, at least on the surface, thriving. But markets can be misleading without knowledge of changes in the prey profile (Colell *et al.*, 1994; Cowlishaw *et al.*, 2005b; Fa *et al.*, 2000), hunting effort (Milner-Gulland & Clayton, 2002), spatial scale (Clayton *et al.*, 1997; Crookes *et al.*, in press) or consumer demand (Wilkie & Godoy, 2000, 2001) over time. As infrastructural improvements, often facilitated or provided by natural resource-based industry, enable hunters to forge ever deeper into previously pristine territory in search of preferred prey, the amount of forest untouched by man is decreasing rapidly, and with it populations of particularly vulnerable species (Auzel & Wilkie, 2000; Walsh, 2003; Wilkie *et al.*, 2000). The result is a 'halo of defaunation' around population centres (Wilkie & Carpenter, 1999a), inhabited only by those species robust to human disturbance and exploitation.

Hunting for wild meat is a world-wide phenomenon, occurring throughout the tropical forest areas of Africa, Asia and Latin America, but much recent attention has focused on west and central Africa (Bakarr *et al.*, 2001; Barnes, 2002; Bowen-Jones, 1998; Bowen-Jones *et al.*, 2002; POST, 2005). This attention is in part due to the well-publicised focus on the threat of the bushmeat trade to flagship species in this region such as the great apes, by both conservationists (e.g. Bowen-Jones &

Pendry, 1999; Walsh, 2003; Waltert *et al.*, 2002) and animal welfare groups (Ammann, 1994; Ape Alliance, 1998; Harcourt *et al.*, 1989; Petersen, 2003; Redmond, 1995). However, it is also in west and central Africa where consumption, hunting and productivity of wild meat is greatest (Fa and Peres, 2001; Fa *et al.*, 2002b; Robinson and Bennett, 2000b), and the very term 'bushmeat' is synonymous with Africa. The scale of bushmeat hunting here is staggering: an estimated 1-5 million tonnes of bushmeat are consumed in the Congo Basin each year (Fa *et al.*, 2002b; Wilkie & Carpenter, 1999a). For a large number of species, in many areas, this level of offtake is almost certainly unsustainable (e.g. Bakarr *et al.*, 2001; Bennett, 2002; Robinson & Bennett, 2000b).

With national poverty reduction strategies now the focus of international development aid, there is debate on the role that bushmeat plays in poverty alleviation (Bowen-Jones *et al.*, 2002; Brown & Williams, 2003; DfID, 2002; Mainka & Trivedi, 2002). Bushmeat provides rural people with a direct, open-access source of animal protein and/or a valuable source of income in the absence of alternative employment opportunities (Bowen-Jones *et al.*, 2002). There are concerns that the removal or reduction of this resource might have negative short- or long-term consequences for the food security and overall well-being of people at the individual, household, community or national level. However, the extent to which people really depend on bushmeat, and would be unable to adapt if either supply ran out or access was denied, is still not well understood (Bennett, 2002; DfID, 2002).

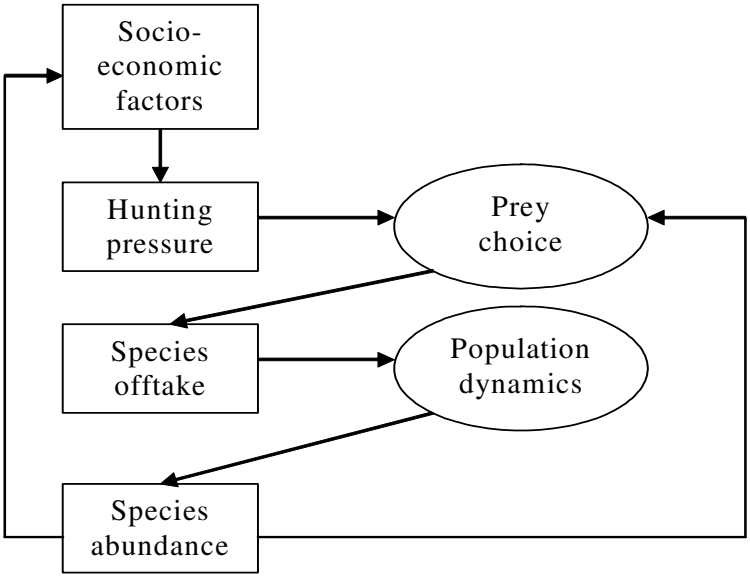
The bushmeat trade often involves a wide variety of actors, with hunters a critical link between demand and supply (Cowlishaw *et al.*, 2005; Mendelson *et al.*, 2003). The sustainability of bushmeat hunting can be improved by removing or reducing their incentives to hunt in the first place, or creating disincentives, through addressing consumer demand and socio-economic necessities. Alternatively, if people are dependent on bushmeat as a resource, a focus on hunter behaviour and prey choice may help to reduce the impacts of hunting on species vulnerable to overexploitation (Rowcliffe *et al.*, 2003), whilst continuing to contribute to livelihoods and food security.

Bushmeat hunting is influenced and ultimately controlled by a multitude of biological, sociological and economic factors (see figure 1.1). Many researchers have studied certain aspects of these complex interactions, but few have taken a truly interdisciplinary approach and attempted to tackle all these components together. This in part reflects their respective backgrounds, interests and capabilities, but the very breadth of the bushmeat issue means that the time, cost, effort and expertise required to carry out such interdisciplinary research, not to mention action, is prohibitive. The aim of this thesis is to fill this gap, and it is hoped that this case study will provide new insights

into the bushmeat problem by providing one of the most complete, simultaneous evaluations of an entire bushmeat supply chain conducted to date.

In this introduction, I first give some brief background on the causes and effects of bushmeat hunting in west and central Africa, and where current knowledge is lacking (section 1.2). I then describe Equatorial Guinea (section 1.3) and the study site (section 1.4) and the reasons for choosing it for this study. Finally, I outline the structure of the thesis, and the questions I will address herein (section 1.5).

Figure 1.1 The causes and effects of hunting (adapted from J.M. Rowcliffe, unpubl.)



1.2 CAUSES AND EFFECTS OF BUSHMEAT HUNTING

Bushmeat hunting systems are complex and dynamic (figure 1.1), controlled and influenced by many different factors. These can be broken down into two types: 'intrinsic' factors, which are internal to the system and affect each other through positive or negative feedback, and 'extrinsic' factors, which are external influences that operate independently on the system. Intrinsic factors relate to consumer demand (including prices, availability, consumption and preference), livelihood issues (why and how people use or depend on bushmeat), hunter behaviour (including quantities and returns to hunting effort over time and space) and biological capacity (including sustainability of harvests over time and space, given changes in demand and effort). Extrinsic factors include demographic changes (such as population growth and changes in urbanisation), extra-sectoral

industries (such as logging, mining or international aid), international policy, political systems and the capacity and will of national governments for monitoring, management and control. An understanding of all these factors – essentially the 'causes' and 'effects' of hunting – and how they may change over time and space, is necessary if useful predictions about the sustainability of bushmeat hunting are to be made.

Here follows a brief overview of the main causes and effects of bushmeat hunting in west and central Africa: the underlying drivers, who is involved and why, and the consequent effects on wildlife populations and ultimately people. I start at the consumer and move down the supply chain to the prey (in effect following the steps in figure 1.1) and then discuss issues of sustainability, linking cause and effect. I end with a summary of gaps in our knowledge, and what further research is needed to fill these gaps and inform future management strategies.

1.2.1 Socio-economic drivers

Humans have been hunting wild animals for meat in the forests of west and central Africa for millennia. The current 'bushmeat crisis' in the region arises from the fact that this hunting is now widely thought to be unsustainable in many areas and for many species. There are three main reasons for the increase in bushmeat hunting: (1) increasing consumer demand, from growing human populations and a lack of alternative sources of protein, (2) greater efficiency of hunting, due to easier access to wildlife source areas and more efficient gear types and (3) increasing hunter supply, resulting from rural poverty and a lack of alternative rural livelihoods reducing hunters' opportunity costs.

Increasing consumer demand

An increasing proportion of hunting is not for local consumption but to supply the demand for animal protein stemming from distant, more urbanised populations. The size of this trade is substantial: for example, Anstey (1991) estimated that the value of the bushmeat trade in Liberia exceeds that of timber, and the ratio is similar in Côte d'Ivoire (Caspary, 2001). Bushmeat volumes in many urban markets in west and central Africa have increased in recent years. For example, repeat surveys of markets on the island of Bioko in Equatorial Guinea in 1991 and 1996 showed an increase in the number of bushmeat carcasses on sale, although the mean body size of carcasses had reduced and total biomass had increased to a lesser extent, suggesting depletion of larger prey (Fa *et al.*, 2000). However, markets are only the tip of the iceberg, as much bushmeat trade passes through informal channels (e.g. Mendelson *et al.*, 2003). More accurate estimates of exploitation should in theory be obtained by calculating consumption patterns (Fa *et al.*, 2001). Unfortunately, the paucity of data on either urban or rural consumption patterns in west and central Africa (but see

Chardonnet *et al.*, 1995, studies in Wilkie and Carpenter, 1999a, and limited recent studies such as Starkey, 2004), and the degree of variability between sites, has called the validity of such extrapolations (e.g. Fa *et al.*, 2002) into question. This said, all the available evidence points to an unsustainable increase in levels of overall bushmeat consumption and trade in the region over the past few decades.

Why is bushmeat hunting becoming increasingly commercialised? The population of Africa, as in the rest of the developing world, is growing dramatically, and expected to exceed 1 billion by 2010 (UNDP, 2005). As well as getting larger, the population is becoming increasingly urban, with 42% of the population of sub-Saharan Africa living in urban areas in 2003 compared to 36% in 1975 (UNDP, 2005). In central Africa, the population is urbanising at a faster rate than in sub-Saharan Africa overall (*ibid*). Gabon's population is particularly skewed, with 84% of the population living in urban areas in 2003, compared to Cameroon at 51% and Congo at 54%. Equatorial Guinea's urban population increased from 27% in 1975 to 48% in 2003 and is predicted to continue to increase (*ibid*).

Food production (in particular animal protein) in sub-Saharan Africa is struggling to keep up with the demand from these burgeoning populations. For example, Africa has gone from being a net exporter in the 1970s to a net importer of beef, and per capita beef consumption has decreased across the continent (Tambi and Maina, 2003). Central Africa has also experienced a decline in beef productivity (*ibid*). Over the same timescale, per capita production of freshwater fish in Africa has also decreased (von Bubnoff, 2005). Due to the extent of the growth in demand and the fact that tropical forests are quite unproductive (Barnes and Lahm, 1997; Robinson and Bennett, 2004), bushmeat supplies are insufficient to fill this gap (Fa *et al.,* 2003). Tropical forests cannot support human population densities of greater than one person per km^2 (Robinson and Bennett, 2000b), but the population in west/central Africa now far exceeds this at 99 people per km^2 of forest (Naughton-Treves and Weber, 2001), with trade to population centres effectively increasing this population size.

Whilst on average rural people consume more wild meat per capita than urban dwellers (in the Congo Basin, sometimes ten times as much: Chardonnet *et al.*, 1995; Wilkie and Carpenter, 1999a), the greater proportion of people now living in urban areas is increasing urban and overall consumption on a national or regional scale (Chardonnet *et al.*, 1995; Starkey, 2004). Fifty per cent of people in central Africa are already reported to be food insecure (FAO, 2001). Unless substantial efforts are made to increase domestic protein supply, both wildlife populations and the food security of millions of poor people will be severely compromised.

For some rural, subsistence communities the demand for wild meat is driven primarily by the nutritional need for animal protein in the absence of acceptable alternatives (see Bennett, 2002), hence the greater per capita rural consumption. It is true that for the majority of remote rural consumers in central Africa, there are often few cheaper substitutes (Wilkie & Carpenter, 1999a); for example, in three local markets in Cameroon the price of bushmeat was only 10-25% of available substitutes (Gally & Jeanmart, 1996). However, at the urban level demand for bushmeat – which tends to be less available and more expensive here - appears to be less straightforward. There is evidence for a growing wealthy urban elite who regard bushmeat as their cultural heritage and are willing to pay a premium over alternatives such as livestock (Wilkie & Carpenter, 1999a). In Gabon, where the population is relatively wealthy and urbanised due to the discovery of offshore oil in the 1970s and an ensuing economic boom, the price of bushmeat in the capital, Libreville, greatly exceeds that of domestic meats such as beef and has done consistently for at least the past decade (Starkey, 2004; Abernethy *et al.*, 2002; Steel, 1994). Starkey (2004) suggests that this is in part because 'bushmeat is regarded as a desirable, "organic", healthy meat, in contrast to imported and "adulterated", intensely farmed frozen poultry and livestock'. However, bushmeat consumption in Gabon is still income and price sensitive, being only rarely consumed in Libreville as a luxury item due to its high cost, with less preferred fish and poultry being the staples (Starkey, 2004).

Factors such as preference, price and availability often do not work independently, but few studies have attempted to disentangle these different drivers of demand (Fa *et al.*, 2002a). The elasticity of demand, which integrates preference and price, is crucially important (Wilkie & Godoy, 2000, 2001). If demand is elastic, when bushmeat becomes scarce, causing its price to rise and substitutes to become more competitive, hunting will only continue in areas where capture and transport costs remain comparable to the costs of livestock rearing, or to satisfy demand as a luxury item (Wilkie, 2001). If no cheaper substitutes are available, then demand should be inelastic, and an increase in the price of bushmeat would not decrease demand (Milner-Gulland & Mace, 1998). In Gabon, the price and elasticity of demand have been shown to vary along a spatial gradient, with bushmeat becoming cheaper and demand more inelastic, compared with domestic meats and fish, the further one travels from the market that supplies these alternatives (Abernethy *et al.*, 2002; Starkey, 2004).

Familiarity is another important factor in determining preference and consumption patterns. Using a combination of taste tests and questionnaires in a study in Nigeria, cane rat, or grasscutter (*Cricetomys emini*), was rated highest by consumers according to sensory quality, but behind goat and beef in terms of preference; the authors concluded that both consumption and preference of

cane rat was constrained by cost and availability (Ladele *et al.*, 1996). Where a food becomes rare in the diet, preferences eventually subside. Anstey (1991) found that once hippopotamus (*Hippopotamus amphibius*), previously one of the most preferred meats, had been locally extinct for a decade or so, it dropped off people's preference lists. This suggests that preferences are not fixed but adapt according to experience and circumstance. In Asia, people have already made the switch from wild to domestic meat, as a result of dwindling wildlife populations (Bennett and Rao, 2002). People already consume greater quantities of livestock and fish in west Africa, where human population densities are greater and fewer wilderness areas remain to provide bushmeat (e.g. Brashares *et al.*, 2004; Cowlishaw *et al.*, 2005b), and unless the bushmeat resource can be proactively managed, this may be the future for central Africa as well. In the Republic of Congo, where bushmeat has become hard to find in the vicinity of a logging camp established for 27 years, businesses have developed that sell alternative protein, such as frozen fish, chicken and turkey (Auzel & Hardin, 2001). Both workers and surrounding villagers have been found to adapt their diet to whatever available foods they can afford (*ibid*).

More efficient hunting

Natural resource extraction industries and macroeconomic conditions and policies affect levels of bushmeat exploitation and thus livelihoods and wildlife in several interlinked ways. Logging has played a particularly important role in increasing bushmeat hunting (e.g. Fimbel *et al.*, 2001; Wilkie *et al.*, 1992; Wilkie *et al.*, 2000). Even though logging is selective in west and central Africa (Newing, 2006), wildlife and habitat is disturbed, forest is lost due to the construction of roads, logging camps and other infrastructure and, crucially, these roads improve access to the forest, thereby increasing the hunting area available (Laurance *et al.*, in press). This triggers immigration of hunters, traders and consumers into often previously inaccessible and undisturbed areas (Bennett and Robinson, 2000). Logging trucks are often used as a cheap and convenient means to transport bushmeat to market (Wilkie & Carpenter, 1999a; Wilkie *et al.*, 1992). Logging camps also create a new local bushmeat demand, by creating a substantial and sustained (often for decades) increase in the local population which must be fed, so that employees either hunt themselves or purchase bushmeat hunted by neighbouring villagers. As logging workers have more expendable income, they can afford to purchase bushmeat and have a correspondingly higher proportion of meat in their diet than those in surrounding villages (Auzel & Hardin, 2001). However, in time this bushmeat has to be brought in from further away as the area around the camp becomes increasingly depleted (Wilkie *et al.*, 2000).

Although less pervasive and not necessarily directed at forests, other natural resource extraction, commonly mining for minerals and oil extraction, can also increase access to forested areas, either

directly, if the activity falls within a forested area, or indirectly, if revenues are used to fund infrastructure development by the national government. In countries where governance is weak, logging and other resource extraction companies take on a quasi-statal role, carrying out social development projects such as the construction of schools, and clinics, in addition to the infrastructure required for the extraction itself, such as bridges and roads (Newing, 2006). Other international capital transfers, such as bilateral credits, aid or debt relief, can work in much the same way, by financing major development projects and thus contributing to macroeconomic changes (Wunder and Sunderlin, 2004).

In addition to access, hunting technology has also improved. Wire is now normally used in snares rather than traditional vines (Noss, 1998a; 1998c; 2002) and shotguns and even rifles are increasingly available, due to increases in individual incomes (e.g. Crookes *et al.*, in press; Starkey, 2004) or following conflict (e.g. de Merode, 1998), allowing ever more efficient hunting. The shift from traps to more efficient guns is predicted by models (Damania *et al.*, 2005) and has been shown in field studies (Bassett, 2005) to have dire consequences for the sustainability of hunting.

Increasing hunter supply

Hunting typically has low fixed and opportunity costs. In the case of trapping, fixed costs are simply the occasional cost of wire (although the cost of more efficient technology such as guns and nets is a barrier to entry for some potential hunters: de Merode *et al.*, 2004). The opportunity cost of hunting is the wage forgone by the hunter for not taking up the best-paying alternative employment (Milner-Gulland, 2001a). If there is no alternative livelihood available, then even a low hunting effort may be profitable. In the low-income countries of central Africa, hunters can earn more than the official minimum wage, as found in studies undertaken in the Central African Republic (Noss, 1998a) and Cameroon (Gally and Jeanmart, 1996).

Economic stagnation and political strife both lead to increased levels of hunting (Bowen-Jones and Pendry, 1999). In the 1980s and 1990s structural adjustment programmes by the World Bank exacerbated a general decline in the export of agricultural products in west and central Africa due to commodity price swings (Bassett, 2005), and the Central African Franc (CFA) was devalued in 1994. This decreased rural employment opportunities and forced rural African communities to rely on local natural resources such as bushmeat to generate alternative and supplementary income (Bassett, 2005; Fa and Peres, 2001). However, given that the economy of Equatorial Guinea was already depressed as a result of a crippling dictatorship following Independence in 1968 (Butynski and Koster, 1994; Sabater-Pi, 1981), this effect was probably experienced a couple of decades before other countries in the region. In fact, following a ban on firearms during the 1970s by this

dictator, Macias, it was reported that gun-hunting actually reduced on the island of Bioko (Butynski and Koster, 1994; section 1.3.9).

Poverty, civil war, political insecurity, and even incapacity of protected area management authorities to pay salaries can lead the military, park guards and civilians alike to rely on hunting for food or income (e.g. de Merode, 1998). In many west African countries during the 1990s, hunters and their associations were called upon to bring order where the police or military proved to be incapable or unwilling to do so; in countries like Cote d'Ivoire, it became easier to obtain and carry firearms without legal repercussions, thus encouraging hunting (Bassett, 2005).

Both economic stagnation and economic opportunities can cause immigration into forest areas. In the first case, hunters may move to forested areas in search of better hunting opportunities, thus increasing the pressure in an area. In the second case, the local population may increase as a logging company or construction project moves into the area, with employees either hunting themselves or local residents hunting to sell to employees, in order that they can feed their families and supplement their income (Wilkie *et al.*, 2000; Wilkie, 2001).

Increased sedentarism is also increasing effective human populations, and thus increasing hunting pressure around new permanent settlements. Formerly nomadic forest people, such as the pygmies of central Africa, are encouraged to settle in one place by government agencies and evangelical missions (Bennett and Robinson, 2000). This enables access to education and health services, but also tends to increase reliance on agriculture and involvement in the market economy, which also means that people rely on hunting to generate cash in order to purchase material goods.

1.2.2 Livelihood issues

Hunting itself is clearly an important livelihood activity, but a wide range of stakeholders besides hunters are involved in the bushmeat trade and gain some sort of livelihood from it. It is important from both a conservation and development perspective to understand what role each of these actors plays in the bushmeat trade and to what degree they depend on hunting as a livelihood, in order to understand the impacts of policies aimed at controlling bushmeat hunting and trade.

The commodity chain

A commodity chain can be described as 'a series of interlinked exchanges through which a commodity and its constituents pass from extraction or harvesting through production to end use' (Ribot, 1998). Many different actors are involved in the bushmeat commodity chain. In addition to hunters, these can include traditional leaders, loggers, dealers, government authorities, market

traders, restaurateurs (including 'chopbar' owners), exporters and consumers (which are found at all levels of the chain). The bushmeat trade provides either their entire livelihood or some degree of profit (Homewood, 1999). Gender is important in defining roles of actors in the chain. Whereas hunters are nearly always men (e.g. Infield, 1988), traders are typically women (although there are exceptions to this - for example a large proportion of the middlemen leaving Dja Reserve to trade bushmeat (among other products) were male: Solly, 2001).

The trade chain is complex and poorly studied; it is often unclear who controls it and sets the prices, and who simply acts as an agent or intermediary (Bowen-Jones *et al.*, 2001). A study in west Africa, in Takoradi, Ghana, found that the majority of bushmeat sales to consumers (85%) were made through chopbars (small restaurants) (Cowlishaw *et al.*, 2005a, Mendelson *et al.*, 2003). The multi-actor aspect of this bushmeat commodity chain suggests that there is no single best entry point to regulate the trade (*ibid*). This is in contrast to a study conducted near Garamba National Park in the Democratic Republic of Congo by de Merode (1998). Here, 'bigman' entrepreneurs (army officers or commercial businessmen) drove bushmeat extraction by bankrolling poor local hunters, supplying them with weapons and ammunition or other gear along with a small cut of the profits, and also managing transport. In this case, curtailing their activities would have a large impact on the trade. Clearly the structure of bushmeat commodity chains and the role of different actors within them can vary widely, and further comparative research is needed into the wider applicability of such findings.

Reasons for hunting

Hunters can be classified along a spectrum from purely subsistence to predominantly profit-making, and have a correspondingly complex variety of incentives and behaviours. Hunters hunt for a variety of reasons. In some areas hunting is a cultural tradition, sometimes with an element of prestige (Sabater-Pi & Groves, 1972) or ceremony (Mitchell & Tilson, 1986) associated, particularly for larger or more dangerous animals.

Many wild animals may also be seen as a threat to local people, in the form of crop pests (Anstey, 1991; Mittermeier, 1987). An extreme example of this was the extermination of over 250,000 monkeys (mainly crop-raiding species, but bounty payments were indiscriminately awarded for any species) in monkey drives organised by the government of Sierra Leone in the 1950s (Jones, 1998). Traps are also put up in fences around fields during the harvest season which serve the dual purpose of protecting crops and providing meat in the form of species such as cane rats (Davies *et al.*, in press; Fitzgibbon *et al.*, 1996; ULG Consultants Ltd, 1998).

Most importantly, hunters hunt for food and for cash, the latter increasingly so with the growth of the commercial bushmeat trade and increasing rural poverty. It is the relative importance of these two incentives that are of most relevance to conservation and development policy.

Bushmeat as a protein and income source

Bushmeat hunting is critical to the livelihoods of many rural poor and provides rural people with a direct, open-access source of animal protein (Bowen-Jones *et al.*, 2001). Hunting has been estimated to contribute between 30-80% of the protein intake for forest-dwelling people in the Congo Basin (Koppert *et al.* 1996, cited in Wilkie 2001). In contrast to urban areas where bushmeat may be a luxury food, in rural areas with poor access to markets, bushmeat is usually the cheapest - or even only - type of animal protein available (e.g. Gabon: Starkey, 2004).

Bushmeat also provides a valuable source of income for many individuals, households and communities. Hunters can be classified as three types: local opportunists, specialist hunters or outside commercial operators (Homewood, 1999), although the distinction between these is often blurred (Bowen-Jones & Pendry, 1999). A primarily subsistence hunter may sell on any surplus and thus supplement his income (Wilkie *et al.*, 1992). The high demand for bushmeat has resulted in an increasing number of professional or commercial hunters (Fa, 2000).

Alternative livelihoods to hunting

Hunting effort is likely to be influenced by what alternative livelihoods are available (if any). This determines the time available to hunt and also the relative dependency on hunting as a source of income. Hunting may be a full- or part-time activity, usually depending on the availability or preference for alternative livelihoods, and sometimes with seasonal or unpredictable temporal variation. In Ghana, hunting was a fall-back livelihood during the lean agricultural season (Cowlishaw *et al.*, 2005). Caspary (2001) reports that in Cote d'Ivoire, 55% of the male population over the age of 15 consider themselves to be hunters, although 90% of these also work in the agriculture sector. Solly (2001) found that in the Dja Reserve in south-west Cameroon, many young men preferred hunting as a livelihood to cocoa farming, even though the average income from hunting was significantly lower (53,000 CFA/yr compared to 95,000 CFA/yr). This was because although hunting income was low, it was steady and required relatively little, short-term effort – 'easy money' compared to the larger but one-off income from the annual cocoa harvest, which required long-term investment and planning and was usually only carried out by married men once they had to bear greater responsibilities.

Alternative livelihood options are not static or necessarily predictable. For example, a new logging camp may offer employment opportunities in an area and so bring an influx of migrants, who remain after logging has ceased and therefore have to find an alternative source of income. Similarly a downturn in the economic climate or an increase in political instability may result in a situation where people are forced to hunt for subsistence or income generation (such as the outbreak of civil war in Liberia: Anstey, 1991, during civil unrest in Democratic Republic of Congo: de Merode, 2004, or following economic decline in Cote d'Ivoire: Bassett, 2005).

Bushmeat and international development

Development agencies have recently shifted their focus from traditional areas such as large-scale agriculture and natural resource extraction to livelihoods, in an attempt to reduce poverty. This stems from the uptake of the Millennium Development Goals, which aim to reduce by one-half the proportion of people living in extreme poverty (less than US$1 a day) by 2015 (UNDG, 2003). Many authors suggest that bushmeat is an important component of rural livelihoods (e.g. Mainka & Trivedi, 2002), and therefore argue for the inclusion of bushmeat and biodiversity conservation in general in national poverty reduction strategies (e.g. Adams *et al.*, 2004; Davies, 2002b) but hard evidence for bushmeat-poverty linkages is surprisingly scant (DfID, 2002). While it is generally agreed that bushmeat is indeed important to many rural populations in west and central Africa, the scale of bushmeat use, whether poor people depend on bushmeat or not, and whether it is most important to the poorest sections of society, is still under debate (Brown, 2003).

Dependence on bushmeat

Traditionally, international development assistance programmes have not addressed the needs of remote forest people who live at the margins of the cash economy (Milner-Gulland *et al*., 2003). The extent to which people depend on bushmeat or could cope if the resource were removed is still not well understood (DfID, 2002), but recent evidence suggests that use of bushmeat varies widely between (Bennett, 2002) and amongst (de Merode *et al.*, 2004) communities and by season (de Merode *et al.*, 2004; Dei, 1989).

There is considerable disagreement among conservationists and development practitioners as to the extent to which poor people use bushmeat - in particular which communities or sectors of a community are more reliant on bushmeat. Two recent studies conducted in central Africa suggest that it is not necessarily the poorest that are most reliant on bushmeat, with use either being greatest for middle-income households (Gabon: Starkey, 2004) or for wealthier households (Democratic Republic of Congo: de Merode *et al.*, 2004; although in this example, wealth is relative, as all households in the community were actually classed as living in extreme poverty). Whilst in Latin

America bushmeat is reported to play a greater role in household consumption (e.g. Godoy *et al.*, 1995), both these studies suggest that bushmeat is more important to rural communities as a source of income in central Africa, reflecting the increased commercialisation of the bushmeat trade.

Finally, whether poor people would suffer if bushmeat were no longer available is also under question (e.g. DfID, 2002). The ability of poor people to adapt if access was prevented or supply ran out is also likely to vary between and among communities, depending on factors such as market access, availability of alternative foods and livelihoods, and educational, skills or cultural barriers to alternative sources of income (Bennett, 2002). Dependence on bushmeat may also be temporary; for example bushmeat hunting can be an important fall-back livelihood during the agricultural lean season or in periods of crisis (de Merode *et al.*, 2004).

1.2.3 Hunter behaviour

Hunters employ several methods to catch their prey, including snares (foot, neck, fence, tree, pitfall snares), iron-jaw or gin traps, pit traps, net drives, guns, crossbows, bow and arrows, blowpipes, spears, catapults, dogs, machetes, poisoning, fire, dazzling by torchlight and gathering by hand (for species like tortoises: King, 1994; ULG Consultants Ltd, 1998). Gear types can be divided into those that are passive, such as trapping, or active, such as pursuit hunting with shotguns or blowpipes. Trapping with wire snares (hereafter referred to as trapping) is the most widespread method in use in central African forests today, but gun-hunting, usually with shotguns but sometimes with rifles, particularly in areas of civil unrest (e.g. Democratic Republic of Congo: de Merode, 1998), is also common and increasing.

Trapping

Trapping is relatively unselective, although different snares are designed to catch different types of prey due to their particular behaviour or size/weight (Noss, 1998c) and it has also been reported that hunters sometimes call in duikers to lure them into traps, thus targeting particular species (Infield, 1988). The specific location and type of snare can also enable some small degree of prey selectivity, as they are usually not sited completely at random as is often perceived (e.g. Fa and Peres, 2001) but commonly set on trails or outside burrows made by targeted species (*pers. obs.*). Snares tend to catch medium to large mammals, in particular duikers (Fa & Garcia Yuste, 2001; Noss, 1998b, c). Duikers weighing less than 25 kg made up 55% of the animals snared in Western Dja Reserve, Cameroon (Muchaal & Ngandjui, 1999). This compares to 49% in Korup National Park, Cameroon (Infield, 1988) and 42% found in markets in Equatorial Guinea (Fa *et al.*, 1995). Noss (1998c) reported that 75% of captures in the Central African Republic forest were made up of three duiker species and the brush-tailed porcupine.

Snaring often results in large amounts of wastage, due to animals being scavenged or decomposing between checks of the snare, as well as animals escaping, often with fatal or debilitating injuries (Hart, 2000; Noss, 1998b, c; Noss, 2000). Noss (Noss, 1998a; 1998c) found that wastage amounted to 27% of captures, whilst 37% escaped. This is a grim indication of the true level of offtake, given the proportions that make it out of the forest and eventually to market.

Gun-hunting

Hunting with guns allows a much greater degree of prey choice. Certain species are selected preferentially, such as elephants, which must be hunted with rifles rather than shotguns (Bowen-Jones, 1998). Hunters sometimes imitate monkey vocalisations to locate prey and lure them in, and thus attract particular species (Gadsby, 1990). Red colobus were sought out by hunters in Sierra Leone as they are generally easy to catch, smoke well (therefore can be kept for longer and transported further) and are preferred by many people (Davies, 1987). On the whole, gun-hunting is more efficient and less wasteful than trapping, but has greater barriers to entry in terms of start-up (the gun itself) and running (cartridges, maintenance and licence fees) costs.

Choice of gear type

In the Western Dja Reserve, Cameroon, Muchaal & Ngandjui (1999) report increased snaring in the rainy season, as duikers ranged farther and so became more susceptible to encountering a snare. The roads are also impassable at this time, so bushmeat is the only forest/agricultural commodity that is economic to transport to market (*ibid*). In this area, hunting with guns increases in the dry season as primates are more susceptible (due to fewer fruiting trees being available), resulting in an increase in the proportion of primates in the offtake (Muchaal & Ngandjui, 1999). King (1994) reports that in Western Bakossiland, Cameroon, the 'hunting season' for both guns and snares is the wet season, due to seasonal abundance of game and 'wet mulchy ground that allows hunters to stalk prey undetected' (Gadsby, 1990). As mentioned above, increasing incomes and changes in political and social conditions are causing a switch from traps to guns in many areas (Bassett, 2005; Damania *et al.*, 2005).

Prey choice

Native hunters had been hypothesised as the 'ecologically noble savage', living in balance with their environment and deliberately restraining their hunting to ensure sustainability (see Redford, 1991). However, Alvard (1993; 1994) demonstrated that the subsistence hunting Piro of Amazonian Peru in fact make decisions that are consistent with the predictions of optimal foraging theory rather than resource conservation. What in some cases at first appeared to be active

conservation by the hunters (prey switching to alternative species as the preferred species becomes scarce) was more likely in fact to be an epiphenomenal effect of a low harvesting rate due to low hunter density (Alvard, 1995).

Such prey switching to alternative species is in accordance with the prey choice model described by Winterhalder and Lu (1997). According to the model, the prey type(s) that yields the highest rate upon encounter should always be pursued. For example, Peres (1990) found that because it was uneconomic for Amazonian gun-hunters to hunt primates weighing less than 3 kg due to the cost of cartridges; they duly ignored them when encountered. The hunters would however travel up to 9 km in order to hunt rarer, large-bodied (greater than 5 kg) and therefore more profitable primates. However, the model also predicts that if hunters encounter profitable prey when passing through a depleted area, they will attack rather than ignore them (Alvard, 1994). This means that in a multi-species prey community, the more vulnerable (larger, more profitable and therefore preferred) prey are threatened with 'piggyback' extinction if they continue to be hunted incidentally due to the existence of alternative prey (Clayton *et al.*, 1997; Milner-Gulland & Leader-Williams, 1992).

Consumer preference can affect prey choice, or the choice of prey which are taken to market once caught (Bodmer, 2000). Cane rats, Maxwell's duiker, porcupines and pigs were preferred in markets in south-west Nigeria (Anadu *et al.*, 1988) and similar preferences were recorded in north Cameroon (Njiforti, 1996). The buying power of the market (demand) determines the amount and type of meat marketed rather than sold locally or consumed by the rural household (Juste *et al.*, 1995). Duikers are most commonly found in markets (Robinson & Bennett, 2000b) because they are of medium size so transportation is more economic than for smaller or larger species (Fa *et al.*, 1995) and they may well be preferred by consumers; for example, 80% of antelopes caught compared to 10% of rodents were shipped to market in Bioko (Colell *et al.*, 1994).

Some species are reported to be deliberately avoided because of their bad taste, such as tapirs by Mayas (Jorgenson, 1995) and black colobus by the Fang of Equatorial Guinea (Sabater-Pi & Groves, 1972) and some tribes in neighbouring Gabon (Blom *et al.*, 1992). The existence of traditional taboos or totems (food avoidances) means that certain species may be ignored if encountered. Great apes and sometimes other primates are often avoided due to their similarity to man. Even the formerly cannibalistic Fang of Río Muni in Equatorial Guinea were reported as citing this as the reason that they avoid eating chimpanzee, although this taboo did not extend to gorillas (Sabater-Pi, 1981; Sabater-Pi & Groves, 1972). Alternatively, bushbabies (*sic*) are avoided in Bioko as they are considered to be evil (Colell *et al.*, 1994). Religious beliefs also result in avoidance of particular species, Muslims shunning pork (and therefore wild pig), primates and

snake (Davies, 1987). However, in the absence of alternatives, as prey becomes increasingly scarce and traditional community customs are weakened with the expansion of the 'global village', such beliefs and taboos, and indeed apparent cultural preferences, are being eroded as the profit motivation or basic need for protein increases (Bowen-Jones, 1998; Peres, 1990). With increasing access and transport options, increasingly there is a market for most species within reach. In addition, taboos are often expressed at the individual or household level rather than throughout an entire ethnic group or area (Davies & Richards, 1991).

Hunter effort and spatial patterns of hunting

Many studies, particularly those making assessments of sustainability of markets across time, have failed to take changes in hunter (or trader) effort fully into account. Even long-term data may not give accurate insights into sustainability if confounding factors are involved (e.g. dealers are travelling ever further, hunting technology is improving or market dynamics, such as prices or consumer preferences, are changing: Crookes *et al.*, in press; Milner-Gulland and Clayton, 2002). For example, Sulawesi wild pig traders were found to be travelling further over time as pigs became depleted close to the market (Milner-Gulland and Clayton, 2002). The increasing use of geographical information systems is encouraging the inclusion of spatial factors into new field and theoretical studies (e.g. Broseth and Pedersen, 2000; Ling and Milner-Gulland, in press).

1.2.4 Biological impacts

Overhunting of species can lead to both local and global extinctions (Robinson and Redford, 1991). Exploitation of wildlife for food in west and central Africa has caused serious population declines (e.g. Bakarr *et al.*, 2001; Robinson and Bennett, 2000a), local species extinctions (Brashares *et al.*, 2001) and possibly species extinctions (Oates *et al.,* 2000, but see McGraw and Oates, 2002). In west and central Africa, 84 mammalian taxa are threatened with extinction due to hunting (IUCN, 2004). Bushmeat consumption in the Congo Basin alone is estimated at 1-5 million tonnes per year (Fa *et al.*, 2002b; Wilkie and Carpenter, 1999). Given the productivity of tropical forests, this may be up to six times the sustainable rate (Bennett, 2002). Fa *et al.* (2003) make the alarming prediction that given current supplies of bushmeat and alternatives, within 50 years only three countries in central Africa will be able to maintain a protein supply above the recommended daily minimum of 52g/person/day. Even though the accuracy of these calculations has been brought into question, it seems clear that vast and probably unsustainable quantities of bushmeat are indeed being hunted and consumed in the region.

Species vulnerability

Species vary in their vulnerability to hunting; in general, slower-breeding, late-maturing, larger-bodied species such as elephants and apes are more at risk (Duncan *et al.*, 2002). Primates, having unusually slow life-histories for their size and living at particularly low densities, are particularly vulnerable to overexploitation (Mittermeier, 1987; Cowlishaw and Dunbar, 2000). Other fast-growing species with a high r_{max} (maximum intrinsic rate of increase), such as rodents, can tolerate relatively high levels of harvesting. In some cases, depensation (where the growth rate of the population decreases as the population decreases – also known as the Allee effect) may prevent reduced populations from recovering (Milner-Gulland & Mace, 1998) and depleted, fragmented populations are more vulnerable to stochastic events, such as climate change, fire or drought, or natural demographic or genetic variation. Some species may also bear the additional burden of extinction debt from historical deforestation (Cowlishaw, 1999). Social animals may be further affected by disruption of their social structure. As primate species are usually found in groups, they are more susceptible to overhunting when encountered (Peres, 1990).

Direct and indirect behavioural and ecological effects

Optimal foraging theory predicts that adults will be selected over juveniles, and males over females where they are larger (Fitzgibbon, 1998). The consequent distortion in age or sex ratios can adversely affect the population dynamics of a species. Although moderately male-biased harvests in polygynous species may actually increase the maximum sustainable yield, extremely male-biased harvests can disrupt territorial and group structure and can result in reduced female fecundity (Ginsberg & Milner-Gulland, 1994). Noss (2000) observed a greater proportion of female and juvenile duikers snared than found in wild populations in the Central African Republic, which suggests that snaring in this site may be biased towards more productive components of the population, possibly posing a more serious threat to population viability. To compensate for this, there is some evidence that hunting lowers the average age of reproduction (Hart, 2000).

Hunting often causes behavioural changes in prey, such as freezing, avoidance, fleeing, non-calling, increased nocturnality or altered movement patterns (Fitzgibbon, 1998). Muchaal & Ngandjui, (1999) reported that at high hunting intensity, some duikers adapt their behaviour by becoming nocturnal, or are found singly rather than in pairs, and apes emigrate from the areas surrounding villages. According to Noss (2000), the nocturnal *Cephalophus monticola* lies still and doesn't move during net hunts, so is more likely to be speared, whereas the diurnal *C. callipygus* has a large home range and is less likely to be caught in net hunts as it moves away from the noise of approaching hunters.

Hunting can have ecosystem-wide effects. The result of removing a 'keystone engineer' (Begon *et al.*, 1996) such as the elephant can change the whole structure of the forest and prevents the formation of open areas such as *bais* (swampy forest clearings). Removing seed dispersal agents such as frugivorous primates can have unknown affects on seedling recruitment and can prevent the regeneration of important timber species (Redford, 1992; Wright *et al.*, 2000). Large, preferentially hunted animals are often also seed predators, predators and food for predators (summarised in Bennett and Robinson, 2000).

1.2.5 Sustainability

Animal populations are a renewable resource and can therefore sustain the harvest of a certain number or proportion of individuals. Robinson & Redford (1991) stated that 'sustainable harvest requires both the maintenance of the resource so that it can be exploited for human welfare, and the conservation of the species being exploited and the biological community in which it lives'. They argued that sustainable harvesting should achieve maximum long-term production from the wildlife population. However, maximum physical yield from a population (also called maximum sustainable yield, MSY) is not the same as maximum economic yield (maximum profit). Taking the cost of hunting into account means that maximum profit is unlikely ever to coincide with MSY (Milner-Gulland, 2001a). Apparent sustainability from a human livelihoods perspective (at least in the short-term) may not result in sustainability from a biodiversity perspective (Redford & Stearman, 1993).

For hunting to be sustainable, it must be both ecologically and socially sustainable. The harvest rate (driven by the demands of consumers on the one hand and controlled by taboos, rules, regulations, enforcement and incentives on the other) must not exceed production (determined by the number of animals and the reproductive rate of the average individual animal) (Bennett and Robinson, 2000). However, in practice the harvest and production rate are not linear and are influenced by a multitude of complicating physical, biological, social, cultural and economic factors (Robinson and Bennett, 2000a). Due to this complexity and dynamism, measuring the sustainability of hunting is incredibly difficult.

Measuring sustainability

Several indices have been developed to estimate the biologically sustainable level of offtake for a given population size. The most commonly used sustainability index is one by Robinson & Redford (1991), a quick and simple algorithm that uses the carrying capacity and maximum rate of increase (r_{max}) to calculate population production. It is conceptually similar to the logistic equation. Robinson and Redford's method is crude, and they state that offtake levels near the estimated

maximum sustainable limit should be cause for concern, and hence that it should be used to judge whether offtake is *unsustainable*, and not whether it is *sustainable.* Many studies have used it to evaluate the sustainability of offtake (e.g. Fa *et al.,* 1995; Fitzgibbon *et al.*, 1996; Muchaal & Ngandjui, 1999; Noss, 1998c; see also examples in Robinson & Bennett, 2000b). Some studies report offtake of certain species at levels more than an order of magnitude greater than Robinson and Redford's index would suggest is sustainable: for example, Noss (2000) reports the harvest of *Cephalophus callipygus* in the Central African Republic at more than 55 times the maximum sustainable level and Fa *et al.* (1995) report the harvest of *Cercopithecus pogonias* on Bioko island as 28 times the sustainable level.

An alternative is the Bodmer method, which uses fecundity rates rather than r_{max} to calculate population production (Robinson & Bodmer, 1999). However, when tested neither the Robinson and Redford nor Bodmer method was found to be precautionary enough, and therefore both are likely to overestimate sustainable levels of offtake (Milner-Gulland & Akcakaya, 2001; Slade *et al.*, 1998). Milner-Gulland and Akcakaya (2001) found that a simple method developed for fisheries management, the National Marine Fisheries Service (NMFS) index, which uses an estimate of the current population abundance instead of carrying capacity and incorporates uncertainty explicitly, reduced the risk of extinction considerably compared to conventional sustainability indices. However, given the predominance of the Robinson and Redford in the literature and its apparent general acceptance as the standard tool for measuring hunting sustainability, this method has yet to be applied to a new bushmeat case study.

Drawbacks of sustainability indices

One drawback to these sustainability indices is that they require knowledge of r_{max} and the density either at carrying capacity or of the current population. Unfortunately, both parameters are extremely difficult to measure accurately for animal populations in tropical forests (Milner-Gulland, in press). Biological data on the reproductive rates and life histories of many central African species are scant. Often allometrically-derived data have to be substituted in the absence of knowledge of a species' basic biological traits (e.g. Rowcliffe *et al.*, 2003).

Estimating absolute population densities is fraught with error and at very low population density (as in a heavily hunted area) a great deal of effort is required to collect enough sightings of a particular species in order to make a statistically precise estimate of density (Monkkonen & Aspi, 1997). This is particularly true for elusive or nocturnal species, such as many duikers and large rodents such as the brush-tailed porcupine (*Atherurus africanus*), which are some of the most important bushmeat groups in west and central Africa (Koster & Hart, 1988). Carrying capacity (K), which is a

fundamental parameter in Robinson and Redford's index, is particularly hard to estimate, given that most areas logistically accessible for research are also accessible to other forms of human disturbance and exploitation, be it of the habitat (logging) or wildlife (hunting), and therefore rarely support natural prey populations undergoing density dependence.

For this reason many authors advocate using indirect methods to estimate abundance, such as dung counts (e.g. Walsh *et al.*, 2001, for elephants; Plumptre & Harris, 1995, for ungulates) or animal signs (e.g. Carillo *et al.*, 2000). Unfortunately the rate of dung decay or track renewal is not sufficiently constant over time or space due to changes in macro- and microclimatic conditions (Barnes *et al.*, 1997; White, 1995) and therefore estimations can be highly inaccurate unless (and even when) the decay rate is monitored over the course of the survey period (Plumptre & Harris, 1995). Relying on direct sightings to estimate densities is more feasible for primates (e.g. Barnett, 1995; Brockelman & Ali, 1987; White & Edwards, 2000), as the important bushmeat primate species are primarily diurnal and social, so tend to be visually and audibly more conspicuous. However, Plumptre (2000) warns that even if using direct methods, differences of less than 10-30% change in the population are unlikely to be detected between two surveys.

Alternatives to conventional sustainability indices

All these uncertainties make the simplified indices developed so far only useful as a first indication of possible unsustainability, alerting managers to the need for further monitoring and evaluation of the harvest (Milner-Gulland, 2001a). They also underline the need to take a precautionary approach in management. Another approach is to look at changes in the species composition (prey profile) of harvested offtake (Colell *et al.*, 1994; Eves & Ruggiero, 2000; Fa, 2000; Fa *et al.*, 2000; Jerozolimski & Peres, 2003; Rowcliffe *et al.*, 2003). Medium to large-sized animals are preferred prey and thus targeted first by hunters according to optimal foraging theory (e.g. Alvard, 1993; Newing, 2001; Peres, 2000). Such large-bodied species are also usually the most vulnerable to harvesting, as they tend to have slower life-histories and lower reproductive potential. Therefore offtakes in relatively undepleted areas tend to contain higher proportions of larger species, in particular ungulates, and primates where they are targeted, whilst reductions in the proportion of these species could act as a warning signal of depletion. This has more usually been considered when looking at bushmeat markets (e.g. Fa *et al.*, 2004; Fa *et al.*, 1995; Fa *et al.*, 2000), but could be better applied at the village level so long as effort and technology remain constant and market dynamics are not a factor (Milner-Gulland, in press).

Alternatively, monitoring changes in the catch per unit effort (CPUE) over time, a technique originally developed for fisheries management, may provide a simple tool for evaluating the

sustainability of hunting. Catch is measured as number of carcasses or biomass whilst effort can be measured using any appropriate unit, such as time spent hunting or units of 'equipment' (e.g. traps laid or cartridges expended). The offtake should be proportional to the prey population size and harvesting effort, assuming all hunters use comparable technologies and modes of travel, and are of equal competence (Wilkie and Carpenter, 1999). Changes in CPUE could provide an indirect measure of changes in the underlying stock without the need for expensive and time-consuming population monitoring.

A complex and dynamic system

Barnes (2002) warns of a possible 'boom and bust' scenario in west and central Africa. Using a simulation model for three commonly hunted bushmeat species, he showed that under increasing hunting pressure, harvests gradually increased to compensate. However, although harvests remained high for years, due to non-linear relationships and environmental fluctuations, which in reality are often aggravated by unforeseen changes in demand or hunting effort (see section 1.2.1), the populations suddenly crashed. This simulation and human-environmental interaction is similar to the boom-bust trend in catch of the Peruvian anchovy (*Engraulis ringens*) fishery, which experienced a crash in 1970 that has been attributed to overfishing in conjunction with poor recruitment in 1971 and the 1972-3 El Niño (Glantz, 1981).

Consumers, hunters and prey are not static, and one-off surveys are limited in their predictive power. Bio-economic modelling is increasingly being used to lend insights into the sustainability of bushmeat hunting under different management systems, and there is an increasing appreciation of the need for dynamic, adaptive models that take stochasticity and variability across both time and space into account (Clayton *et al.*, 1997; Ling & Milner-Gulland, in press; Lundberg *et al.*, 2000; Milner-Gulland, 2001a; Milner-Gulland, in press; Milner-Gulland *et al.*, 2001; Rowcliffe *et al.*, 2003; Shea & NCEAS Working Group on Population Management, 1998). Such models necessitate the collection of a whole range of time series, spatially referenced data, on all aspects of the system, but there is still a dearth of empirical data upon which to test their predictions (Cannon, 2001; Milner-Gulland, in press).

It must be emphasised that bushmeat is embedded in the general economy (Milner-Gulland, 2002). At the macro-scale, bushmeat hunting is intrinsically linked to the political landscape and national, regional and international economics. It is also important to consider the interactions with other industries such as natural resource extraction (particularly logging and oil), the agricultural sector, fisheries and international development programmes (Brashares *et al.*, 2004; Milner-Gulland, in press; Rowcliffe *et al.*, 2005; Wunder & Sunderlin, 2004).

Overall, predictions for the sustainability of hunting in west and central Africa are not optimistic. The basic underlying drivers, growing human populations coupled with shrinking total and effective forest area, are exacerbated by technological advancements, limited alternative protein production and supply and changes in local and macro-economic conditions, both positive and negative.

1.2.6 Research needs

In order to predict the sustainability of hunting for a case study system, all the above factors – social, economic, cultural, biological and physical – need to be taken into account. So that managers and policy-makers can formulate appropriate action to ensure sustainability, we need first to answer three core questions: (1) why do people consume bushmeat, (2) why do people hunt bushmeat and (3) given an understanding of these causes of bushmeat hunting, and the effects on wildlife, is the system sustainable? We can then attempt to answer the final question: (4) what incentives could ensure sustainable hunting of bushmeat? I summarise the research needs for each of these questions in turn, emphasising different axes of contrast within the system where appropriate.

1. Why do people eat bushmeat?

Clearly the determinants of bushmeat consumption differ between urban and rural settings. We need to understand if consumption at both these scales is through need or by preference, and therefore what the implications of banning the commercial trade would be for consumers. If there are insufficient animal protein alternatives for urban consumers (i.e. they rely on bushmeat for food security), then banning the trade would exacerbate urban poverty and malnutrition. However, given the inability of bushmeat to supply the ever-increasing urban demand, feasible and acceptable alternatives would have to be sought as a matter of urgency. On the other hand, if rural people depend on bushmeat for food security, then banning the trade and preventing access by outsiders could help to improve the sustainability of harvests and thus food security, as long as the rural population remains low enough.

2. Why do people hunt?

Critically, we need to understand the role of bushmeat in livelihoods, particularly those of poor rural people. Whether hunting is **subsistence or commercial** – in other words essentially whether it is for **food or income** – has a bearing on whether policies should be targeted at increasing access to alternative protein sources or to income-generating activities. However, the two are not necessarily distinct; often a hunter will only sell on a surplus once the needs of the household have

been met. In some cases, where a hunter sells his more valuable bushmeat catch in order to buy a larger quantity of replacement food for the household, what may appear to be commercial hunting is actually indirectly for food and ultimately may affect food security.

Whether rural people actually depend on bushmeat or just use the resource as an easier or preferred way of obtaining food or income has important implications for development programmes. If hunting is predominately for food, then an appropriate policy would be to ban the commercial trade, thus potentially creating a win-win scenario, both protecting wildlife and the rural people who may use the resource to meet their daily subsistence needs. However, if hunting is predominately for income, then banning the commercial trade would have a negative impact on the livelihoods of local people.

Hunting may be **active or passive** – in that particular species are targeted or there may be no preference for or selection of one type of animal or another. In another sense, hunting may be **for meat or for some other value**, such as crop protection, personal protection or cultural/traditional reasons. If the latter, then mitigation strategies to reduce the loss/reduction of crops or the threat to human safety, for example, may be more appropriate.

Finally, there is a contrast between **rich and poor,** defining whether a household **hunts or consumes** bushmeat, and whether they use **traps or guns**. A model by Damania *et al.* (2005) predicted two effects of increasing household wealth on hunting and bushmeat consumption. Increasing household wealth caused consumption of bushmeat to increase, as well as a shift in gear type from low-cost but more inefficient traps to more expensive and efficient guns. This suggests that (depending on relative prices and availability of prey) poorer households may be more likely to hunt (in the absence of access to alternative livelihoods) while richer households may be more likely to purchase or eat bushmeat (given greater expendable income).

3. Is hunting sustainable?

Once we have defined the scale, intensity and variability of the threats outlined above, we then need to understand the current and potential effects of these threats on key wildlife populations. By studying hunter behaviour and spatio-temporal patterns of hunting, we can evaluate and then mitigate the impacts of hunters. For example, selective hunting may enable sustainable exploitation of robust species while protecting more vulnerable species. Limiting the zone or season in which hunting is allowed may allow prey to recover, by improving source-sink dynamics (e.g. Hill and Padwe, 2000) or protecting species during breeding or feeding seasons. By combining knowledge of prey population biology and ecology with hunter and consumer behaviour, we can start to make

predictions of sustainability under changing circumstances, and thus the implications for conservation and development policy.

4. What policies could ensure sustainable hunting?

So the debate in many situations is likely to be less about whether bushmeat hunting is sustainable, but why it is unsustainable, and how policy-makers should respond to this. As outlined above, obstacles to sustainable hunting are the lack of property rights, improved access to hunting grounds (allowing commercialisation of hunting and therefore increased effort), low fixed and opportunity costs, multi-species hunting, human population growth (including immigration) and improved technology (Cannon, 2001). Factors that may increase the likelihood of sustainable hunting are access to substitute foods and increased opportunity costs in the form of alternative livelihood opportunities (Homewood, 1999). By understanding the main causes and effects of hunting, we can select appropriate policies that will increase the likelihood of sustainable hunting whilst minimising any potentially adverse effects on more vulnerable groups of people and wildlife.

Different sectors of society play different roles in the bushmeat commodity chain, and some are more vulnerable than others to the effects of reducing or banning the commercial trade. **Hunters, traders, patrons and retailers** all have different influences on the trade and profit differently from it. Ideally, policy should protect more vulnerable actors, such as local hunters who have no alternative livelihood, whilst controlling disproportionately weighted profits to those of independent means, such as commercial operators prepared to overexploit the resource for short-term benefit.

There is also a gender divide among actors in the bushmeat commodity chain, with **males and females** playing different roles and deriving different benefits from bushmeat hunting. Hunters are usually men, whilst traders and retailers are often women. At the rural level, it has been found that women contribute more to the household economy in terms of the proportion of their income; so male bushmeat income may actually contribute less to the well-being of the household as a whole (including the children) than income earned by females (Solly, 2001, 2004; Katz, 1995). It is important to understand too whether income from bushmeat feeds back to the **individual or household**. The role of all actors must be taken into account when devising policy aimed at alleviating poverty and enhancing food security.

Finally, there is a conflict between **conservation and development perspectives.** The conservationist perspective believes that the increase in the commercial trade is driven by the demand from urban populations for bushmeat as a luxury good, and that this trade should be curtailed in order to protect vulnerable species such as great apes. Dependence of local people on

wildlife should be stopped by encouraging alternative sources of food and income (e.g. Bennett, 2002; Robinson and Bennett, 2002b). The development perspective is that bushmeat brings positive livelihood benefits to rural people, and bushmeat hunting should be encouraged in order to maximise revenue flows at both local and national scales, even if this poses a threat to some wildlife populations (e.g. Brown, 2003). Mirroring this polarisation in perspective, opinions also differ as to whether traditional **conservation or development policies** are more appropriate to deal with the bushmeat issue. Traditional conservation policy encourages a preservationist approach, whereby people are excluded from protected areas or limitations are imposed on what, how and where they can hunt, and attempts are made to reduce human impact on natural resources. Development policies aim to rejuvenate the rural economy, by increasing access and encouraging income generating activities. Whilst this may reduce dependence on hunting, particularly for income, it may also increase access to forest areas and the efficiency of hunting (for example by enabling a shift from traps to guns).

There is a wealth of potential policies and actions that may serve to improve the sustainability of hunting. These can be broadly divided into those that act to reduce **demand** for bushmeat (such as changing prices, altering preferences, increasing alternative protein sources, education, imposing taxes, threatening prosecution), and those that constrain **supply** (such as trade barriers, policing of protected areas, community management, limiting access, increasing alternative rural foods and livelihoods). The aim of this thesis is to understand the causes and effects of hunting in Río Muni, and to use this understanding to identify a suite of appropriate policy responses to aid in managing the system sustainably, whilst minimising impacts on consumers and livelihoods.

1.3 EQUATORIAL GUINEA: BOOM, BUST... AND BOOM

The Republic of Equatorial Guinea is a small, Spanish-speaking country in central Africa, just north of the equator. The capital, Malabo, is situated on the island of Bioko in the Gulf of Guinea off the coast of Cameroon, whilst the majority of the country's area and population is found in Río Muni, the continental region (figure 1.2). Río Muni is particularly interesting for the purposes of this study for several reasons. Firstly, and most importantly, it has extremely high biodiversity for its size, but conservation measures are lacking and threats to biodiversity are largely unknown. Secondly, although there is an extensive bushmeat trade in the country, much previous work has focused on Bioko Island and has been largely documented from market studies (e.g. Fa *et al.*, 1995;

Fa *et al.*, 2000), with little work on bushmeat hunting and trade across Río Muni. Thirdly, because the country is small, the bushmeat commodity chain is relatively short, making it feasible to follow the route of meat at all points in the chain from forest to market. Finally, enforcement of official restrictions on hunting and trade is almost completely lacking, so it is relatively easy to interview people and collect data on illegal practices which are often much more clandestine in other countries.

There is one final reason that makes Equatorial Guinea particularly interesting to study at the present time. It is in the midst of an economic boom, due to the 1995 discovery of extensive oil deposits in its waters. The country's growth has been dramatic, resulting in a metamorphosis from 'one of the most backward countries in the world' (Klitgaard, 1990) to the 'Kuwait of Africa' (Walsh, 2004) in less than a decade. It therefore provides a neat case study of the consequences of economic changes on the conservation of natural resources in general, and on the demand and supply for bushmeat specifically, over a more condensed time-scale than is usually possible.

Figure 1.2 Satellite image of central Africa, showing Río Muni and the islands of Bioko (containing the capital of Equatorial Guinea, Malabo), Annobon and Corisco/Elobeys in the Gulf of Guinea (Global Forest Watch, 2003).

Research on the bushmeat trade on Río Muni is thus urgently required, and in some respects more logistically feasible than might be expected. However, it must be noted that whilst the unique peculiarities of Equatorial Guinea make it a fascinating and important, if challenging, place to

study, they also mean that some of the findings may not be easily transferable to other countries in central Africa with quite different political, economic and cultural dynamics, let alone further afield. This said, given the great variability in the bushmeat trade in general, this point is not specific to Equatorial Guinea. Here follows some background on the country to put this study in context and set the scene.

1.3.1 Geography

Equatorial Guinea is composed of the continental region, Río Muni (26,000 km^2), two volcanic islands, Bioko (2000 km^2) and Annobon (17 km^2), and three small islands off the Río Muni coast, Corisco, Elobey Grande and Elobey Chico (figure 1.2). In total the country covers an area of 28,051 km^2, with 17,520 km^2 of this estimated to be forest in 2000 (World Bank, 2005b). The natural vegetation type of the majority of Río Muni is evergreen humid closed forest (Senterre & Lejoly, 2001). Habitat and topography of Río Muni varies with distance from the coast. The western littoral zone (less than 200m a.s.l.) extends in a band 20-30 km from the coast, and is separated by the continental plains of the eastern 'interior' (500-700 m a.s.l.) by the Río Uoro and the Niefang mountain chain (400-1350 m a.s.l.) (Wilks & Issembe, 2000). The Monte Alén National Park (MANP) (see below) forms the backbone of the Niefang mountains, which are the northern continuation of the Monts de Cristal chain in Gabon (Conservation International, 2003). Mounts Alén and Mitra are the highest peaks on Río Muni at around 1,300 m a.s.l., although altitudinal data are inaccurate (Birdlife International, 2005). Malabo, situated on Bioko island, is the national capital and Bata is the regional capital of Río Muni.

1.3.2 History

The first inhabitants of Equatorial Guinea were thought to have been Pygmies, of whom only isolated populations may remain in northern Río Muni. They were largely displaced by waves of Bantu migrations between the 17th and 19th centuries, first of all various coastal tribes and later the Fang (Liniger-Goumaz, 1989). One of these coastal tribes, the Bubi, migrated to Bioko and they are still the main ethnic group on the island.

Bioko was formerly known as Fernando Po after the Portugese explorer who discovered it in 1472. The island was sequentially colonised by Portugal, Spain, Britain and Spain, finally being united with the mainland as the colony of Spanish Guinea between 1926 and 1959 (Wikipedia, 2005). Following a period of autonomy, during which a Spanish-elected Government had limited political freedom whilst still being financially supported by Spain, the country voted to sever its colonial ties in a referendum, and in 1968 Equatorial Guinea became officially independent, with the former

mayor of Mongomo, Francisco Macias Nguema (Macias), becoming President. After over a decade of infamous human rights abuses, during which a third of the population were killed, exiled or fled, he was overthrown in 1979 in a military *coup d'état* staged by his nephew, Teodoro Obiang Nguema Mbasogo (Obiang) and executed (BBC, 2005). President Obiang has been in power ever since.

International bodies estimate the population of Equatorial Guinea to be around 500,000 (e.g. estimate for 2003 of 494,000: World Bank, 2004), a figure that differs dramatically from the latest national census data, which gave a population projection for 2003 of 1,157,000 (Ministério de Planificación y Desarrollo Económico, 2002). The national census data are probably less believable, particularly as they suggest that the population nearly doubled in seven years, from 595,995 in 1994 when the previous census was taken (Ministério de Planificación y Desarrollo Económico, 1997). It is in the interests of developing countries to inflate population figures, in order to obtain increased international aid and political recognition, and in Gabon it was reported that during the oil-boom this was done to make the country appear poorer (Yates, 1996).

1.3.3 Culture

The Fang are the largest and most powerful ethnic group in Equatorial Guinea (80% of the population) and the tribe of the President. They are the most numerous tribe of the Beti-Pahuin group of the Niger-Congo language family (Wikipedia, 2005). The Fang traditionally live in forested areas, are polygamous, cannibalistic, take part in traditional medicine and hunt (Pigeonnière, 2001). The Fang are the minority group on Bioko next to the Bubi, but exert strong political and economic influence. Other tribes (totalling around 5%), such as the coastal Ndowe (encompassing a number of different groups, such as Kombe and Bisio), are found primarily on Río Muni. They have a strong fishing tradition. There is an increasing number of foreigners, mostly in Bata and Malabo, including Cameroonians, Nigerians, Beninoises, Spanish, Lebanese, French and Americans.

The official languages of Equatorial Guinea are Spanish and recently French, but unique in Africa, Spanish is most widely spoken, as a result of its colonial past. The adult literacy rate is 84% (UNDP, 2005). The population is nominally Christian, traditionally Roman Catholic as a result of its Spanish influence, but there are many other Christian sects due to heavy missionary influence. However many people continue to practice traditional animist beliefs (often alongside Christianity), including witchcraft (pers. obs.).

1.3.4 Politics

President Obiang kept the absolute control he had inherited from his uncle, and although the country is now an official democracy, the country's first multi-party presidential election was held in 1997 amid reports of widespread fraud and irregularities, returning Obiang and his '*Partido Democrático de Guinea Ecuatorial*' (PDGE) with 99% of the vote (BBC, 2005). 'Criticism of the leadership is not tolerated and self-censorship is widespread' (BBC, 2005) and Obiang has been consistently listed in the world's Top 10 Worst Living Dictators (Wallechinsky, 2003). Transparency International has put Equatorial Guinea in the top 10 of its list of most corrupt states (BBC, 2005) and there have been accusations of embezzlement of oil profits by Obiang and his associates (Blum, 2004). There is only one State-run television channel, two official radio stations (one owned by Obiang, the other by his son) and books and newspapers are incredibly scarce (even the bi-monthly State pamphlet, *La Gacetta*), unlike in neighbouring countries such as Gabon and Cameroon (pers. obs.).

The presidential election of December 2002 (which caused some disruption to the start of this study as we followed the advice given to us to leave the country for the entire 5-week campaign and post-election period), was reportedly no less fraudulent than the previous one (anon., pers. comm.), with Obiang this time gaining 97% of the vote. The recent upturn in Equatorial Guinea's economy (see below) has meant that Obiang's power base is increasingly under threat. Politics within the country are reputedly dominated by tensions between Obiang and his son Teodorín, Minister of Forests during this study, as well as with many of the other members of his family who make up much of the Government. Obiang has survived many coup attempts, including one in March 2004 allegedly backed by British and South African businessmen, as well as Britain's MI6, the USA's CIA and Spain (BBC, 2005).

1.3.5 Economy

In 1959 Equatorial Guinea had the highest per capita income of Africa (Wikipedia, 2005). Bioko was at one time during the colonial period the world's cocoa-producing capital, and coffee, palm oil and logging were other mainstays of the economy. Following Independence and the anarchy of Macias' crippling rule, the plantations were abandoned (Butynski & Koster, 1994) the administration went into disarray (Sabater-Pi, 1981) and the economy slumped. As well as food crops, the livestock farming (of dwarf cattle, resistant to trypanosomiasis, which commonly plagues livestock in the afrotropics: Fa, 2000) that had been in place on Bioko stopped and pasture land went fallow. The livestock industry on Bioko never recovered. On Río Muni, livestock husbandry

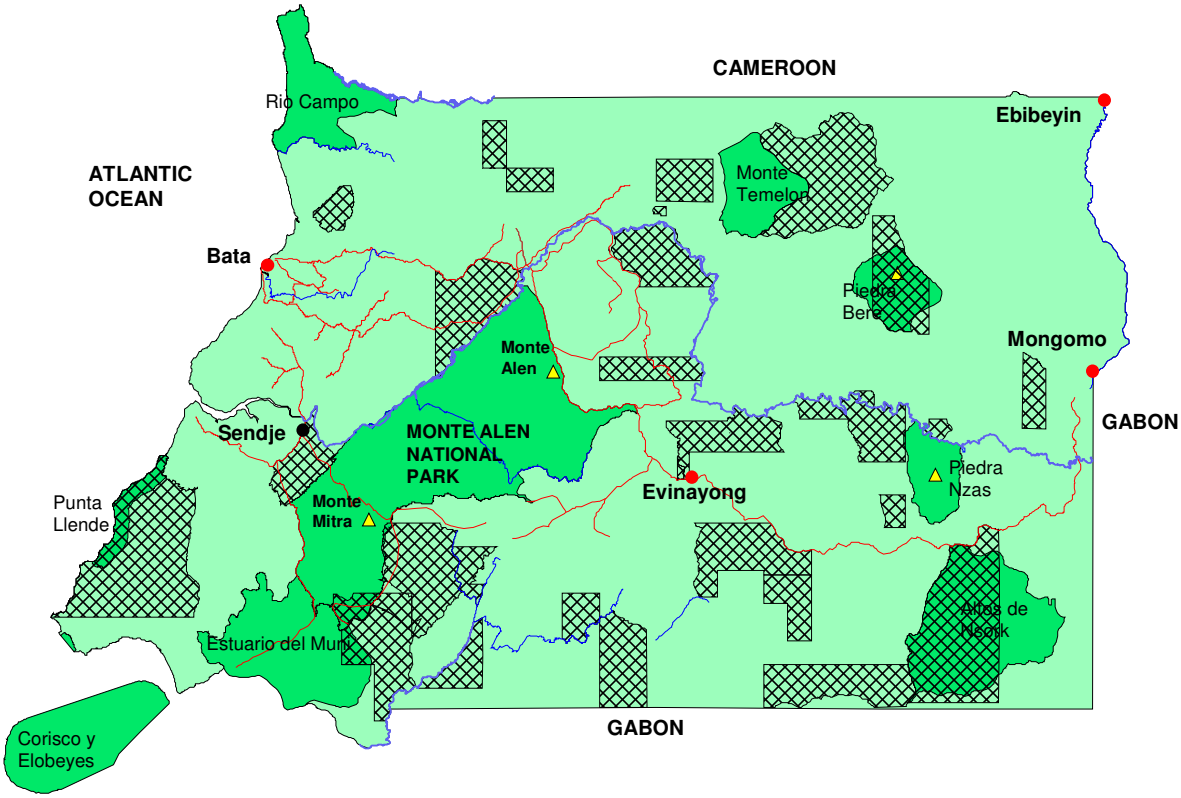
has never been a major activity, even on a local scale, the handful of goats and fowl found in villages being reserved for consumption only on special occasions.

Industrial-scale commercial fishing is severely under-developed, at least by Equatoguineans (although the Gulf of Guinea is heavily exploited by foreign trawlers: Watson & Brashares, 2004). Bizarrely, for a coastal nation with ample freshwaters, 90% of all fish consumed in the country is imported (FAO, 2003). This is partly a hang-over from the 1970s, when Macias outlawed fishing and banned all fishing infrastructure. A project started by the United Nations Food and Agriculture Organisation (FAO) in 2003 to develop local artisanal fishing calculated that Bata has the capacity to sustain fish catches of 240,000 tonnes per year (FAO, 2003), compared to the 4000-5000 tonnes reported in 2001 (Pigeonnière, 2001).

Although lower than during the colonial period, timber production remained the country's main export earner for decades post-Independence, and is still in second-place for hard currency income today (see figure 1.3 for map of active logging concessions in Río Muni in 2002). The majority of Río Muni has been exploited by a logging concession at some point (mainly exporting the prized *Aucoumea klaineana*, *okoumé*), and they are now encroaching on some of the newly-formed protected areas (figure 1.3 and Pigeonnière, 2001), although as logging is selective rather than by clear-felling (Castroviejo Bolivar *et al.*, 1990), much old secondary forest (such as found in parts of Monte Alén National Park; see below) is hard to distinguish from primary forest (pers. obs.). There are concerns that logging of all other forested areas on Río Muni is continuing at such a fast rate that Monte Alén National Park is likely to become a forested 'island' soon (Birdlife International, 2005).

In an attempt to rejuvenate the ailing economy, Equatorial Guinea joined the Bank of Central African States in 1985 under Obiang, thus becoming a member of the Central African CFA franc zone (World Bank Country Brief, accessed 30/09/05). However, Equatorial Guinea really struck gold with the discovery of large off-shore oil reserves in its waters in the mid-1990s. Since then, the economy has rocketed, with American oil-based investment fuelling rapid development and to some extent an opening-up of the country to the outside world. This has been particularly visible in the Government's recent ambitious infrastructural development. At the time of my pilot study in mid-2002, much of Bata was still running off private generators and they were only just starting to pave many of the town's roads. Since then the country has seen the building of roads and airports, improved telecommunications, an increase in direct European flights, and even an embassy opening in London in August 2005.

Figure 1.3 Map of Río Muni (continental Equatorial Guinea) showing main towns (red dots), some roads (red lines), main rivers (blue lines), protected areas (darker green areas), mountains (yellow triangles: Mounts Alén and Mitra are labelled) and 2002 logging concessions (hatched areas) (CUREF, 2002). Information on roads is incomplete (e.g. the main roads leading to Ebibeyin and Mongomo are missing and the road shown cutting through Monte Alén National Park is actually a disused logging track) and that on logging concessions probably inaccurate (the Equatorial Guinea Government were unable to confirm details of logging concessions, pers. obs.). Note the overlap between several protected areas and logging concessions.



In 2004 Equatorial Guinea had the world's fastest growing economy (BBC, 2005). Equatorial Guinea is now the third-largest exporter of oil in sub-Saharan Africa, with production at 360,000 barrels a day in 2004, up from 220,000 only two years previously (Blum, 2004), and a GDP of US $2.9 billion in 2003 (World Bank, 2005b). Between 1999 and 2003, debt service as share of government revenue declined from 13% to less than 1% (World Bank, 2005b). If the figures are to be believed, according to one source, Equatorial Guinea had the world's sixth-highest GDP per capita at purchasing power parity in 2004 ($33,994) (data from IMF, quoted in Wikipedia, 2005). This does of course rely to a large extent on certain data provided by the Equatorial Guinea government, calling its accuracy into doubt (see discussion on census data above), but even so the country now has an indisputably high GDP per capita. Unfortunately, this sudden oil wealth has not yet benefited the majority of the population: Equatorial Guinea still remains near the bottom of the United Nations' Human Development Index, 121st out of 177 countries (UNDP, 2005).

This bust-boom trend has been a double-edged sword for the rural economy of Equatorial Guinea. The economic distortion brought about by sudden 'oil-rents' (Yates, 1996), similar in effect to the receipt of international development aid, causes the local currency to be overvalued, thus increasing the costs of domestic agricultural production relative to the cost of imported goods (Wunder & Sunderlin, 2004). Certainly Equatorial Guinea is highly reliant on imports to supply most of its basic needs, and domestic trade in agricultural goods is minimal (see also chapter 2). The deterioration of the rural economy under successive brutal regimes has also diminished any potential for agriculture-led growth: the agriculture sector, which was already far behind other countries in the region such as Cameroon and Nigeria, is now being surpassed in favour of the urban economy, as has been observed in Gabon (Wunder & Sunderlin, 2004). In Gabon, Equatorial Guinea's until now richer neighbour following an oil boom in the 1970s (but otherwise very similar in geography, climate and culture), oil wealth led to a rural exodus as the productive population were both attracted to urban areas in seek of oil-related employment, and driven away from the uncompetitive rural economy (Starkey, 2004).

1.3.6 Climate

Average annual rainfall is about 2,500 mm (Wilks & Issembe, 2000), with a lesser rainy season between March and May and a greater rainy season between September and November. The climate is typically equatorial, with average humidity at 90% (higher in the rainy seasons) and an average minimum temperature of 25˚C throughout the year. Rainfall in the Monte Mitra area is known to be particularly high, with humidity reaching 100% (Senterre & Lejoly, 2001). See appendix 1 for daily average minimum and maximum temperature and total rainfall per month during this study, as recorded by one of my local research assistants in Sendje, the study village (littoral zone, 10 km west of Monte Alén National Park). I recorded a total of 2841 mm rainfall in Sendje during 2003. My study period (November 2002 – January 2004) was remarked upon by locals to be unusually rainy, particularly during the first half of 2003, with some rain recorded in most months of the year (appendix 1).

1.3.7 Biodiversity

There are still extensive tracts of forest in the country (forest cover is estimated at 66%: World Bank, 2005a), harbouring an immense amount of biodiversity for the country's small size. The country as a whole has the fourth highest primate diversity in Africa (Chapman *et al.*, 1999), and with 11 endangered primate species or subspecies, the highest number of endangered primate taxa on the continent behind Madagascar (Wallis, 2004). This is in part due to its geographical diversity, with the wildlife of Bioko (classed in the Cameroon rain forest region) being distinct from that of

Río Muni (classed in the Western Equatorial rain forest region: IUCN, 1996). Bioko is home to several endemic sub-species, including the drill (*Mandrillus leucophaeus poensis*), Africa's most endangered primate (Hearn & Morra, 2001; IUCN, 1996), which has led to considerable interest by conservation academics and campaigners (Hearn & Morra, 2001; Hearn, 2001; Wallis, 2004), including Arcadia University (USA) and Conservation International.

Río Muni also contains rich wildlife, although it has been considerably less studied than neighbouring countries in continental Central Africa such as Gabon and Cameroon. Monte Alén National Park harbours at least 109 mammal, 65 reptile, 57 amphibian, 62 fish (Lasso Alcala, 1995) and 265 bird (Birdlife International, 2005) species. Sixteen primate species are found within the park, including gorilla (*Gorilla gorilla*), chimpanzee (*Pan troglodytes*) and black colobus (*Colobus satanus*) (Garcia & Mba, 1997; Gonzalez Kirchner, 1994), as well as other flagship species such as elephant (*Loxodonta africana*), leopard (*Panthera pardus*), buffalo (*Syncerus caffer*), sitatunga (*Tragelaphus spekei*), giant pangolin (*Manis gigantea*) and grey-necked picathartes (*Picathartes oreas*) (Lasso Alcala, 1995). The botanical diversity of Río Muni has been rather better studied, due to interest by several Belgian and Spanish botanists (e.g. Aedo *et al.*, 2001; Senterre & Lejoly, 2001; Stevart, 1999; Wilks & Issembe, 2000) and the botanical slant to the CUREF project (see below). Monte Alén National Park is part of the Niefang mountain chain, which was thought to be an island refuge during the Pleistocene era, contributing to this high biodiversity (Senterre & Lejoly, 2001).

Equatorial Guinea has a total of 101 threatened species of animals and plants in the 2004 IUCN Red List (those listed as Critically Endangered, Endangered or Vulnerable), including 17 mammals, six birds, two reptiles and five amphibians (IUCN, 2004). Several of these are hunted for bushmeat (appendix 2). Note that IUCN threatened status has little bearing on whether the species is afforded protection under the 1988 national legislation described below (República de Guinea Ecuatorial, 1988), partly a result of poor scientific capacity and resources in the country (appendix 2).

1.3.8 Conservation

The protected areas established under Spanish colonial rule prior to 1970 (including the Monte Alén Partial Reserve) were abandoned during the 1970s and 1980s (Castroviejo Bolivar *et al.*, 1990). In 1988 Law 8/1988 on Wildlife, Hunting and Protected Areas was passed, banning hunting in a new system of protected areas as well as the hunting of certain protected species (República de Guinea Ecuatorial, 1988). An area of 80,000ha was designated as Monte Alén National Reserve. The reserve was managed by the European Union (EU) funded project ECOFAC (*Conservation et Utilisation Rationelle des Ecosystèmes Forestiers d'Afrique Centrale*) from 1992. In 1997 Law

3/1997 was passed, creating Monte Alén National Park and including the northern part of the Monte Mitra forest, augmenting its area to 120,000ha (República de Guinea Ecuatorial, 1997). The area of the park was increased further in 2000, to include the southern part of the Monte Mitra forest, bringing the total area to 2000 km^2 (República de Guinea Ecuatorial, 2000). There is now a network of 11 protected areas (nine of which are on Río Muni), covering 16.8% of the country's area (WRI, 2003).

The ECOFAC project as a whole managed protected areas in seven Central African countries (Equatorial Guinea, Gabon, Cameroon, Central African Republic, Republic of the Congo, Democratic Republic of Congo and São Tomé and Principé), with its final phase of funding from the EU being completed at the end of 2003. During this period ECOFAC-GE built a hotel at the park headquarters in Moca (on the west side of the park, on the Niefang-Bicurga road) and employed park guards and tourist guides, with a total staff of 60 people in 2003 (M. Allen, ECOFAC Jefe de Composante 2002-2003, pers. comm.). It attempted a cane rat captive breeding project (Heymans, 1994) and set up '*economatos*' (community-managed shops with goods sold at cost price, with the intention of providing alternative food and livelihoods to bushmeat hunting). With the cessation of EU-funding, ECOFAC was maintained by funding from the Equatorial Guinea Government (mainly paying salaries rather than operational costs) and is now continuing park management with funding and technical assistance through the CARPE programme (see below). ECOFAC gave me logistical support whilst in Equatorial Guinea and all fieldwork was conducted under the auspices of the project.

Another EU-funded project, CUREF (*Proyecto de Conservación y Utilización Racional de los Ecosistemas Forestales*), was started in 1986, working within the Ministry of Forests and Environment (as it was then). The project was intended to build capacity in cartography (see figure 1.3), zoology, botany and socio-economics. CUREF as a body ended in 2002, after which there was a two-year gap in funding, but has since been reformed into INDEFOR (the National Institute of Forestry Development), with some funding under the CARPE programme (see below).

Conservation International (CI) has been the only major international conservation non-governmental organisation (NGO) active in Equatorial Guinea, collaborating initially with the Bioko Biodiversity Protection Programme run by Arcadia University and UNGE (the National University of Equatorial Guinea, in Malabo) on Bioko as part of its West Africa Programme. After involvement in Bioko, CI is now administering a three-year USAID-funded project under the Central African Regional Programme for the Environment (CARPE), to conserve the biodiversity of the contiguous Monte Alén-Mont de Cristal Inselbergs Forest Landscape, one of 11 CARPE-

designated priority landscapes. The project is part of the Congo Basin Forest Partnership, attempting to promote economic development, poverty alleviation, improved governance, and natural resource conservation, and involves INDEFOR, UNGE, Missouri Botanical Garden, the University of Alcala (Spain) and Imperial College London/Zoological Society of London (ZSL). As part of this CI project Imperial College London and ZSL's Institute of Zoology currently have two new PhD students working on different aspects of bushmeat hunting and trade in Río Muni. CI also contributed to some of this PhD's fieldwork and research costs.

Given its high biodiversity, conservation efforts have been minimal in Equatorial Guinea. Since Independence, very few international conservation organisations have been active in the country, mainly because of its political insecurity (CIA, 2002), reflecting international interest in the country as a whole before the advent of oil. For example, Equatorial Guinea has largely been excluded from initiatives such as GRASP (Great Ape Survival Project; D. Jay, pers. comm.) and the Regional Action Plan for the Conservation of Chimpanzees in Western Equatorial Africa (Tutin, 2005), even though it harbours both gorillas and chimpanzees. The language barrier should also not be underestimated, Spanish being unfamiliar to most conservationists with experience of working in Africa.

1.3.9 Bushmeat hunting and trade

Prior to Independence in 1968, shotguns were common among the people of Bioko, used primarily to control squirrels in cocoa plantations but also for bushmeat hunting (Butynski & Koster, 1994). In 1974, President Macias set a ban on firearms, and nearly all shotguns were confiscated. Officially a permit is now required to own a shotgun, and a separate licence to hunt. Rifles are still illegal throughout the country. Butynski (1994) found during surveys on Bioko conducted in 1986 that the primate encounter rate had actually increased since a previous study by Eisentraut (1973) in the late 1960s, and postulated that this may have been due to a combination of a decrease in gun-hunting as a result of the gun-ban, together with an increase in suitable primate habitat as a result of the abandonment of colonial cacao plantations. It has been suggested that the fact that there is a ready supply of marine fish may limit hunting on the island (http://www.bioko.org/primates/hunt.asp). However long-term work by Fa and colleagues suggests that hunting on the island is unsustainable (Albrechtsen *et al.*, in press; Fa, 2000; Fa & Juste, 1994; Fa *et al.*, 2002a; Fa *et al.*, 1995; Fa *et al.*, 2000; Juste & Fa, 1994; Juste *et al.*, 1995).

Less is known about the history of hunting in Río Muni since Sabater-Pi's work there several decades ago (e.g. Sabater-Pi, 1981; Sabater-Pi & Groves, 1972). There is clearly a major commercial bushmeat trade in both Bioko and Río Muni, documented mainly from market studies

(Fa, 2000; Fa *et al.*, 1995; Fa *et al.*, 2000; Juste *et al.*, 1995; Morra *et al.*, 2004; Puit, 2003). Non-market studies are rarer, but some studies have looked at rural hunting patterns (Colell *et al.*, 1994; Fa & Garcia Yuste, 2001; Keylock, 2002) and urban consumption (East, 2003; Fa *et al.*, 2002a).

Trapping with wire snares is the main type of hunting practised (Castroviejo Bolivar *et al.*, 1990; Heymans, 1994) in part due to the gun ban, making guns and cartridges expensive and hard to obtain ever since. There are several types of snares, which can be crudely separated into two main types: foot snares and neck or body snares. *Nga* are the most common type of foot snare, whereby the animal steps on a pressure pad, triggering a bent-over sapling to spring up and tighten the wire noose around their foot. *Ebeneñong* are the most common type of neck snare, usually aimed at rodents, often set outside their burrows or holes but also around fields set in stick fencing. *Abenquá* are set usually on fallen tree trunks, using a wooden frame to force the animal through the snare as it runs along the trunk/branch. *Nbong* are similar but set along tree branches. *Aberetong* are a more old-fashioned type of snare, designed to catch mandrills by the hand as they reach for bait. *Nkua* are specific bird traps.

Net hunting is not carried out in Río Muni, in part because it is not a traditional activity and in part due to the prohibitive cost of nets (people complained that they could not afford them to fish with, and it was cheaper to travel to Cameroon and buy them there oneself, pers. obs.). Specialised elephant, crocodile and parrot hunting are, however, carried out. Elephant hunting is carried out solely by Government-controlled, elephant-hunters, who are the only people licensed to use rifles, whereby when rogue, crop-raiding elephants are culled (under a Government-issued permit), the ivory is taken by the Government and the meat sold by the hunter. I was present for the butchering of one such elephant carcass near Binguru village in March 2003. Parrots are captured to supply a seemingly sporadic market for foreign export (reports from the two parrot hunters in my study village were that they sold them to either '*negros*' from Gabon or to '*blancos*' buying them to ship to Europe, including Britain). Freshwater crocodiles (*Osteolaemus tetraspis*) are a common sight in the markets in Bata and are usually caught by a limited number of specialised hunters, by lassoing them over the snout at night.

The bushmeat trade is in theory regulated by official protection of particular species from hunting (see appendix 2), as well as all hunting being prohibited in protected areas (Law No. 8/1988: República de Guinea Ecuatorial, 1988), with a maximum fine of 10,000 CFA (approximately US $18) levied. However, in practice laws are not enforced, and the bushmeat trade is completely open regardless of a species' legal status (with the exception of marine turtles, following a campaign by CUREF in 2002 to ban their trade; now the trade continues but has been forced underground: pers.

obs. and A. Formia, pers. comm.). Unlike other Central African countries (e.g. the Central African Republic: Noss, 1998c), there is no legislation banning trapping with wire snares. Although ECOFAC reported the removal of 2000 wire snares inside Monte Alén National Park by park guards during the first six months of 2002 (ECOFAC, 2002), the use of ECOFAC vehicles to transport bushmeat to the park headquarters and Bata was also common (pers. obs.).

1.4 STUDY AREA

This study follows the route of bushmeat from the Monte Mitra extension of Monte Alén National Park (the central third of the current park), through the village of Sendje, about 10 km to the west of the park, and up to Bata, the capital of Río Muni – a maximum distance of about 80 km from forest to market. A pilot trip was conducted in Río Muni in April-June 2002, predominately to settle on this study area, focus my research plan, and test some of my methodology. During the pilot trip I spent time familiarising myself with Bata and other areas of Río Muni, and then travelled to Sendje where I conducted initial focus group exercises, hunter and household interviews and accompanied a hunter in the forest for a three-day trip. The main fieldwork season, and the bulk of quantitative data collection, was then conducted from October 2002 to January 2004.

Bata

Bata is the largest urban centre on the mainland, with a population of 132,235 in 2001 according to the latest national census (Ministério de Planificación y Desarrollo Económico, 2002; but see comments above and below). It has historically always been of relatively minor political, social and to some extent economic importance next to the capital, Malabo, on Bioko, but the recent discovery of large oil deposits off the shores of Río Muni (much more than those in the waters around Malabo), has meant a rapid increase in domestic and foreign interest in the city. During the second half of 2003, a Danish construction company had started building a new camp for US employees of Triton-Hess, a Texas-based oil company granted the new oil concession off the coast of Río Muni, already substantially increasing the number of expatriates living in Bata (pers. obs.). The population of Bata is increasing rapidly as people move to the city in search of employment opportunities as a direct or indirect result of the oil boom.

There are two main markets in Bata, Central and Mundoasi, which are the main outlets for bushmeat in the city. Unlike other countries in the region where much bushmeat is not sold through the open market, such as Gabon (Starkey, 2004; Abernethy *et al.*, 2002) or Ghana (Cowlishaw *et*

al., 2005; Mendelson *et al.*, 2003), the majority of bushmeat sales, even of officially protected species such as apes, are made openly through these markets (pers obs.). The Central Market is supplied by bushmeat from south of Bata as far as and extending into parts of Monte Alén National Park (from along the Mbini and Cogo roads and the logging road that skirts the north-western border of the park). Mundoasi Market is supplied with bushmeat from a larger catchment area, spreading north to the Cameroon border and eastwards along the Ebibeyin road as far as Niefang district (about half-way across Río Muni) and to the south-east of Monte Alén National Park through Evinayong, almost down to the Gabon border (see chapter 2). To the east of the Niefang and Evinayong districts most bushmeat is traded north-eastwards to Mongomo (the President's home village) or Ebibeyin, both populous areas on the eastern border of Río Muni.

Sendje

The village of Sendje (throughout this thesis referred to as 'Sendje', but officially Sendje I, the centre of which is found about 1 km south of the river Uoro, and distinguished from the smaller neighbouring village of Sendje II just north of the river: see appendix 4) is 41 km south of Bata by dirt road (in the process of being paved since 2001) and is a major source of bushmeat for Bata's Central Market. It lies about 10 km west of the boundary of the Monte Mitra extension to Monte Alén National Park, accessible by disused logging track (appendices 3 and 4 and figure 1.3). In the past, there had been human settlements and logging camps throughout the surrounding area of forest, including within Monte Alén National Park, but following a Government policy upon Independence of regroupment of rural communities to the main roads (similar to that in Gabon: Starkey, 2004) and the cessation of logging in the area, these are now abandoned. A study by CUREF (1998) reported that about 1500 inhabitants, contained in the villages of Sendje, Binguru, Mitong, Emangos, Ncoho, Ncohambeng, Basilé and Mitong, live along the western periphery of the park.

Sendje is a reasonably large village for Equatorial Guinea, with a population of just over 300 recorded by this study (see chapter 3 for details). However, the 317 people (199 people 18 years of age or above) registered in my January 2003 census of Sendje contrasts to two recent official censuses taken of the village: the '*censo general*' in 2000, which gave a total of 543 inhabitants, and the 1995 '*censo electoral*', which counted 263 people over 18 years of age (J. Masolo, Sendje Village President, pers. comm.). Similarly, there is a lack of consensus between my household sizes and those of the 2001 census. They report a mean household size of 7.7 in Bata and 8.7 in rural Littoral province, whilst we found household sizes of 8.7 in Bata and 5.4 in Sendje. Given that both the overall and rural population of the country is reported to be increasing (Ministério de Planificación y Desarrollo Económico, 2002), this suggests that either my results or the official

census data would appear to be inaccurate, or that Sendje is an anomaly in bucking the national trend. As my stringent methodology and long-term presence in Sendje meant that I knew all households and most residents by name, it is unlikely that I could have missed more than a handful of people. Even allowing for sampling issues (for example, if the 2000 *censo general* included children away at school in Bata – see chapter 3), the electorate should be comparable. Unless there had been a dramatic emigration of Sendje residents during the previous couple of years before my study, which was not reported by anyone in the village or during focus group discussions, these findings again call the official national census data into doubt, at least at the rural level.

In the colonial era and for some years afterwards, many people were employed in plantations (mainly palm oil and coffee, which were found particularly to the west and south-west of Sendje as far as the coast and the river Uoro) and on logging concessions operating in and around the present park. After Independence, political instability and economic decline reduced employment opportunities, but some logging companies remained active around Sendje, and following the oil boom, recently construction companies have moved into the area mainly to improve/rebuild the Bata-Cogo road (Cogo is the main town on the southern border with Gabon), which runs through Sendje (table 1.1). This has provided employment for Sendje villagers on either a permanent (period of years) or a temporary/seasonal (weeks to months) basis, depending on their connections and skills and the needs of the company. Most jobs are as either manual labourers or skilled workers, such as truck/machinery drivers, chainsawers, surveyors and markers.

Many people also have links to Gabon (often with relatives there) and have either worked for some years, attended school or gained vocational training there (usually in Libreville, the capital). However, due to problems with work permits and general discrimination (Equatoguineans appear to some extent to be looked down on by many neighbouring countries, even though, for example, they have a high literacy rate for the region), as well as a feeling that Equatorial Guinea is their home, the majority eventually return.

In the absence of paid employment, the majority of men in the village are now largely dependent on hunting for a living. Many commercial hunters use the old villages and logging camps in the forest as hunter camps, many of which are inside the park, up to 30 km walk away and accessed by two main disused logging tracks that run north-east and south-east from the park border (see appendix 4 and chapters 4, 5 and 6). These hunter camps are well-established and more or less permanent, most having been in use for decades. Whilst the topography of the original 800 km^2 area of Monte

Alén National Park has been mapped, unfortunately no topological maps are available for the Monte Mitra extensions.

Table 1.1 Companies reported by focus group (June 2002) as active in or near Sendje since the colonial era.

Company name	Type of work	Dates active in Sendje	Notes
Izaguirre (Spanish)	Logging	Until 1969 (Independence)	Operated from Anvila to east of Sendje (now hunter camp within MANP). Logs transported via river to Mbini port.
Garita (Spanish)	Logging	Until 1969 (Independence)	Operated from Churu to south-east of Sendje (old hunter camp, now ECOFAC camp, within MANP). Logs transported via river to Mbini port.
Matransa (Spanish)	Logging	1985-6	Reconstructed logging road bisecting Sendje, to transport logs from forest to east to river to west.
Buertas Urcolas	Bridge construction	1993-1996	Reparation of collapsed bridge.
SOFOGE (Lebanese)	Logging	1994-1997	To west of Sendje. Logs transported via road north to Bata port.
SINOSA* (Chinese)	Logging	1995 (four months) 2003 (May – Aug.)	Both times cut short due to problems with Government permits – no wood actually removed. In 2003 built road about two-thirds of way to MANP border, but no trees felled.
SOCOBA (French)	Road construction	2000 - present	Based in Sendje II, north of bridge over R. Uoro. Paving road from Bata to bridge. Still no tar on road at end of 2003.
General Work (Italian)	Road construction	2001 - present	Based in Sendje II, north of bridge over R. Uoro. Improving and partly constructing new road from bridge south to Cogo (Gabon border).

* May be a subsidiary of Shimmer International (Puit & Ghiurghi, 2004)

Choice of study area

Sendje was identified as a possible site for this study following the publication of a survey of the offtake of 42 predominately commercial hunters over a 16 month period operating from Sendje in the Monte Mitra forest between January 1998 to April 1999 (Fa & Garcia Yuste, 2001). The authors recorded the movements of the hunters between hunter camps, and documented a dramatic drop in both catch and effort (in terms of days hunting) over the period of the study. They concluded that the offtake of six species (*Cephalophus dorsalis, C. callipygus, C. silvicultor, Mandrillus sphinx, Colobus satanus, Cercopithecus nictitans* and *Atherurus africanus*) was unsustainable in at least one camp each, and that of *C. dorsalis* in all camps. The existence of this prior study in the village therefore provides an interesting comparison for this study a few years later.

Sendje also proved to be an excellent choice of study site for several other reasons. Firstly, it is a major centre for commercial hunting supplying Bata, and thus is heavily influenced by and impacts on consumer demand from this nearby urban centre. Secondly, its geographical proximity to Bata and therefore short commodity chain meant that there was little leakage of bushmeat *en route* and

that I was just able, even as a lone researcher with limited logistical support, to study the entire chain single-handedly. Thirdly, its proximity to Monte Alén National Park (within which a large proportion of hunters from the village operate) makes the study particularly relevant to national conservation efforts and future management. Fourthly, the large number of active hunters operating from a well-established system of hunter camps over a large area was as close to an ideal experimental set-up as possible, enabling a detailed and extensive study of spatial and temporal hunter behaviour. Finally, recording the path of bushmeat at various stages proved to be relatively simple and straightforward. There was one main access route (an old logging road that had grown over into a path at the start of the study, but was reopened to provide logging truck access again in April 2003) from Sendje into the Monte Mitra forest area. The house I lodged in, that of the village president, was the first house in the village reached upon return from the forest. The sale of meat between hunters and traders was highly organised and predictable; the traders from Bata waited every Monday, Wednesday and Friday in the '*casa de palabra*' (outdoor covered seating area) of this house, where they bartered with the hunters and porters over the price of the carcasses. In fact, following a village meeting in September 2003, an official price list of different sizes and types of bushmeat was posted up in this trading post, although this did not appear to greatly reduce the need - or desire - to barter.

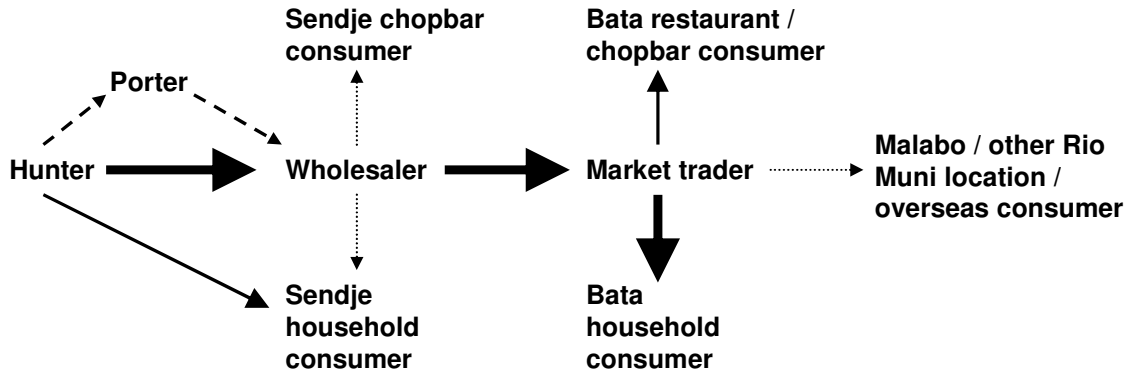
It is difficult to gauge accurately how typical Sendje is compared to other villages in Río Muni, given my limited experience of much of the country (my opportunity to travel being restricted by permit and time constraints) and the paucity of other sources of information. Sendje is in the littoral region, a coastal strip about 50 km wide as far as the Niefang mountain chain that runs through Monte Alén National Park. Many people living in villages along the road between Sendje and Bata have close ties with and family and/or jobs in Bata. While most villages in this zone conduct some hunting, hunting for the commercial trade appears to be a more important livelihood in Sendje than neighbouring villages, due mainly to its access to a larger than average area of uninhabited forest (the central third of Monte Alén National Park). The fact that non-native hunters came to Sendje from other areas of Río Muni to hunt both during this study and that of Fa and Garcia Yuste (2001) would appear to support this conclusion. During this study, large volumes of bushmeat were also arriving in Bata's markets from other villages around Monte Alén National Park, particularly from those in previously more remote areas to the south-east that were currently or formerly being actively logged, such as Taguete and Midyobo-Anvom (Puit, 2003), and it seems that the structure, size and the availability of alternative livelihood options in these other villages, in the central part of Río Muni, is to some extent comparable to Sendje.

In the littoral region, whilst plantations were seemingly productive during colonial times, agriculture is now generally only practised for subsistence, with '*yuka*' (cassava) and peanut being the main staples. However, agriculture is a more important livelihood activity in other areas of Río Muni, in particular the more populous north-east, and hunting less prevalent (S. Allebone-Webb, pers. comm.). There may therefore to some extent be differing hunting and other livelihood opportunities between the north-east and north-central part of Río Muni, compared to the west and south-central areas, although as a result of lack of investment by the government for decades, nowhere in the country is there a thriving rural economy. Agricultural trade from even the most productive villages is largely domestic, in contrast to other countries in the region such as Cameroon, Nigeria or Ghana, where agriculture is a major export earner. In this respect, the structure and economy of Río Muni is closer to that of Gabon.

Monte Mitra – Sendje – Bata commodity chain

The commodity chain in Río Muni is relatively simple and short and 'leakage' of bushmeat *en route* to market appears to be minimal in comparison to the few other studies of commodity chains conducted in the region, such as Gabon (Abernethy *et al.*, 2002), Ghana (Cowlishaw *et al.*, 2005) and the Democratic Republic of Congo (de Merode, 1998). This is mainly due to Río Muni's small size and limited number of important urban centres, but also because the trade is quite open and thus meat can pass relatively unhindered from producer to consumer. The main flow of bushmeat is from the hunter via a wholesaler in Sendje (usually female traders from Bata) and a market trader in the Central Market to a Bata household consumer. The other actors in the chain are porters who transport meat between the hunter (usually when based in a hunter camp), and four other types of more minor consumer: Sendje household and occasional informal chopbar consumers, Bata restaurant/chopbar consumers and consumers from elsewhere (commonly Malabo and other locations in Río Muni, and probably other countries – although very little is known about the foreign export element of the trade). There are occasional transactions between other actors not included in figure 1.4, such as gifts of bushmeat from a hunter not native to Sendje to his family in Bata or another village, but for simplicity I have included only the more common and therefore more important pathways in the figure. The majority of bushmeat caught in the Monte Mitra forest is sold, mostly to Bata rather than within the village, and of this, most ends up being consumed by Bata households (see chapter 2). There appears to be little or no trade of bushmeat from Sendje south, towards or to Gabon, although there are reports of cross-border trade from villages around Cogo in the south-west and in the relatively sparsely inhabited south-central area of Río Muni (figure 1.3).

Figure 1.4 Patterns of trade in the bushmeat commodity chain through Sendje (from Kümpel *et al*, in press). The majority of bushmeat flows from the 'hunter' (operating in the Monte Mitra forest) via the 'wholesaler' (usually a female trader from Bata) and a 'market trader' (operating in the Central Market) to the consumer (usually a Bata household); this flow is marked with thick arrows. The thinner and dashed arrows demarcate the flow of progressively smaller relative volumes of bushmeat.



1.5 STRUCTURE OF THE THESIS

The aim of this work is to evaluate the factors influencing the incentives for hunting[1] and ultimately the effect of hunting on wildlife populations. I do this by first considering each element of the commodity chain as pictured in figure 1.1, from demand down to supply (chapters 2-6), and finally considering the interactions between them (chapter 7).

In chapter 2, I address the demand for bushmeat, using household interviews, market and restaurant consumer interviews, trader interviews, and market surveys (both conducted as part of this study and taken from the literature), to evaluate the determinants of bushmeat consumption in urban and rural locations, and the interactions between price, preference and availability of bushmeat and its alternatives. I then look at how Bata bushmeat market trends over the past decade may demonstrate changes in the spatial pattern of hunting across Río Muni. Finally I put this in the context of changes in the economy, and predict how demand for bushmeat may change in the future.

[1] Note that throughout thesis I refer to 'hunting' as a generic term for all methods of capturing animals, whilst 'gun-hunting' is used to refer explicity to shooting (as opposed to trapping, for example).

I use a combination of household interviews, hunter interviews, wealth categorisation and a village offtake survey in chapter 3 to look at bushmeat as a component of rural livelihoods in the village of Sendje. I consider the extent to which households and individuals use bushmeat as an income or food resource, and what determines household hunting and consumption of bushmeat.

I consider the individual hunter and what influences his hunting behaviour in chapter 4, using hunter interviews, trapper and gun-hunter follows and a village offtake survey. Firstly, I focus on trapping and evaluate the factors determining the success rate of individual hunters, traps and camps. I then address what triggers trapper movement within and between camps. Finally I look at what determines the gear type used, and what conditions might trigger a switch from one gear type to another.

In chapter 5, I examine the effects of gun-hunting on diurnal primates, the most common target of gun-hunters from Sendje, using mammal surveys, hunter interviews, gun-hunter follows and a village offtake survey. I estimate densities of primates in a relatively unhunted area, consider the amount and type of gun-hunting currently being practised in the Monte Mitra area, and then consider the effects of this level of gun-hunting on primate populations in a more heavily hunted area. I then consider the conservation implications of gun-hunting in Río Muni and suggest appropriate policy action.

The final data analysis chapter (chapter 6) then addresses the sustainability of hunting in the Monte Mitra area, using hunter interviews, trapper follows, a village offtake survey and hunter camp consumption diaries. I look at evidence for sustainability on three different time-scales: over the course of this study period (just over a year), since the previous study conducted in the area by Fa and Garcia Yuste (2001) five years previously, and since 1990 from hunter interviews conducted during my study.

Finally, I discuss the significance of these findings and implications for policy in chapter 7.

Chapter 2

Economic drivers of the bushmeat trade in Río Muni

2.1 INTRODUCTION

Humans have been hunting bushmeat for subsistence in the forests of equatorial Africa for millennia. However the size of human populations in forested areas has increased dramatically in recent years due to factors such as population growth, habitat loss and improved access, often ultimately exacerbated by international markets. As a result, bushmeat consumption in many areas is now thought to be unsustainable (e.g. Bakarr *et al.*, 2001; Milner-Gulland *et al.*, 2003; Robinson and Bennett, 2000b). Why people consume bushmeat is not well-understood, and generally varies between urban and rural areas and between economically disparate countries or regions. It has often been assumed that rural people are dependent on bushmeat for basic food supply (Milner-Gulland *et al.*, 2003; Ntiamoa-Baidu, 1998a) but increasingly studies have found bushmeat to be more important as a source of income for rural communities, enabling them to participate in a market economy (e.g. de Merode *et al.*, 2004). This commercial trade depends on market demand for bushmeat, and increasing demand from urban populations is widely perceived to be behind the increasingly unsustainable rate of bushmeat harvesting. The reasons for both rural and urban demand for bushmeat vary; in some cases it may be due to a lack of other acceptable or affordable alternatives, whereas in others bushmeat may be a luxury good for which a wealthy elite are willing to pay premium prices (Asibey & Child, 1991). Undertanding the determinants of bushmeat consumption is a critical first step in designing effective policy to mitigate the effects of an unsustainable trade, from both a conservation and development perspective.

Often a preference for bushmeat over domestic meats or fish, as part of one's 'traditional heritage', is assumed (particularly for urban consumers). However such an assumption ignores the great variability in taste, availability and price within the 'bushmeat' category. Traditional or religious preferences and taboos can become eroded as cultural identities are homogenised and the basic need for protein increases (Bowen-Jones, 1998; Peres, 1990). In addition, preferences may in reality be linked to availability or the perceived cost of alternatives.

To date there have been very few empirical studies analysing the determinants of bushmeat consumption. A study by Anstey (1991) describes changing consumption patterns and preferences for bushmeat in Liberia: preference for bushmeat in general decreased as consumption frequency decreased, as did preference for individual species as they became rarer. These results suggest that preferences are not static but linked to consumption, which in turn may be linked to price or availability. Conversely, Fa (2002a) found distinct differences in the preferences for different bushmeat species between the Fang and Bubi ethnic groups on Bioko Island, Equatorial Guinea. For the Bubi, preference for and consumption of bushmeat species was linked to price and availability, as they generally could only afford the cheaper and more widely available bushmeat species. For the Fang, there was a lack of correspondence between preferred and consumed meats. The authors attributed this to the fact that the Fang, having originated from the mainland, have historically been exposed to many more species, and therefore retain preferences for foods they no longer consume. However, some Fang may still have been consuming their favoured species, either as imports from or on visits to continental Río Muni. Traders from Bata's Central Market reported during the current study that certain clients fly over from Bioko and request particular bushmeat species that are unavailable on the island, such as tortoises, crocodiles and red river hogs (pers. obs.).

A shortcoming of many such studies is that they only consider consumption and preferences for bushmeat, and fail to include alternative protein sources. However, recently researchers in Gabon conducted two-choice taste tests, consisting of a popular type of bushmeat versus a popular type of domestic meat, on both urban and rural consumers (Schenck *et al.*, 2006). They found only a weak preference for bushmeat overall (even though the study sample over-represented bushmeat consumers), and that only rural consumers had a consistent preference for bushmeat over domestic meat. They concluded that not simply taste but also price, familiarity, tradition and prestige drive the demand for bushmeat. They also found that consumers differentiate between bushmeat species, and therefore substitutes like fish and chicken may vary in their acceptability depending on the species of bushmeat. In addition, fish, chicken and livestock may be acceptable substitutes for certain types of bushmeat, whilst non-preferred wildlife species may not.

Changes in wealth and income, and the prices of bushmeat and its substitutes, are also likely to affect consumption patterns. The direction and magnitude of these changes in consumption are determined by the income and price elasticities of demand (Apaza *et al.*, 2002; Wilkie & Godoy, 2001). If demand for a food type is elastic with respect to income or price, the quantity demanded is strongly affected by income or price. With respect to income elasticity, a superior (or luxury) food type is one whose consumption increases by greater than 1% for every percent increase in

income, a necessity is one whose consumption increases between 0 and 1% for a percent increase in income, and an inferior food type is one whose consumption falls with rising income. Wilkie *et al.* (2005) studied the role of prices and wealth in consumer demand for bushmeat in Gabon - the only study of its kind conducted in Africa to date. They found that consumption of bushmeat, fish, chicken and livestock all increased with wealth and where the price of these foods was higher, consumption was lower. This effect of income on consumption was also greater for poorer households than for richer ones. This has important implications for conservation, implying that overall economic development aimed at the poorest members of society may in turn disproportionately increase bushmeat consumption.

It is necessary to understand why people are eating bushmeat, both to predict the effects of changing economics on consumer behaviour and thus its implications for sustainability of the bushmeat trade, and to evaluate the effects of policies on potentially vulnerable actors in the commodity chain. If urban consumption is indeed driving hunting, we need to understand how, whether it is targeting and threatening particular species, and, if so, what policies might work to conserve wildlife without compromising food security, cultural tradition, national development or people's ability to meet basic needs.

This chapter assesses the relationship between consumption of different types of meat and fish, the price and availability of these products, and the income and preferences of its consumers. In doing so, I make a comparison between the city of Bata and the village of Sendje in Río Muni, Equatorial Guinea, and consider changes in bushmeat availability in Bata's markets over time. Surveys were carried out of households, bushmeat consumers and markets in Bata, and households, hunters and offtake in Sendje, in order to get a detailed understanding of the different determinants of bushmeat consumption. By comparing bushmeat consumption and preferences to those for other commodities, I place it within the context of available substitutes. I then predict future changes in consumption, given likely economic development within the country, and suggest possible policy responses.

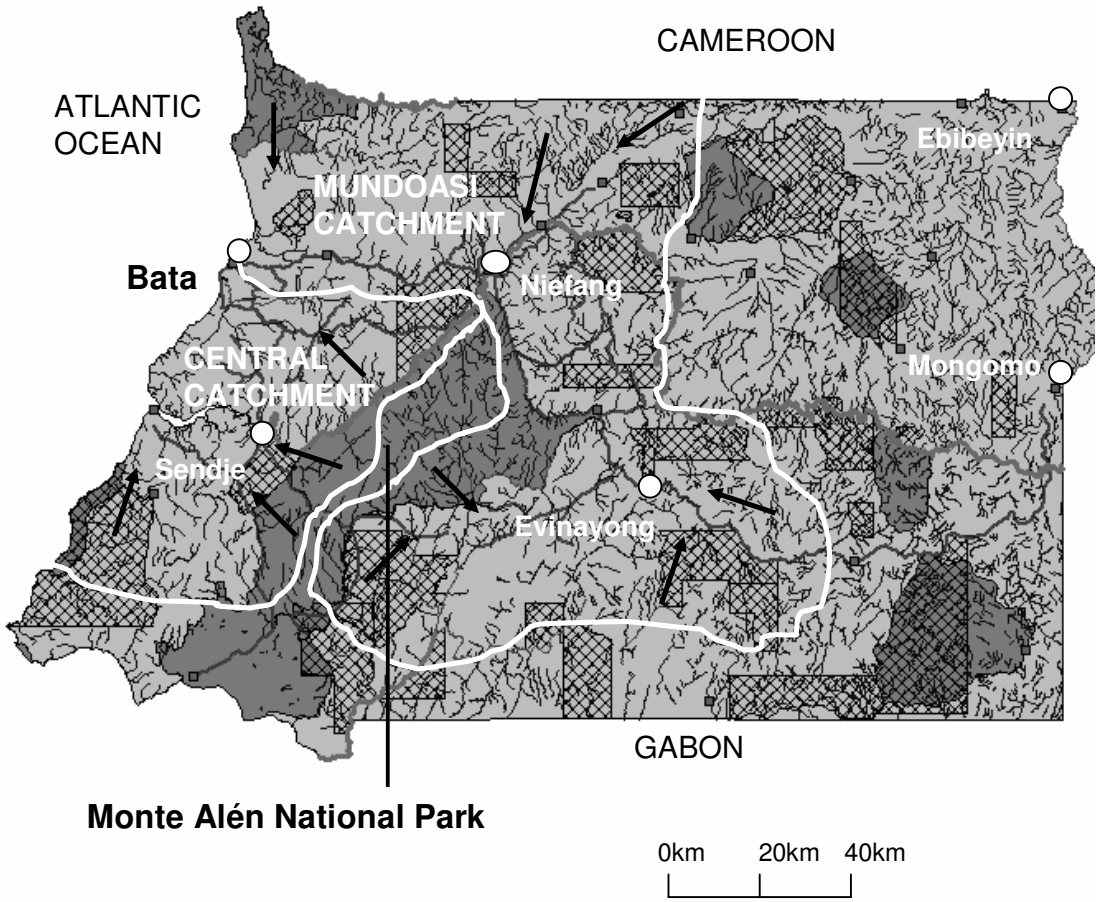
2.2 METHODS

2.2.1 Study area

Bata, the regional capital of Río Muni, is starting to experience a boom in income and population, caused by an emerging oil industry (Pigeonnière, 2001). The official monthly minimum wage has

increased from 25,000 CFA (US $46) in 2000 to 97,000 CFA (US $177) in 2003 (J. Ferreiro Villarino, pers. comm.). Taking 2000 as the base year, this equates to an inflation-adjusted income of 79,780 CFA (US $149) in 2003 (IMF, 2005) – thus over triple that of three years previously, in real terms. The country is attracting much foreign investment (Equatorial Guinea recently received the 4th largest investment from the USA in sub-Saharan Africa: EIA, 2003). The city of Bata has expanded rapidly in the last few years, with a population of 78,684 recorded in the 1994 National Census and 132,235 in the 2001 National Census (Ministério de Planificación y Desarrollo Económico, 2002). That said, it should be stressed that government census data differs greatly from the majority of international estimates; the former gives a 2003 national population projection of 1,157,000, whereas the World Bank estimate for that year is 494,000 (World Bank, 2004).

Figure 2.1 Approximate bushmeat market catchments on Río Muni. Bata, Sendje and Monte Alén National Park are marked. Protected areas are shaded in dark grey. Monte Alén National Park, the border of which is about 10 km east of Sendje, is the largest protected area in Equatorial Guinea at 2000 km^2. Hatched areas are active logging concessions in 2002 (note the overlap of some concessions with protected areas). The approximate catchment areas for Mundoasi and Central markets are outlined in white (although there is some overlap between the two markets). Black arrows indicate the direction of bushmeat trade.



There are two main markets in Bata, Central and Mundoasi, which are the main outlets for bushmeat in the city. See chapter 1 for a description of market catchments and the bushmeat supply chain in Río Muni. The village of Sendje is a major source of bushmeat for Bata's Central Market. It is situated 41 km south of Bata by dirt road, and about 10 km west of Monte Alén National Park. In the colonial era and for some years afterwards many people were employed in plantations and on logging concessions in the surrounding area. But since independence political instability and economic decline have limited employment opportunities, and the majority of men in the village are now largely dependent on hunting for a living.

The bushmeat trade in Equatorial Guinea is little known, particularly in Río Muni. However the trade is prevalent (Bowen-Jones, 1998) and likely to be at least locally unsustainable (Bakarr *et al.*, 2001; Fa & Garcia Yuste, 2001; Fa *et al.*, 1995). There are still extensive tracts of forest in the country, sheltering relatively rich wildlife populations, including great apes (Garcia, 1997; Gonzalez Kirchner, 1994; pers. obs.). The bushmeat trade is in theory regulated by official protection of particular species, but in practice laws are not enforced, and the trade is completely open regardless of a species' legal status.

2.2.2 Meat and fish availability and prices

The number of each bushmeat species on sale in the Central Market was recorded daily by a long-term market research assistant (a frozen meat stallholder opposite the bushmeat stalls) from December 2002 to December 2003 (a total of 336 survey days). He was educated to secondary level, and knew the market and traders well. The market research assistant was actually selected by a previous research assistant, with whom I had been working closely in the market from October to November 2002, but was due to leave for a college scholarship in Spain in January 2003. I spent this period getting to know the market traders and teaching her how to measure animals and record data systematically. Following the unexpected announcement of the Presidential election for 15th December and advice to avoid being in Equatorial Guinea during the entire month-long campaign period and direct aftermath, I left the country on 14th November and thus had to entrust subsequent market data collection and training of a replacement to this original research assistant. I then conducted extensive checks on the quality of the new research assistant's data collection upon my return to Bata after the election, and continued to make random visits every week or two throughout the survey period to ensure that data recorded in his notebook (which were then transcribed onto pre-printed data sheets in the evening) were accurate.

The bushmeat market traders were given small gifts of items such as household crockery or jewellery every four months or so, to thank them for their continued compliance and patience with

the daily questions required of the survey. However, even with these gifts, some of the trader women were at times unwilling to cooperate fully and often the research assistant was busy on his own stall, so the record of carcasses is incomplete. An attempt was made to record carcass age, sex, method of capture (e.g. gun, leg or neck snare), state (e.g. live, fresh, smoked, singed or rotten), head-body length and location of capture, but as this information required detailed questions and/or interference with the animals themselves, this was often not attempted due to the issues outlined above and thus information on these variables is incomplete. I therefore do not include it in my analyses here.

Prices of all common species were recorded in two periods: first, during December 2002, by a different local research assistant asking market traders how much they would charge for each carcass or part carcass, and second, between May and July 2003, by a collaborating MSc student from Imperial College London, Tamsyn East, who noted actual transaction prices at the point of sale, before interviewing the purchaser. These two sets of prices were cross-checked with each other (Pearson's product-moment correlation = 0.99, n = 10, $p < 0.001$, two-tailed) and with the Sendje offtake prices (Pearson's correlation = 0.935, n = 8, $p < 0.001$), and the strong correlation between them confirmed that both methodologies were sound (see appendix 2.1). Stated prices were also sporadically recorded by the market research assistant throughout 2003 and these were used for those rarer species which had not been recorded during the other three price surveys. Availability of frozen domestic meat and fish for sale in the market was recorded on a daily basis during February and March 2003 by a vegetable stallholder and standard prices per kilogram were recorded throughout the main study period. Availability and prices of all fresh domestic meat and fish within the market were recorded from July to December 2003 by the long-term market research assistant.

The price of all bushmeat and other meat and fish available in Sendje was recorded from January to December 2003 during village offtake and household consumption surveys (see chapter 3). Using these data, the mean price of meat and fish types in Sendje (which did not fluctuate apart from a slight universal increase in May 2003, in line with an increase in the official minimum wage) were compared with those in Bata (see appendix 2.1). Hunter offtake data during the same period were used to estimate the proportion of bushmeat of different species traded.

2.2.3 Bata consumption

In order to evaluate urban drivers of meat and fish consumption, interviews were conducted in Bata between May and July 2003 by Tamsyn East, with a stratified, random sample of households and an opportunistic sample of fresh meat and fish purchasers in the Central Market, one of the two main markets in Bata (East, 2003).

Sampling for the household survey was done by first obtaining a recent map of the city, on which all districts were marked (about 20, excluding the surrounding suburbs). Eleven districts were randomly chosen from this map for interviews, in an attempt to cover as much of the city as possible. For all interviews, Tamsyn was accompanied by a local Bata resident, a female employee of the ECOFAC project, who was fluent in the main languages spoken in Bata, Fang, Kombé and Spanish. The assistant assisted in explaining the reasons for the study, answering respondents' questions and general translation. Within each district, a zig-zag transect walk was carried out. After each one minute period of walking, the nearest available house in which someone was prepared to be interviewed was surveyed. Only two households declined to be interviewed. The zig-zag approach ensured that houses off the street were sampled as well as those on streets, and the one minute interval between households allowed an entire district to be sampled with a sample size of approximately nine households per district. One hundred households were sampled, representing 867 people. 91% of these were Equatoguinean, of whom 73% were of the Fang tribe (traditionally from the interior), 25% were Ndowe (a coastal tribe), and the remaining 2% Bubi (from the island of Bioko, where Malabo, the capital of Equatorial Guinea, is situated). The interview was normally conducted with the household head, together with the person responsible for preparing the meals (usually his wife or wives). Interviewees were questioned on household structure and presence of selected wealth indicators, and asked to name their first, second and third most consumed and most preferred meat and fish types (including state, if relevant – e.g. fresh, frozen or smoked). They were also asked about taboo foods, why they consider it is important to eat meat and if there are any foods they consider substitutes.

In order to obtain a measure of wealth for respondents, a focus group of four key informants from CUREF, all of secondary or tertiary education level and residents of Bata, was interviewed. Whilst not representative of the population of Bata, they were well-informed and relatively impartial, being to some extent familiar with the point of the study and socio-economic research in general, and the best candidates available given the severe limitations on time. These informants identified income rather than wealth as the major factor in consumption decisions, and employment as the key determinant of income. They also identified a number of indicators of income such as lighting and

cooking facilities, house type and vehicles. A list of possible income indicators was drawn up based on the focus group discussion (see East, 2003, for detail).

At the end of the household interviews, respondents were asked to indicate into which of 13 categories their total household earnings in the last month fell. However 45% of respondents declined to indicate a category. In order to obtain an income category for these non-responders, indicator assets were tested for their association with income category for responding households, using both forward and backward stepwise regression. The best explanatory model included cooking method used (fire, petrol stove, gas hob, oven), number of fans in the household and number of mobile phones in the household ($R^2 = 0.706$, $df = 6$, $p < 0.001$). These indicator variables appeared from observation to correspond with income, and the first two were also identified as important in the focus group. The model was used to assign income categories to the 45% of non-responders, all of whom had been happy to provide information on household assets. Household income in the sample followed an approximately normal distribution across categories, with a modal category of 50,000-100,000 CFAs/month (535 CFA = US$1).

The market consumer survey encompassed all of the stalls in the Central Market that sold fresh meat or fish. All interviews were conducted by Tamsyn herself, after spending several days in the market familiarising herself with the layout and species on sale, and building up trust and friendship with the traders, blow-torchers and porters. There were seven stalls selling predominantly bushmeat (as well as a limited number of locally-sourced domestic animals such as poultry, pigs and goats), four selling fresh fish and one butcher's shop selling imported beef and goat. Each stall was visited a number of times (between 5 and 30 times per stall), split evenly between different days of the week, with a higher visitation rate to the bushmeat stalls than the fish or butcher's stalls. One hundred and sixty interviews were conducted with people directly after they had made a purchase (100 at the bushmeat stalls and 30 each at the fresh fish and butcher's stalls). The interviews took place throughout the opening times of the market (7am-6pm) but with more in the mornings when the market was busier. The interviews were brief as people were usually not willing to spend long answering many, complicated questions whilst in the course of doing their shopping. Tamsyn either listened in on the transaction between buyer and seller and recorded the transaction price of the purchase directly, or otherwise asked the buyer the price subsequently. In nearly all cases the buyer was happy to name the price. The interviews included basic information on the market consumer's age, sex, job and education level, as well questions on the interviewees' top three most consumed and most preferred meat and fish types, as for the household interviews. It was not feasible to obtain information on income class or indicator assets, hence the occupation of the household head was recorded as a proxy for wealth, based on the focus group's assessment

that this was the most important single wealth determinant (see table 2.1 for a summary of head of household occupations for both the Bata and Sendje household samples).

Table 2.1 Occupation of household head (or main income-contributor for the household) for Bata market consumer (n = 80), Bata household (n = 100) and Sendje household (n = 41) samples, with percentage of occupations in each income category.

Income rank	Occupation of household head	Bata market consumers	Bata households	Sendje households
High	Accountant/banker/lawyer	6	4	0
High	Business manager/director	13	5	0
High	Civil servant	11	10	0
High	Doctor/nurse	3	3	0
High	Engineer/architect	2	5	0
High	Military/police	8	2	0
High	Office worker	2	2	0
High	Senior-level government	2	4	0
High	Teacher/lecturer	4	6	0
	Sub-total	**64%**	**41%**	**0%**
Medium	Bar/restaurant/cook/maid	9	4	0
Medium	Construction worker	2	3	0
Medium	Driver	2	5	0
Medium	Factory worker	0	1	0
Medium	Manual labour	0	4	2
Medium	Religious	0	1	0
Medium	Skilled worker	7	21	5
Medium	Trader (small-scale)	5	7	3
	Sub-total	**31%**	**46%**	**24%**
Low	Housewife	0	4	0
Low	Peasant	0	4	31
Low	Student	1	1	0
Low	Unemployed	3	3	0
	Sub-total	**5%**	**12%**	**76%**

2.2.4 Sendje consumption

I conducted a study of rural consumption and preferences in Sendje in June 2002 during the pilot study, in collaboration with another MSc student from Imperial College London, Nick Keylock (Keylock, 2002). We first conducted participatory exercises with a focus group of 4-6 people of mixed age and sex (the composition of the group varied according to availability of participants over the four-day period during which the exercises were conducted), during which a village map

was drawn and all 56 permanently resident households given a code (appendix 3). From this list, 41 households (accounting for 288 people) were then interviewed at random according to availability, ensuring that all areas of the village were covered equally. All people in Sendje were Fang, within seven different sub-tribes.

The majority of interviews were carried out with just one respondent (53%), who in most cases (86%) was the head of the household. As for the Bata household survey, interviews were normally conducted with the head of the household (86% of the time), with the person responsible for preparing the meals also present in about half of the interviews. Ideally, both would have been present in all interviews, but this was not feasible due to tight time constraints during the pilot trip. Interviewees were asked about household structure, livelihood activities carried out by each member of the household, and regularity of consumption (five categories: most days, weekly, monthly, rarely or never) and preference (five categories: love, like, neither like nor dislike, don't like or hate) for 37 different food types of different states. As for the Bata households, interviewees were also asked about taboo foods and meat substitutes. Interviewees were provided with cigarettes for the adults and sweets for the children during the interviews, and thanked for their participation at the end. At the end of the pilot study, the members of the focus group were given gifts of a bottle of brandy each and a special dinner, and exercise books, pencils and footballs were donated to the village school, to show our gratitude to the entire village for their friendship, openness and assistance, and to help ensure a warm welcome upon my return for the main field season.

2.2.5 The restaurant trade

In order to determine the relative importance of restaurants in the bushmeat trade, I carried out a long-term survey from December 2002 to November 2003 of the daily availability, price and source of different dishes for 'chopbars' (small cafés selling traditional meat stews) and restaurants around the Central Market, using local female research assistants. The research assistants usually observed the dishes directly. As for the market traders, the chopbar owners and restaurateurs were thanked and encouraged to comply with the survey with gifts of small items such as cutlery and crockery every four months or so. Detailed consumer and restaurateur interviews were also conducted by Tamsyn East between May and July 2003. There were up to 40 chopbar stalls (usually only 15-30 open on any one day) selling cooked food within the Central Market, ranging from kidney bean baguettes to frozen and fresh meat/fish stews; in these budget establishments bushmeat dishes were rarely available due to their relatively high cost. Two of the few chopbar stalls regularly selling bushmeat were chosen for detailed interviews. There were 11 small-scale restaurant-bars in the immediate vicinity of the market, which sold more expensive fresh meat or fish dishes, including bushmeat; such establishments abound in the streets of Bata. Three of these, which regularly sold

bushmeat dishes, were randomly chosen for interviews. There were only three large-scale restaurants in the entire city which sold bushmeat; all of these were also targeted for interviews. Interviews involved spending the day in the restaurant, talking informally to the owner and interviewing up to five independent customers per restaurant (not from the same group). A total of eight chopbar and restaurant owners and 37 customers were interviewed.

2.2.6 Bushmeat market trends

The proportion and absolute numbers of different taxa observed in this survey of the Central Market in Bata were compared with a survey of Mundoasi Market (the other main bushmeat market in Bata) conducted as part of my project, from April to May 2003 (a total of 50 days, on all days of the week), in collaboration with a Belgian MSc student from Université de Liège, Marielle Puit (Puit, 2003), as well as with a previous survey of both Central and Mundoasi Markets (212 days each, across all months of the year) conducted between 1991 and 1992 (Fa *et al.*, 1995). Possible differences due to seasonal bias were tested for and this was found to be non-significant.

Interviews were also conducted with the three Bata-based female traders who had been visiting Sendje on a regular basis for 10, 16 and 17 years respectively, and were also active in the market itself, to help elucidate changes in the broader spatial and temporal dynamics of the bushmeat trade.

2.3 RESULTS

2.3.1 Availability and price of meat and fish

Availability of fresh meat and fish varied with the day and the weather (rather than season *per se*) and between commodities. In Bata, fresh beef and goat were available every day from the butcher's shop in the Central Market, but often sold out by midday; this was the only source of fresh beef in the city until late 2003, when two other butchers shops opened (see appendix 2.2 for market layout). The shop imported live cattle from Cameroon on a monthly basis, slaughtering one every day or two, and also usually sold 2-3 goats per day. Some fresh fish was available daily in the market from up to four stalls, except after heavy rains (which prevented fishing), but tended to sell out early in the morning. Many people preferred to buy directly from the fishermen on the beach at dawn where the price was cheaper and the choice was greater.

A total of 11,574 carcasses of 42 species (fresh, singed or smoked) were recorded on the seven bushmeat stalls in the Central Market between January and December 2003 (appendix 2.2). This

should be treated as a sample of the total number of carcasses on sale, due to the issues discussed in the methods section above, but as there was no enforcement of trade bans in the market, it is unlikely to be biased towards any particular species for these reasons (but see section 2.3.7). Saturday was the busiest day with most carcasses available, and the fewest available on Sundays. Volume of bushmeat in the market varied slightly by month (ranging from 851 carcasses in December to 1164 in February) but was not correlated with mean rainfall or minimum/maximum temperature or agricultural cycle. Although there was less bushmeat when the previous day had been rainy, no direct correspondence with wet/dry season was observed (probably because, at least for 2003, there was some rain in most months and the distinction between wet and dry season was not very marked; see appendix 1 for monthly weather patterns). Bushmeat arrived throughout the morning and some was usually still available in the afternoons. All bushmeat was sold openly, including those species which were officially illegal to hunt or trade. Appendix 2.3 lists the prices of bushmeat species most commonly on sale in the Central Market during the study period.

Also available on the bushmeat stalls were pigs, goats, sheep, chickens and ducks, as well as freshwater fish, crayfish and crabs, the majority having been brought from villages outside Bata with the bushmeat. The proportion of fresh livestock arriving from the villages was generally very low compared to bushmeat, apart from the period leading up to Christmas and New Year, when people traditionally eat livestock; large numbers of live goats and pigs were available at this time (out of a total of 455 pigs and goats recorded throughout the whole year, 23 were recorded on 24/12/03 and 50 on 31/12/03). The fact that all locally-produced fresh domestic meat was sold on the bushmeat stalls is important; both perception and price of these domestic species was similar to that of wild-caught analogues.

Many types of imported frozen meat and fish were widely available throughout Bata, most commonly mackerel (*Scomber* spp.) and various cuts of chicken, pork and beef, sold in local shops and supermarkets as well as 27 stalls in the Central Market. Price per kilogram only varied very slightly by outlet type (for example, frozen chicken thighs were 1200 CFA/kg (US $2.24/kg) in the markets and 1300 CFA/kg (US $2.43/kg) in the supermarkets) and remained constant in Bata throughout 2003. Much greater volumes of frozen produce than fresh were available in the market and throughout the city in general. However, this has only recently been the case; one of the bushmeat traders interviewed stated that frozen produce was not available in Bata before 1988-9, when imports from neighbouring Gabon began, and that now frozen produce comes mainly from Europe it is much cheaper than it used to be.

In Sendje, although nearly every household owned chickens or ducks, and sometimes goats as well, they were generally only reared to sell at market or reserved for consumption on special occasions such as weddings. As 34 out of the 41 households contained men who hunted to some extent, and most households (men, women and children) did some freshwater fishing, both bushmeat and fresh fish were widely available in the village, either from the household's own catch or through purchase of another household's surplus.

Availability of frozen meat and fish in Sendje increased during the study period. In 2002 only occasionally was frozen produce, usually mackerel, sold in Sendje itself as none of the bars had freezing capacity, and the only source was the shop of a road construction company camp based 2 km away in a neighbouring village. However, in early 2003 one of Sendje's wealthier bars purchased a generator and chest freezer and began to sell a variety of frozen produce in the village itself. Prices of frozen produce were the same whether purchased in Sendje or the next-door village, but underwent a universal increase in May 2003, following an increase in the official minimum wage by the Government in April 2003 (for example, frozen chicken thighs increased in price from 1200 CFA/kg (US $2.24/kg) to 1300 CFA/kg (US $2.43/kg)).

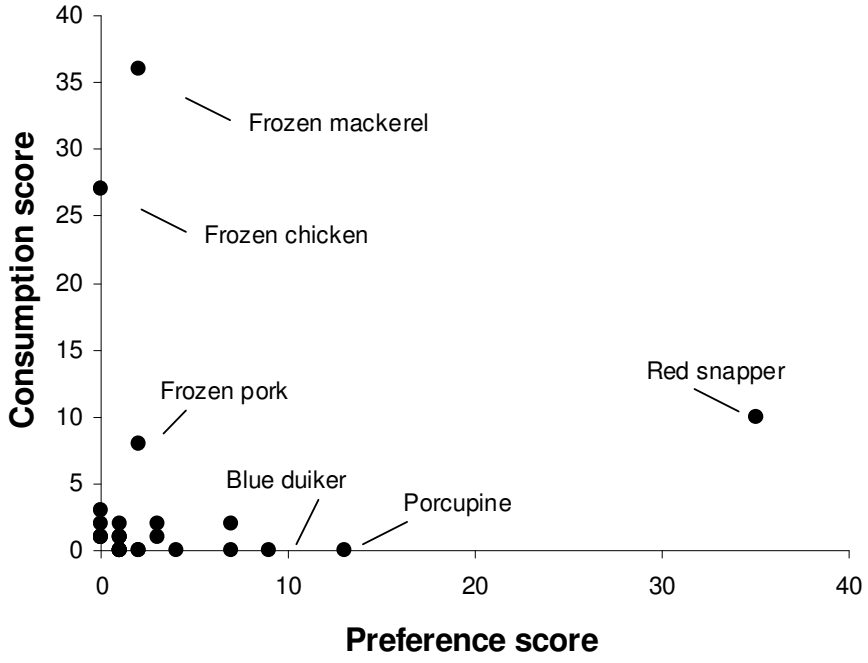
2.3.2 Consumption and preference

Twenty-nine meat and fish types were cited as most consumed or most preferred by households in the Bata household survey. The number of times each meat or fish type was rated top for consumption or preference was summed to give a score for each food type. There was a clear negative relationship between consumption and preference, with the most highly preferred types tending to have low consumption scores, and vice-versa (figure 2.2). The top five most preferred foods were all fresh fish or bushmeat species: red snapper (*Lutjanus campechanus*) was the most preferred food (35/99 first-choice responses), followed by porcupine (*Atherurus africanus*) and then blue duiker (*Cephalophus monticola*). The top five most consumed foods were all frozen, with frozen mackerel first, closely followed by frozen chicken and then frozen pork. No bushmeat types were cited as most consumed (hence the zero consumption score for porcupine and blue duiker in figure 2.2) but three species (porcupine, blue duiker and pangolin, *Phataginus tricuspis*) were mentioned as second or third most consumed by a handful of households.

There was a negative relationship between consumption and preference for Bata households when consumption and preference scores were summed within broader categories (figure 2.3a). Frozen fish was the least preferred but most consumed food type, while fresh fish and bushmeat were the most preferred types, but were relatively infrequently consumed. A similar, but less polarised, pattern of differences between consumption and preferences could be seen in Sendje (figure 2.3b).

Again frozen fish was the most consumed food type and fresh fish the most preferred. However, consumption patterns were much closer to preferences, suggesting that there were fewer constraints for rural consumers compared to urban consumers. In both places, the distinction between food state is clearer than that between food type; frozen foods were more consumed, whereas fresh foods were by far the most preferred.

Figure 2.2 First-choice consumption and preference scores for all types of meat and fish for Bata households. Households were asked to name the type of meat or fish which they ate most frequently at home and the type that they found had the best flavour. The first choices for consumption and preference were then summed across respondents to give a total score for each food type. Highly preferred and consumed food types are indicated.



2.3.3 Reasons for the discrepancy between consumption and preference patterns

Price variability between the different food types was much higher in Bata than in Sendje (figure 2.4). Prices of particular food types were also more variable in Bata than in Sendje. At both urban and rural levels, fresh bushmeat and fresh livestock were the most expensive food types (although there is considerable variability between species within the bushmeat category), and frozen fish the cheapest. Consumption of a food type was inversely correlated with price. However fresh fish was only slightly more expensive than frozen foods in Bata, and actually cheaper than frozen livestock in Sendje, which may explain why fresh fish had a higher consumption score than the other fresh food types, and therefore was closer to its preference score. Additionally, as many households in Sendje fish, their catch cost nothing except overheads, so price was not such an important factor. The more extreme price differences in Bata, coupled with a greater disparity in availability of fresh

and frozen food types, may explain the greater differences between consumption and preference scores than in Sendje.

Figure 2.3 Comparison of consumption and preference scores for different fresh and frozen food types, between a) Bata and b) Sendje households. Trends can be compared between the two samples, but frequencies are not directly comparable due to differing and evolving methodology. For Bata, scores are the frequency of first choice consumed and preferred meat/fish type named by all households, grouped together into categories; hence the sampling unit is the household. In Sendje, households were asked about specific food types from a list of 37 that was biased towards bushmeat (there being many more bushmeat types available to villagers than, for example, frozen fish types), hence the food type was taken as the sampling unit. The most consumed or preferred food type in each category (the type with the highest 'eaten most days' or 'love' counts) was taken as the frequency of consumption and preference for that category. For example, porcupine was the top-scoring bushmeat type, with 24 out of 41 households putting it in the 'love' category, so the bushmeat category received a preference score of 24. For both Bata and Sendje samples, all scores are displayed as proportions (of the total number of households in each sample for Bata, and of the total count of 'eaten most days' or 'loved' foods for Sendje). The 'other' category consisted of smoked, salted, dried and tinned foods; the large consumption score for this category in Sendje is due to the wide availability of cheap dried fish from the coastal town of Cogo on the Gabon border.

Figure 2.3a

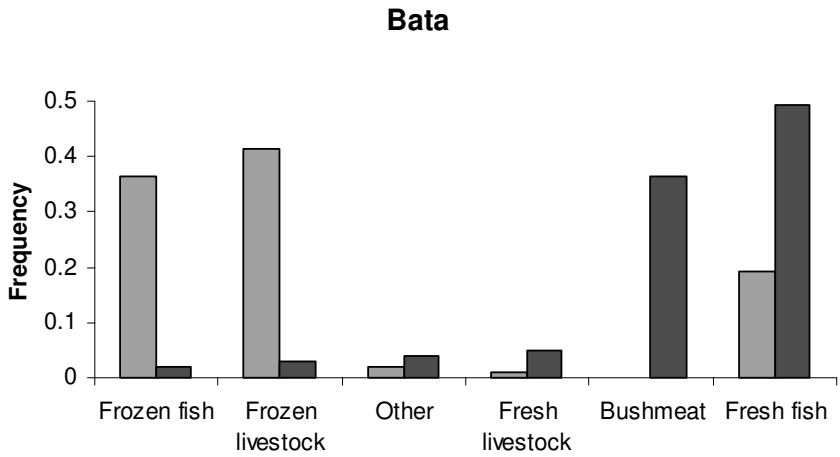


Figure 2.3b

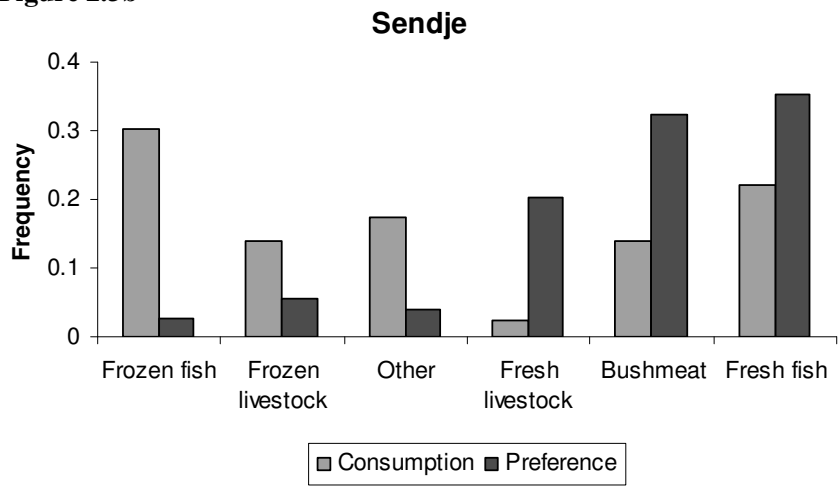
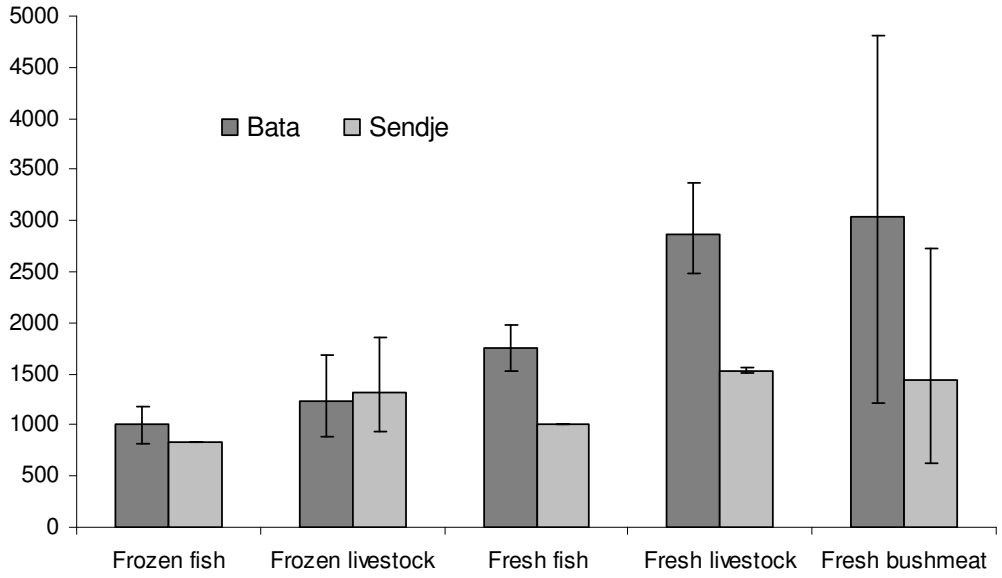


Figure 2.4 Price variability of different meat and fish categories in Bata and Sendje. Prices are the 0.05-0.95 percentiles of a representative group of food types in each category. Data for Bata are taken from appendix 2.2. Data for Sendje were taken from an offtake survey of all bushmeat traded (see chapter 6) and alternative food types recorded in regular household surveys (see chapter 3), during 2003. The 'other' category is not included here as it includes smoked, dried and tinned foods, which are difficult to compare directly with fresh or frozen cuts in terms of price per kilogram (the same applies to smoked bushmeat). The reason frozen fish appears cheaper in the village than the city is an anomaly due to the fact that mackerel, the cheapest type of frozen fish, was the only type sold there during the study period.



In both samples there was great variation in prices within the bushmeat category. This partly explains the greater consumption of bushmeat in Sendje. The majority of households in Sendje hunted, and whilst they sold the higher-priced and more marketable species such as crocodile (*Osteolaemus tetraspis*), pangolin and porcupine, cheaper species, and carcasses too small or rotten to sell, were frequently kept for their own consumption (see chapter 3).

Apes were consistently at the bottom of people's preference lists: neither gorilla (*Gorilla gorilla*) nor chimpanzee (*Pan troglodytes*) appeared in the most preferred list for both Bata's household and market samples, and they were the two least preferred species in the list of 37 foods presented to Sendje interviewees. This is reflected in the fact that they were the very cheapest meats per kilogram in both the market (see appendix 2.3) and the village (see chapter 5). However, a *caveat* should be made when estimating prices for rare and large species such as apes; because of their small sample size (in the case of apes, only four gorillas were recorded in the market survey and one chimpanzee in the Sendje offtake survey) and great variability in adult body mass, calculating prices using average weights taken from the literature can create severe bias.

2.3.4 Specific consumption decisions

Meat and fish are important components of the Equatoguinean diet, and the majority of households in both Bata and Sendje said they ate meat or fish every day. Both urban and rural households stated 'health' as the reason for eating meat or fish. People often used the term '*comida*' (food) to imply meat, and the idea of a balanced vegetarian diet was generally incomprehensible. Leafy greens were most commonly cited in both Bata and Sendje as the main substitute when meat or fish was not available. Protein-rich substitutes such as eggs, pulses, nuts and vegetables such as avocado or aubergine did not feature highly as meat-substitutes, particularly in Sendje where availability and affordability of many of these substitutes was particularly low.

Having made the decision to eat meat or fish, the choice is then between meat or fish types. The distinction between eating fresh or frozen food appeared to be more important to consumers than that between domestic meat, bushmeat and fish. When market consumers were asked why they bought bushmeat, a large proportion stated it was because it was fresh (28%) or healthy (7%). In Bata, there was a very strong negative association between prices and household consumption scores of food types (Pearson's correlation; $R = -0.97$, $n = 5$, $p = 0.006$), showing that consumption decreased the more expensive a food type was. The same pattern was found in Sendje (Pearson's correlation; $R = -0.95$, $n = 5$, $p = 0.015$). However species-specific preferences within food types were also expressed, particularly with respect to bushmeat. Many people had taboo foods at the tribal, sub-tribal, family or individual level, with a particularly high number of taboos for women of child-bearing age and children. In Sendje the top three taboo species were gorilla, chimpanzee, then snake, and in Bata snake, monkey and chimpanzee (with gorilla a close fourth). Reasons for avoidance were varied, but included tradition, similarity to humans (for primates), an evil expression, fear and infertility (the latter depending on the respondent's age, sex and reproductive state).

Within the bushmeat category, different factors explain the consumption of different species. The bushmeat preferences of the household and market samples were very significantly correlated (Pearson's correlation = 0.97, $n = 8$, $p < 0.001$) (appendix 2.4), suggesting that market consumer preferences for bushmeat species were typical of those of the population of Bata as a whole. For 11 bushmeat species, there were data available on both household consumption and preference in Bata, as well as prices and availability in the Central Market during the study period (table 2.2). In a multiple stepwise linear regression, consumption scores were positively related to both preference scores ($t = 4.27$, $df = 10$, $p = 0.003$) and availability (the number appearing in the market) ($t = 3.88$, $df = 10$, $p = 0.005$) of different bushmeat species, but there were no significant trends between consumption and either species body mass or price per kilogram. Simple (univariate) regressions

showed that both preference (t = 5.73, df = 10, $p < 0.001$) and availability (t = 5.27, df = 10, $p < 0.001$) had positive effects on consumption. Hence it is difficult to disentangle the effects of availability and preference on consumption patterns; it seems that within the bushmeat category more available species are both preferred and consumed more, regardless of either price or species size.

Table 2.2 Consumption, preference, availability and price of the 11 main bushmeat food types mentioned in the Bata household surveys, listed in decreasing order of consumption. Average mass is taken from the Sendje offtake survey from November 2002 – January 2004. Households were asked to state their first, second and third most consumed and preferred foods. Scores of 3 if named first, 2 if second and 1 if third were then totalled, and the mean score for each species was calculated by dividing this total by the sum of all consumption/preference scores.

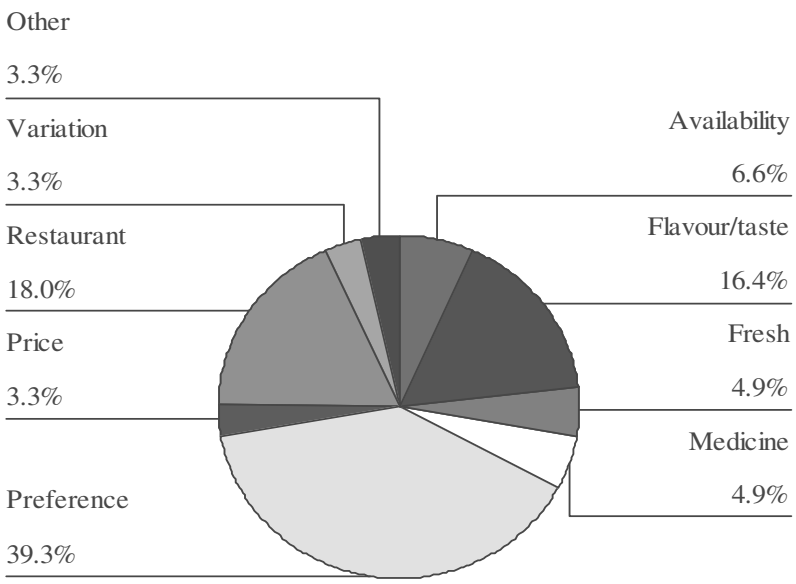
Species (common English name)	Species (Latin name)	Adult body mass (kg)	Consumption score	Preference score	No. in market during 2003	Dressed price/kg (CFA)	Price/ carcass (CFA)
Blue duiker	*Cephalophus monticola*	4.8	0.297	0.087	3034	2022	6344
Brush-tailed porcupine	*Atherurus africanus*	3.2	0.264	0.154	2008	3711	7625
Tree pangolin	*Phataginus tricuspis*	2.0	0.093	0.084	435	5414	7071
Mandrill	*Mandrillus sphinx*	13.8	0.055	0.018	389	3886	34961
Putty-nosed monkey	*Cercopithecus nictitans*	5.2	0.044	0.01	1205	2093	7000
Red duiker	*Cephalophus spp.*	20.4	0.039	0.009	738	2919	34181
Giant pouched rat	*Cricetomys emini*	1.2	0.028	0.01	81	3306	2500
Red river hog	*Potamochoerus porcus*	22.7	0.022	0.005	116	3589	53000
Cane rat	*Thryonomys swinderianus*	4.6	0.016	0.005	21	3100	9286
Hinge-backed tortoise	*Kinixis erosa*	1.7	0.011	0.01	1189	2903	3200
Northern talapoin	*Miopithecus ogouensis*	1.2	0.011	0	26	2121	2545

Similarly, purchasers approached in the Central market tended to give 'preference' or 'taste' as reasons for consuming a particular species, rather than price (figure 2.5). It seems that whilst consumers chose between broad food types on the basis of price, within food types choices were affected by complex interactions between tastes and availability, rather than cost.

No interviewees stated an explicit preference for smoked bushmeat over fresh, and traders stated that preference for bushmeat state was a matter of personal taste. However, the price of a smoked carcass was always cheaper than a fresh one, suggesting that there is certainly no particular demand for smoked meat; this is in contrast to findings from other countries such as Ghana (Cowlishaw *et*

al., 2005). Reasons for buying smoked meat are probably not limited to taste, but also factors such as convenience and ease of storage.

Figure 2.5 Reasons cited by purchasers at bushmeat stalls in Bata's Central Market for buying a particular piece of bushmeat.



2.3.5 Major determinants of urban consumption

In Bata income was a primary determinant of consumption frequency for meat and fish. In a generalised linear model of household consumption against income and nationality, bushmeat, fresh domestic meat and fresh fish all showed significant positive coefficients for income, while frozen domestic meat and fish showed non-significant or negative coefficients (table 2.3). In other words, consumption of fresh food types increased with increasing income, while consumption of frozen produce tended to decline (see East *et al.*, 2005, for more details). This result is supported by the finding that purchasers of fresh produce in the market were a comparatively rich subset of the Bata population as a whole (table 2.1).

The influence of ethnic origin, city district and educational level of the household head were also tested for, but only the first of these had any significant effects on consumption (table 2.3). Equatoguineans were much more likely than other nationalities to buy bushmeat, while purchasers of fresh domestic meat were more likely to be from other African countries (mainly Cameroon or Nigeria). This is likely to be a result of religion rather than nationality, as many immigrants from elsewhere in Africa were Muslim and therefore less inclined to eat bushmeat, in particular monkeys,

than the predominantly Christian Equatoguineans. The nationality of interviewees purchasing fish was more representative of the sample as a whole (figure 2.6a). Within Equatoguineans, the Fang bought more bushmeat, while other tribes (predominantly the coastal Ndowe) bought more fish and to some extent domestic meat (figure 2.6b).

Table 2.3 Results of generalised linear models of the factors affecting consumption rate, based on household surveys in Bata. The recall of actual consumption the day before is used in all cases, but for bushmeat, which was rarely recorded by daily recall, typical frequency of consumption per month is also analysed. The coefficients for income are given, together with tribe/nationality if significant. Other factors were non-significant. Fang and Ndowe are primarily Equatoguinean tribes, while the "other" category represents primarily non-Equatoguineans. Consumption rate per household was regressed against $\log_e$ income (taken as the central value of each income category), with Poisson error structure and log link function. A slope of one would thus indicate that change in consumption is proportional to a change in income. Non-significant income coefficients are given in brackets. Rates of consumption are shown here as meals per unit recall period; where possible, weight (kg) per unit recall period was also analysed, giving similar results.

Food Type	Recall period	Explanatory variable	F	dfs	*p*	Coefficients: income	Fang	Ndowe	other
Bushmeat	day	income	2.24	1, 97	0.14	(0.55)			
Bushmeat	month	income	8.23	1, 89	0.005	0.26			
		tribe/nationality	6.81	2, 89	0.002		-1.51	-2.43	-2.41
Fresh	day	income	4.51	1, 95	0.036	0.81			
livestock		tribe/nationality	4.50	2, 95	0.014		-13.14	-20.08	-11.32
Fresh fish	day	income	4.25	1, 97	0.042	0.55			
Frozen livestock	day	income	1.75	1, 97	0.19	(0.11)			
Frozen fish	day	income	4.10	1, 97	0.046	-0.27			

Another important determinant of consumption patterns is one that is commonly overlooked and difficult to quantify: nutritional awareness or 'marketing' of foods and their relative benefits. Although cultural traditions were important (as is clear from the finding that ethnicity is an important determinant of consumption), there was a clear readiness of Equatoguineans to take on foreign ideas, culture and tastes and our sample included a number of respondents who stated that they did not eat bushmeat because it was "dirty meat". However, response to external influence was not always positive: there was a general perception that frozen produce has low nutritional value compared to fresh, and in Bata several respondents alleged that frozen food was dangerous as it had been dead a long time.

Figure 2.6 Frequency of customers buying different fresh meat or fish types in Bata's Central Market, split a) by nationality, and b) within Equatoguineans, by tribe. Of 24 non-Fang Equatoguineans, 20 were Ndowe and 4 Bubi. In total, 86 customers were recorded buying bushmeat, and 37 each buying fresh domestic meat and fish respectively. Chi-squared tests for significant departure from random: a) χ^2= 65.4, df = 2, p <0.01; b) χ^2= 36.4, df = 2, p <0.01.

Figure 2.6a

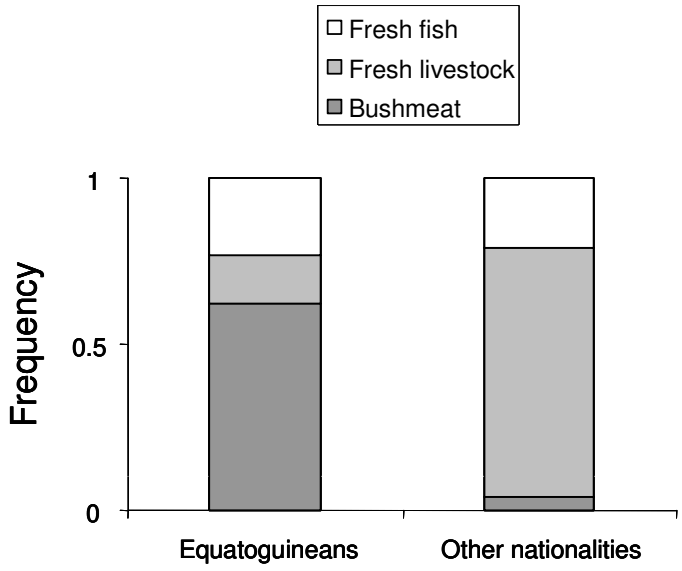
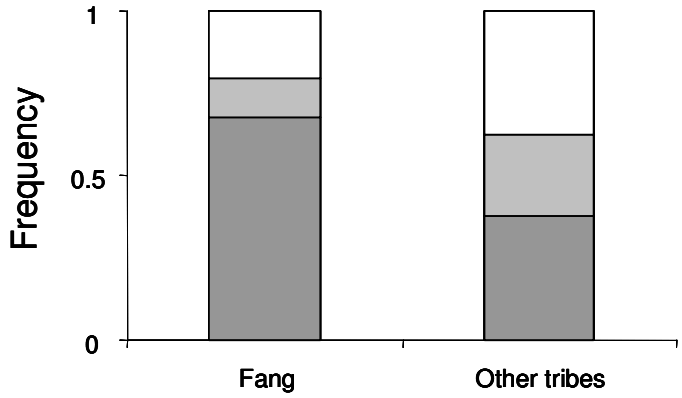


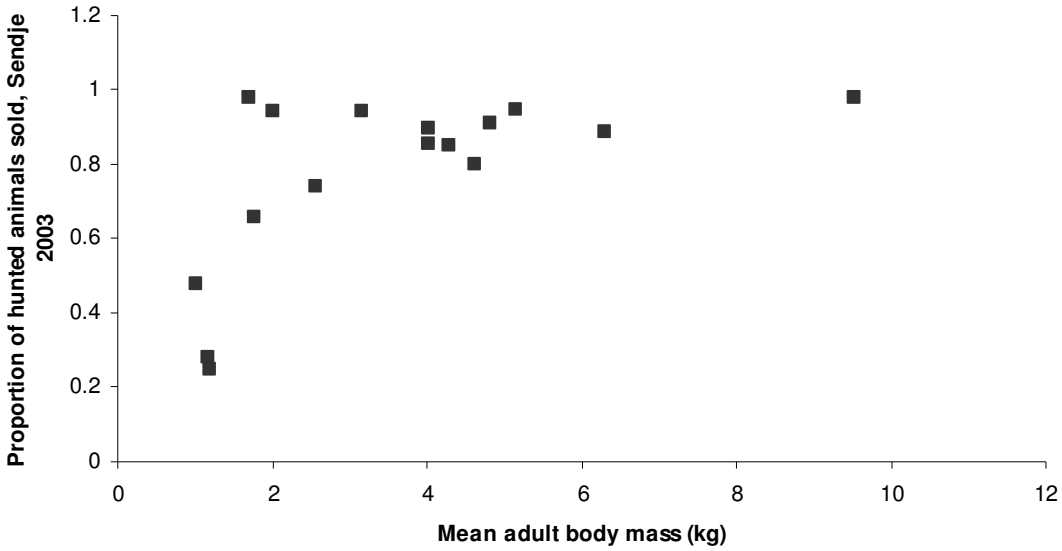
Figure 2.6b



2.3.6 Drivers of the trade in specific bushmeat types

In many cases price per carcass rather than price per kilogram was a better indicator of the marketability of a species. For example, black colobus (*Colobus satanus)* was one of the cheapest bushmeats per dressed kilogram in both Bata (1152 CFA/kg) and Sendje (800 CFA/kg), suggesting that it was not a preferred species; however, because its carcass price was comparable to that of the considerably smaller-bodied guenon species, it was still a profitable commodity for the hunter. Conversely, although some small-bodied and relatively common species such as the great blue turaco (*Corythaeola cristata*), talapoin monkey (*Miopithecus onguensis*) and giant pouched rat (*Cricetomys emini*) were above the mean price per kilogram for bushmeat species overall (appendix 2.3), and thus had a relatively large mark-up between village and market price (see latter example in appendix 2.5), they rarely appeared in the market as (table 2.2). This is because the relationship between a species' adult body mass and the proportion of animals traded is non-linear; below around 2 kg the proportion traded drops as absolute profit on a carcass tends to be too low for it to be worthwhile trading (figure 2.7). The fact that 49 species of bushmeat were recorded in the Sendje offtake survey and only 42 in the market confirms that not all hunted species are sold to market.

Figure 2.7 Correlation between mean adult body mass and proportion of animals hunted in Sendje sold to Bata market, for species weighing less than 10 kg and with a sample size ≥ 5 (Pearson's correlation = 0.60, n = 16, p = 0.014). The absolute profit on carcasses below around 2 kg tends to be too low (even where the price per kilogram is high) to make them worth selling.



There was a subtle preference by Bata consumers for purchasing entire carcasses (which may be linked to appearance, portability or hygiene); this may also help to maintain demand for the numerous, affordable medium-sized species on sale such as blue duiker, brush-tailed porcupine and the guenons. Larger species tended to be cut into smaller, more marketable pieces, the sum of their parts costing more than the whole (in the case of bay duiker, *Cephalophus dorsalis*, the mean price for a whole adult carcass was 22,000 CFA, whereas the total mean price for a carcass sold in pieces was 29,000 CFA).

18% of people purchasing bushmeat in the Central Market were buying it for use in a restaurant (figure 2.5), highlighting the importance of restaurants as customers for bushmeat traders (a fact that was not picked up during the household survey, where less than 1% of households reported obtaining their bushmeat from restaurants). Only one of the restaurateurs interviewed, from the largest and most exclusive restaurant, obtained his bushmeat directly from hunters. All other restaurateurs bought from market traders, because of the relatively small daily volumes of meat required. Hence the volumes of bushmeat sold to restaurant buyers in the markets should be a relatively accurate reflection of bushmeat consumption by restaurants.

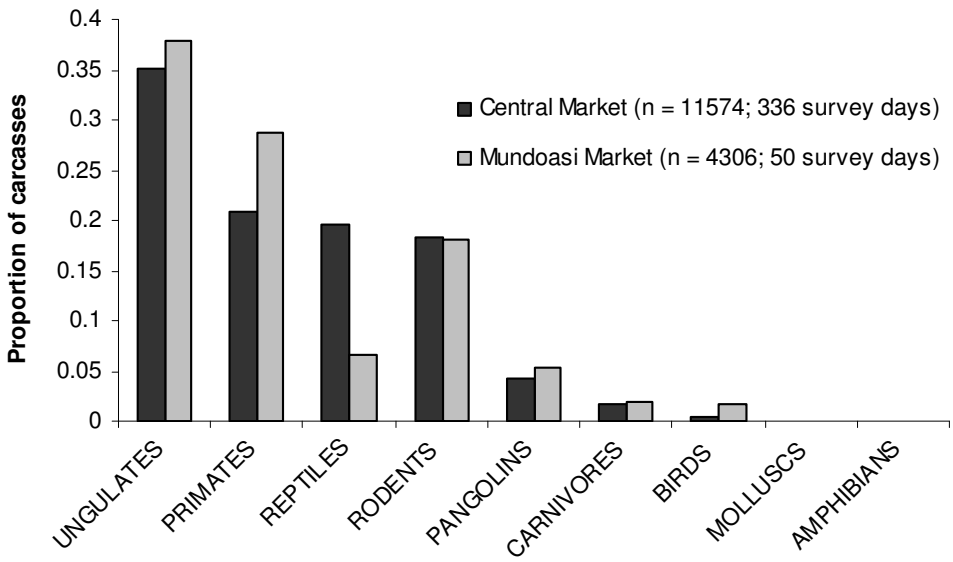
Although there was no relationship between preference and price, there were particular tastes for some species that help to drive their trade (either positively or negatively). One example is crocodile, a species which had many personal dislikes and taboos, but which maintained a thriving restaurant trade for a small 'elite' of high-level male civil servants and was the second most expensive type of bushmeat in the market. Crocodile tended only to be sold in the more expensive restaurants as this clientele was limited and the general public tended to prefer common species like porcupine and duiker, which were more affordable and had all-round appeal (table 2.2). In places like Ghana, those who like bushmeat but cannot afford the cost of purchasing it in sufficient quantities for home consumption tend to consume bushmeat in chopbars (Ntiamoa-Baidu, 1998b). This would appear to be the case in Bata too, where restaurant consumers were generally male white-collar workers, consuming bushmeat in their lunch-break while their families ate cheaper frozen produce at home.

Many species have cultural taboos against them, which reduces their trade value. Crowned guenon (*Cercopithecus pogonias*) and African palm civet (*Nandinia binotata*) are thought to make women infertile, whereas snakes and monitor lizards (*Varanus niloticus*) are traditionally only eaten by elders. Others are considered to have magical or medicinal properties that increase their value. One example is blue duiker, which costs 1000-2000 CFA more per carcass when live, due to its perceived curative powers for sick children.

2.3.7 Market trends

The proportions of different taxa for sale in Mundoasi and Central markets were significantly different. Firstly, there were more primates available in Mundoasi (figure 2.8). This may be due to the greater incidence of gun-hunting in Mundoasi's catchment, which tends to target primates particularly. A large proportion of carcasses in the 2003 survey of Mundoasi Market were found to be hunted with guns: 63% of all *Cephalophus* spp., *Cercopithecus* spp. and *Atherurus africanus* (Puit, 2003). Breaking this down by region showed that up to 80% of all species found in the market that had come from the Bata district were shot, and as much as 40% from other areas to the north (Micomiseng and Anguma, near the Cameroon border) and the region south of Evinayong, to the south-east of Monte Alén National Park (adapted from Puit, 2003). Unfortunately data on the proportion of shot to trapped animals recorded by my long-term research assistant in the Central Market were incomplete, so a direct gear type comparison between the two markets is not possible. However, the results from Mundoasi indicate that there was more gun-hunting in the areas supplying this market than the Central Market, as far more animals in Sendje (one of the main sources of bushmeat to the Central Market) were trapped than shot (a 9:1 ratio: see chapters 5 and 6), and fewer primates (the taxa most easily gun-hunted) were recorded in the Central Market.

Figure 2.8 Proportion of different taxa found in Bata's Central (this study) and Mundoasi (taken from (Puit, 2003) markets. The composition of the two markets is significantly different (χ^2= 487, df = 6, p <0.001).



There were also considerable more reptiles recorded in the Central Market than Mundoasi Market. One explanation for this may be double-counting; as reptiles such as tortoises and crocodiles tend to

be sold live, they can remain on a stall for several days before they are bought, and this may not have been picked up by the local research assistant. This issue of double-counting may also apply to smoked bushmeat, but would probably apply equally to all species so would not affect the proportions of different taxa.

Much greater volumes of bushmeat were traded in Mundoasi than Central (there were 14 bushmeat stalls in Mundoasi compared to seven in Central), supporting my estimation of the catchment area for Mundoasi at over twice the size of that for the Central Market (figure 2.1). If the number of survey days in each market is scaled up, the annual estimate for Central is 12,600 animals compared to 31,400 animals in Mundoasi.

Figure 2.9 shows changes in the proportion of different mammalian taxa available in the two markets from an earlier survey (Fa *et al.*, 1995). Although statistically there is a difference in the proportion of different taxa between study periods for both markets, this is not unexpected, given the very large sample sizes involved. In reality, the changes in taxon proportions between surveys are not very great. Interestingly, there appears to be a reduction in the proportion of rodents in both markets (which is the opposite effect to that seen in mature, depleted bushmeat markets: Cowlishaw *et al.*, in press). However, rather than being evidence for a sustainable level of hunting, this is more likely to be because traders were still expanding into new areas of Río Muni previously not involved in the commercial trade. This hypothesis is supported by interviews with bushmeat traders who had been active in the Central Market for 10-15 years, who asserted that due to improvements in roads and vehicles, and the opening up of new logging concessions, they were able to reach new areas to purchase their bushmeat, following the depletion of those close to Bata. Again, Mundoasi shows higher numbers of primates (which are mainly hunted with guns) in 2003 than 1991-2, suggesting that there was increased gun-hunting feeding this market.

In addition, if the daily carcass number is scaled up to give an annual estimate, the numbers of carcasses in both markets have greatly increased between 1991-2 and 2003: the number in the Central Market has more than doubled, from 5,400 to 12,600 animals per year, whilst the number in Mundoasi Market has increased five-fold from 6,200 to 31,400. This would appear to be further evidence of expansion of the bushmeat trade into new areas. This is supported by reports from the traders that had been active in the market since this time: they asserted that there was more bushmeat in the markets because it was coming from more villages (although in general fewer animals from each village over time). As well as ease of transport, the costs of transport had also decreased. For example, a decade or so ago, when the road was bad, the traders who visited Sendje used to hire an entire taxi for 15-20,000 CFA round trip; in 2003 the trip cost only around 6,000

CFA (before adjusting for inflation) for each trader and a large load of animals, in one of the frequent share-taxis.

Figure 2.9 Proportion of different mammalian taxa found during 2003 (this study) and Puit (2003), compared with 1991-2 (Fa *et al.*, 1995) in Bata's a) Central Market and b) Mundoasi Market. The composition of both markets between the two study periods is significantly different (Central: χ^2= 127, df = 4, p <0.001; Mundoasi: χ^2= 291, df = 4, p <0.001). The Central Market was surveyed for 212 days in 1991-2 and 336 in 2003; Mundoasi was surveyed for 212 days in 1991-2 and 50 in 2003.

Figure 2.9a

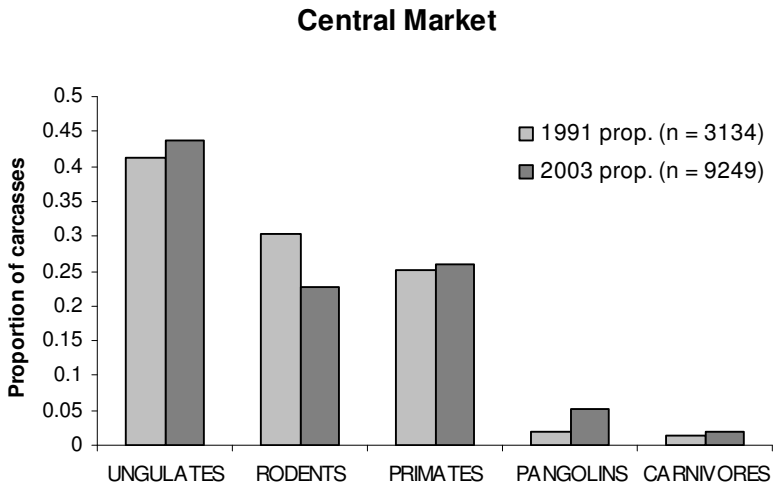
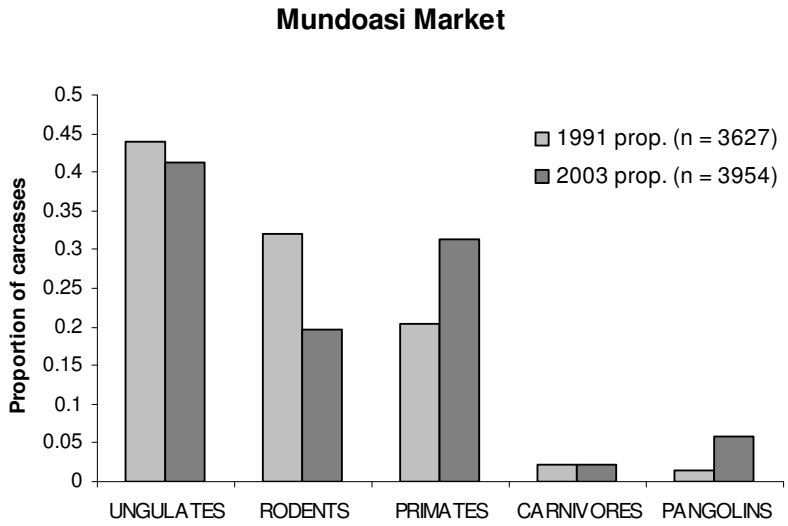


Figure 2.9b



2.4 DISCUSSION

Bata's consumers had a strong preference for fresh meat and fish over frozen produce, but on cost grounds they most often ate frozen foods. The degree to which they were able to satisfy their preferences was significantly related to their income. In this city, it seems that frozen produce is an inferior good, while fresh produce, including bushmeat, is a necessity. The perception that bushmeat is a luxury good in urban settings is commonly cited in the bushmeat literature (e.g. (Bowen-Jones *et al.*, 2002). However it seems that here, fresh produce in general is the focus of demand, and at present has necessity (income coefficient < 1) rather than luxury status (income coefficient > 1).

In Bata, the most preferred food category was fresh fish, followed by bushmeat and then fresh domestic meat. There were particular preferred items within these categories, including red snapper amongst the fish species, and porcupine, blue duiker and pangolin amongst the bushmeat species. Other studies in Central Africa have shown similar orders of preference among bushmeat species (e.g. Njiforti, 1996). These species were also amongst the most common items in the market. Preference and availability were correlated in the analysis of individual bushmeat species, and it is likely that there is strong feedback between them.

Urban preference patterns were mirrored at the rural level in Sendje, as were urban consumption patterns to some extent. The reason for such similarities can be explained by Sendje's cultural homogeneity with, and geographical proximity to, Bata. The observed differences help to explain the determinants of bushmeat consumption. Where availability and accessibility to fresh foods is not such a constraint, as in Sendje, people consume more fresh fish and bushmeat, and less frozen fish, even though they are poorer.

Other studies of bushmeat consumption have not observed widespread use of frozen foods as a cheap source of protein, or considered the interaction between fresh and frozen food consumption. Two-choice taste preference tests in Gabon (Schenck *et al.*, 2006) demonstrated that domestic meat may be an acceptable substitute for bushmeat there. However, when asked about preference, only 28% of respondents in Gabon stated fish compared to 44% for bushmeat, suggesting that fish is less universally preferred in Gabon than in our study. The authors warned that increasing the availability of the low-quality beef sold in Gabon may not encourage a switch away from eating bushmeat, but made no mention of the general acceptability of eating frozen meat and fish compared to fresh. Our finding that 'state' (which may be a proxy for real or perceived quality) is

more important than 'type' has important implications for management, since at present Equatorial Guinea relies heavily on imports of frozen produce as a supply of animal protein.

Currently bushmeat is widely available and consumption is constrained primarily by income. Ethnicity, and to some extent cultural taboos, is a secondary factor. This is supported by the fact that purchasers of bushmeat in the market were a richer subset of the population as a whole, and that restaurant clients eating bushmeat were predominantly male workers. These findings, along with the increase in bushmeat trade we have found since the early 1990s, suggest that bushmeat consumption is likely to increase rapidly as Bata's economic prosperity and population continue to grow. On the other hand, it is possible that this trend may be countered by a westernisation of tastes associated with economic development. For example, specific bushmeat preferences in Río Muni have shifted since the study of Sabater-Pi (1972), particularly away from mandrills, *Mandrillus sphinx*.

Bushmeat is widely available in Bata, and many restaurants sell bushmeat regularly. The commodity chain is relatively simple, with the majority of the trade passing through the market, both to consumers and to restaurants. This contrasts with some other urban commodity chains in which restaurants buy from intermediary traders, making their purchases less easy to track (e.g. Mendelson *et al.*, 2003).

The species composition of the bushmeat on sale in the market contrasts with that observed in other markets in the region. In a recent study in a Ghanaian market, for example, rodents comprised 59% of the available bushmeat, with primates absent (Cowlishaw *et al.*, 2005), compared to 18% rodents, 37% ungulates and 26% primates in Bata's two markets combined in 2003. Whilst taking into account differences in habitat type, there have been suggestions that the species composition of markets can act as an indicator of the degree of depletion in the supply areas (Rowcliffe *et al.*, 2003). On this basis, Bata would currently appear to be supplied from a relatively undepleted bushmeat resource, given the relatively high proportion of ungulates and primates. However it is possible that expansion of the commercial trade into new, previously unhunted or only lightly hunted areas further from the market may in fact be masking local unsustainability close to the market, an effect seen elsewhere (e.g. Clayton *et al.*, 1997). This has been exacerbated by logging infrastructure, as well as ambitious road-building projects set in place in recent years following the oil boom. For example, large quantities of bushmeat began to arrive in the Central Market in mid-2003 from Tagete and surrounding villages to the south-east of Monte Alén National Park, when the closure of a logging concession that had been operating in the area meant that ex-employee locals and immigrants fell back on hunting for a living, and traders had enhanced access (pers. obs., and

pers. comm.., J. Rist). However, the prevalence of ungulates and primates in the market suggests that healthy prey populations do still persist in many areas of Río Muni that are currently being exploited.

The larger proportion of primates (which are predominately gun-hunted) available in Mundoasi Market during 2003 compared to the early 1990s suggests an increase in gun-hunting in the market's catchment area. This increase was not observed over the same period in the Central Market, with fewer primates for sale than in Mundoasi during the study period. 63% of all animals sold in Mundoasi were gun-hunted, and the proportion shot compared to trapped was highest for the district closest to the market. It seems that there has been a shift from trapping to gun-hunting in the more populous areas supplying the market; whether this is due to habitat changes, reduced prey densities or increased incomes due to availability of alternative livelihoods, meaning more people can afford guns and ammunition, is not clear from a study of the market alone (but see chapter 7).

In Gabon, fish was found to be a general substitute for bushmeat (Wilkie *et al.*, 2005). This is also almost certainly the case in Equatorial Guinea, given the particularly strong preference expressed for fresh fish. It is therefore encouraging that the FAO has set up a project in Equatorial Guinea aimed at expanding the capacity of sustainable fisheries (FAO, 2003). However, recent linkages in Ghana between a reduction in supply of marine fish stocks and an increase in bushmeat exploitation (Brashares *et al.*, 2004) are a warning that unless coordinated management of bushmeat and fish is undertaken, protection of one may result in depletion of the other (Rowcliffe *et al.*, 2005). Freshwater fish supplies are not much better off: in sub-Saharan Africa, per capita fish supply dropped from 9 kilograms a year in 1973 to 6.6 kilograms in 2001, compared to an increase from 12 to 16 kilograms worldwide (von Bubnoff, 2005). Unlike bushmeat, very little fish is traded to Bata from rural villages, although whether this is a result of dwindling supplies or low market demand relative to bushmeat is not entirely clear (see chapter 3). There have therefore been recent calls for urgent investment in aquaculture projects across Africa in order to match population growth and the subsequent demand for animal protein (*ibid*); apart from anecdotal reports of micro-scale aquaculture projects in Río Muni (S. Allebone-Webb, pers. comm.), this seems some way in the future for Equatorial Guinea.

Fresh domestic livestock currently scores low in terms of preferences in Bata. However, preferences can only develop once a product is reasonably familiar (Turrell, 1998). Livestock rearing in Equatorial Guinea is vastly underdeveloped, and the results of this analysis of availability, consumption and preference reflect this (see also chapter 3). Currently, goats, sheep, pigs and poultry are reared *ad hoc* in villages with no formal livestock husbandry or veterinary

provision, and few of these animals reach the cities. However, there was once an established cattle-ranching industry on Bioko Island, providing around 100,000 kg of meat per year during the colonial period (see chapter 7), and there has been both supply and demand for this bushmeat substitute in the past (Fa, 2000).

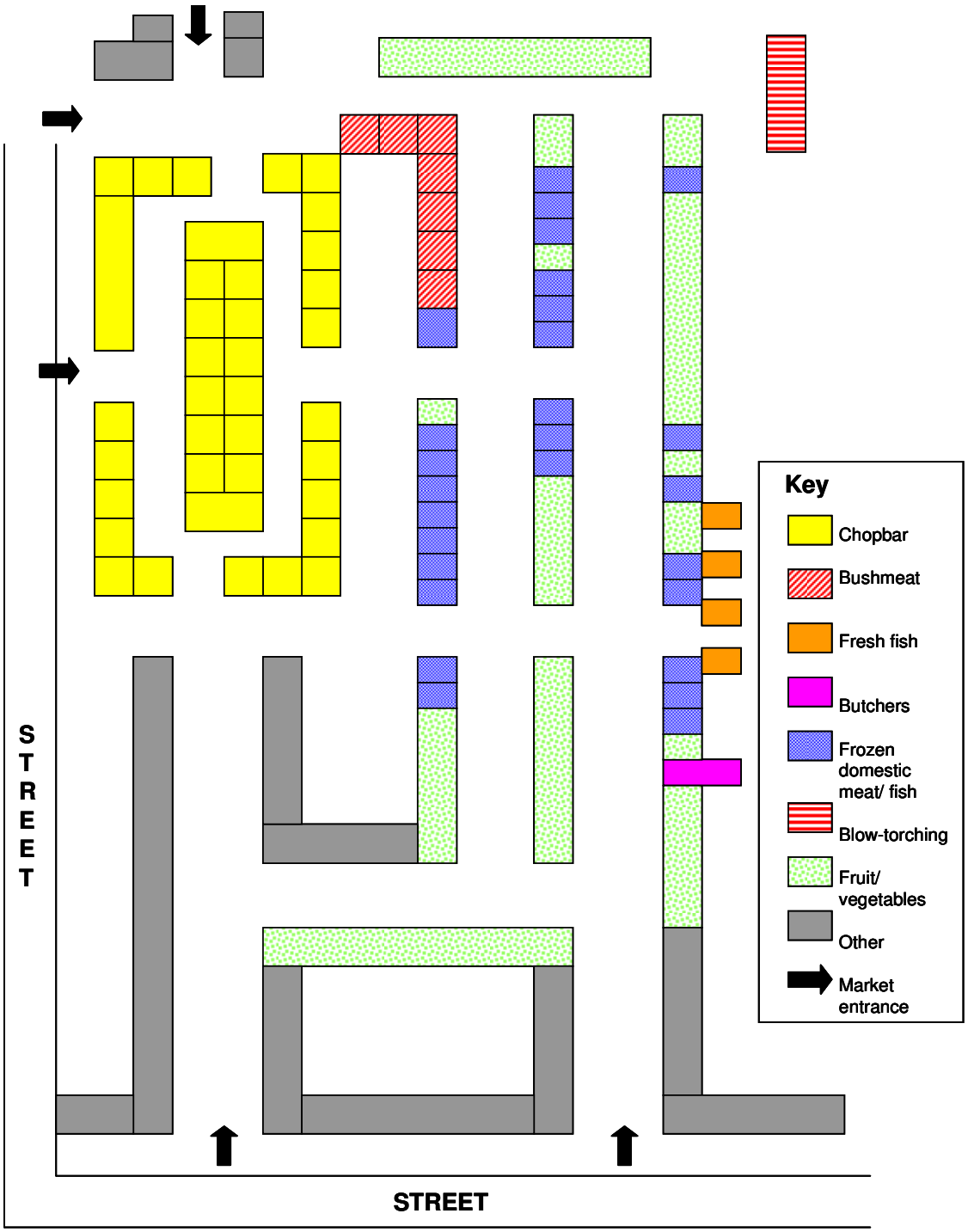
Ultimately, if the sustainability of bushmeat and fresh fish offtake rates is to be ensured (see chapter 6), the potential for substitute goods will need to be explored. Rose (2001) suggests that marketing of bushmeat alternatives has the potential to change consumer behaviour. Equatoguineans spend a relatively large proportion of their expendable income on heavily marketed and expensive Western products such as Coca-Cola or condensed milk as baby food (pers. obs.). In theory, given sufficient economic incentive, awareness could be improved of the nutritional value of frozen meat and fish, or even of vegetarian alternatives. In the long-term, initiatives to increase the production and availability of fresh domestic meat and fish within Equatorial Guinea itself may help to meet the increasing demand for fresh produce.

Appendix 2.1 Prices of common bushmeat types between Sendje (from offtake data November 2002 – January 2004), and Bata's Central Market in December 2002 (from stated market prices recorded by a local research assistant) and May –July 2003 (from transaction prices recorded by Tamsyn East). Bushmeat types are listed in order of decreasing Sendje price per kilogram.

Bushmeat type	Adult carcass weight (kg)*	Sendje transaction prices, Nov 2002 – Jan 2004			Stated market prices, Dec 2002			Observed market transaction prices, May-Jul 2003		
		Sample size	Carcass price (CFA)	Dressed price/kg	Sample size	Carcass price (CFA)	Dressed price/kg	Sample size	Carcass price (CFA)	Dressed price/kg
Crocodile	6.3	63	14492	3540	48	22521	5501	1	20000	4885
Pangolin	2.01	325	3926	3006	/	/	/	7	7071	5414
Porcupine	3.16	995	5062	2464	30	8000	3893	12	7625	3711
Red river hog	22.72	5	24200	1639	1	52000	3521	2	53000	3589
Tortoise	1.7	849	1485	1347	19	2789	2531	5	3200	2903
Putty-nosed monkey	5.15	100	4465	1335	7	7071	2115	3	7000	2093
Moustached monkey	4.02	74	3473	1328	2	6000	2294	3	6167	2357
Giant pouched rat	1.16	107	978	1293	17	2412	3189	1	2500	3306
Blue duiker	4.83	819	3665	1168	23	6043	1926	16	6344	2022
Smoked porcupine	1.53	1095	3482	3506	87	6460	6496	4	5750	5782
Smoked blue duiker	1.88	1385	2551	2088	68	5029	4115	6	5000	4092

* Weights are the mean of all fresh adult carcasses traded in Sendje, Nov 2002 – Jan 2004.

Appendix 2.2 Aerial plan of Central Market, Bata



Appendix 2.3 Mean adult carcass weight and price of adult animals most frequently recorded in the market survey, December 2002 – December 2003, listed in order of decreasing price per kilogram.

English name	Latin name	n (for prices)	Mean adult carcass price (CFA)[1]	Mean adult carcass weight (kg)[2]	Price per dressed kg (CFA)[3]
Tree pangolin	*Phataginus tricuspis*	7	*7071	2.0	5414
Dwarf crocodile	*Osteolaemus tetraspis*	1	*20000	6.3	4885
Giant pangolin	*Smutsia gigantea*	8	54375	20.2	4135
Mandrill	*Mandrillus sphinx*	64	34961	13.8	3886
Brush-tailed porcupine	*Atherurus africanus*	12	*7625	3.2	3711
Red river hog	*Potamochoerus porcus*	2	*53000	22.7	3589
African palm civet	*Nandinia binotata*	31	5919	2.6	3566
Giant pouched rat	*Cricetomys emini*	1	*2500	1.2	3306
Servaline genet	*Genetta servalina*	5	3800	1.8	3299
Northern talapoin	*Miopithecus onguensis*	11	2545	1.2	3263
Great blue turaco	*Corythaeola cristata*	9	2500	1.2	3205
Cane rat	*Thryonomys swinderianus*	7	9286	4.6	3100
Domestic pig	n/a	42	44976	22.7	3046
Bay duiker	*Cephalophus dorsalis*	108	34181	18.0	2919
Hinge-backed tortoise	*Kinixis erosa*	5	*3200	1.7	2903
Domestic duck	n/a	31	5613	2.0	2806
Nile monitor	*Varanus niloticus*	12	7583	4.3	2723
Crowned monkey	*Cercopithecus pogonias*	30	6910	4.0	2646
Peter's duiker	*Cephalophus callipygus*	6	33417	19.7	2610
Domestic chicken	n/a	80	3956	1.6	2473
Moustached monkey	*Cercopithecus cephus*	3	*6167	4.0	2357
Putty-nosed monkey	*Cercopithecus nictitans*	3	*7000	5.2	2093
Blue duiker	*Cephalophus monticola*	16	*6344	4.8	2022
Sitatunga	*Tragelaphus spekei*	25	43700	36.0	1868
Black colobus	*Colobus satanus*	43	7140	9.5	1152
Western lowland gorilla	*Gorilla gorilla*	4	50000	68.0	1131

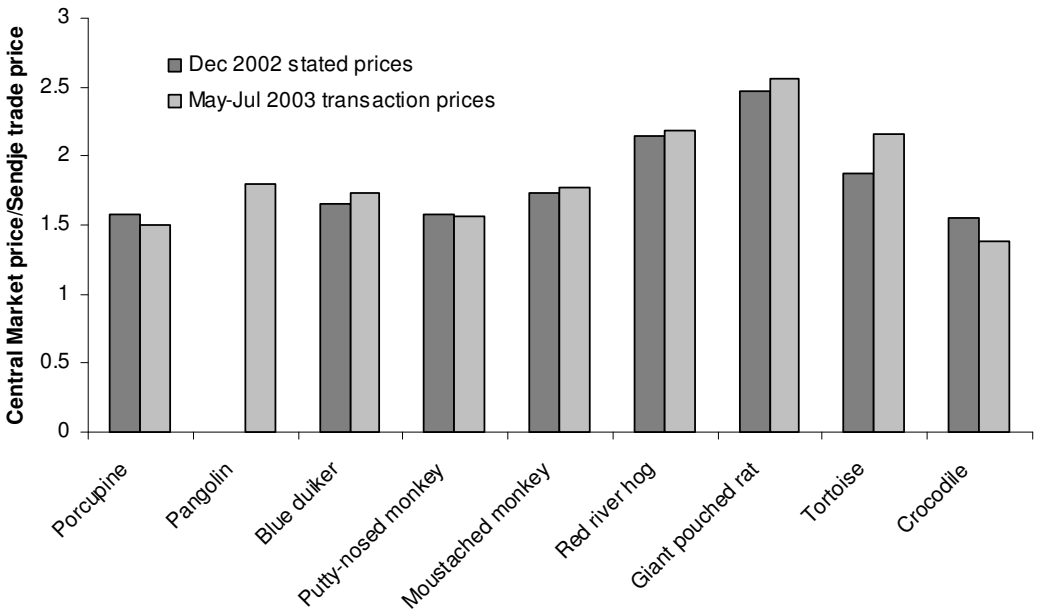
[1] Carcass prices marked * are mean transaction prices recorded by Tamsyn East during market interviews, May-July 2003; all other prices are weighted means from December 2002 stated prices, May-July 2003 transaction prices and July-September stated prices.
[2] Weights are the mean of all adult carcasses traded from the Sendje offtake survey during 2003 (except domestic pig, which was taken as equal to the weight of a red river hog, domestic duck/chicken, for which dressed weights were taken from www.gamefarm.com.au, and gorilla, which was taken conservatively as the lightest adult female body weight in Kingdon (1997).
[3] Dressed weight was calculated as 0.65 of undressed weight.

Appendix 2.4 Preference scores for particular species of bushmeat from people a) purchasing bushmeat in the market and b) in Bata households. There is no significant difference between the bushmeat preferences of the two groups ($\chi^2 = 9.74$, df = 5, NS).

Bushmeat type	Bushmeat-specific preference score*	
	Market bushmeat purchasers	Bata households
Porcupine	116	112
Pangolin	68	57
Blue duiker	38	53
Monkey	32	19
Red river hog	7	15
Giant pouched rat	7	6
Tortoise	3	6
Crocodile	2	1

* Preference scores are taken from the top three preferred meat/fish types cited by the 100 Bata household interviewees and 100 customers interviewed at the Central Market bushmeat stalls. First choice species were given a score of 3, second choice 2 and third choice 1, and summed to give a total score per species.

Appendix 2.5 Price mark-up between Sendje and the Central Market for some common bushmeat species, with a comparison of two price samples (per kg), December 2002 stated prices and May-July transaction prices. There is very high correlation and similarity between the two samples (Pearson's two-tailed correlation = 0.948, n = 8, $p < 0.001$).



Chapter 3

Incentives for hunting: bushmeat as a component of rural livelihoods

3.1 INTRODUCTION

There is growing concern among development agencies about the contribution that bushmeat makes to poverty alleviation, particularly in rural communities (see e.g. Adams *et al.*, 2004; Brown, 2003; Brown & Williams, 2003; Davies, 2002b; DfID, 2002; Mainka & Trivedi, 2002; Robinson & Bennett, 2002). Whilst traditional measurements of poverty have focused on income and consumption expenditure, more recently there has been an appreciation that poverty is a multi-dimensional, complex phenomenon that includes a range of other social dimensions (e.g. DfID, 2001).

However, there is considerable disagreement among researchers and development practitioners as to the extent to which bushmeat benefits poor rural people, in particular which communities or sectors of a community are more reliant on bushmeat. Conventional thought has been that wild foods are most important to the poorest households in a community (Dei, 1989), but recent evidence suggests that it is not necessarily the poorest that are most reliant on wild foods such as bushmeat, with use either being greatest for middle-income households (Godoy *et al.*, 1995; Starkey, 2004) or for wealthier households (de Merode *et al.*, 2004), or having no pattern with wealth at all (Chenevix-Trench, 1997; Wickramasinghe *et al.*, 1996).

The *way* in which the rural poor use bushmeat also seems to differ. In Africa, studies in the Democratic Republic of Congo (DRC) (de Merode *et al.*, 2004) and Gabon (Starkey, 2004) have found that bushmeat is more important as a source of income, whilst in Latin America, bushmeat plays a greater role in household consumption (e.g. Godoy *et al.*, 1995). There does appear to be a difference in bushmeat dependence between these two continents, in that the greater commercial trade within west and central Africa has led to it being increasingly important in many areas as a source of rural income, whilst in Latin America, where bushmeat is less preferred and there are

more alternatives in the form of livestock production, it is still mainly relied upon for subsistence. Wilkie and Godoy (2001) found that the consumption of bushmeat by rural households in central and south America was likely to show an inverted-U pattern with increasing income, in that it changed from being a necessity to an inferior good as households became wealthier. In other words, once they were financially able to, people switched from eating bushmeat to domestic alternatives. de Merode *et al.* (2004) and Starkey (2004) found positive bushmeat consumption elasticities in DRC/Gabon, but these are the only recent such studies to date in west/central Africa.

Finally, whether poor people would suffer if bushmeat were no longer available is also under question (e.g. DfID, 2002). The ability of poor people to adapt if access was prevented or supply ran out is also likely to vary between and among communities, depending on factors such as market access, availability of alternative foods and livelihoods, and educational, skills or cultural barriers to alternative sources of income (Bennett, 2002).

In this chapter I look at the influence of wealth, income and other socioeconomic factors in determining the incentives of households and individuals to take up hunting as a livelihood strategy. Like poverty, wealth is notoriously difficult to measure (Homewood, 2005a), and definitions are vague or, at best, variable. Overall 'wealth', which incorporates social, political and economic dimensions and refers to the long-term ability of a household to bear shocks, is distinct from income, which can be defined in terms of short-term cash-flow, or current household production. There can be a problem of reverse causality between the outcome (in this case, hunting) and the explanatory variable of interest (wealth/income) (as described by Godoy, 2001). If households are actually wealthier as a result of hunting, unless some measure of non-hunting wealth is used, the question as to whether wealthier households hunt more or less may be a rather circular one. I therefore consider here several measures of household wealth on bushmeat use: qualitative wealth categorisation, and quantified income, both non-hunting and overall, at both the household and individual level. I do not measure household production in its strictest sense (defined as the total value of agricultural and wild products produced by the household plus monetary income and the value of gifts received), as has been done in other studies of the household economy (e.g. de Merode *et al.*, 2004; Starkey, 2004). This is because in the cash-based economy of rural Equatorial Guinea it appears to be monetary income that is the most important determinant of potential male livelihood strategies, in particular as an incentive for men to hunt rather than carry out alternative livelihoods, whilst agriculture is practised mainly for subsistence by the women and contributes relatively little in terms of surplus for the household.

I draw on a dataset including household interviews, hunter interviews and an offtake survey, to evaluate (1) what drives individuals to hunt in the first place and (2) the effect of cross-sectional changes in the household economy on the consumption and hunting of bushmeat across households. Although the household interviews were conducted over the course of a year, this period was too short to pick up any longitudinal changes within households. However, by conducting regular repeat interviews I was able to calculate detailed and accurate annual and monthly income for each household, taking into account any seasonal variation. Using these data, I answer the following three questions:

1. What is the importance of bushmeat in household production and consumption?
2. Do hunters hunt through choice or necessity?
3. How do economic differences between households affect bushmeat hunting and consumption?

3.2 METHODS

3.2.1 Study area

The study took place in the village of Sendje, 41 km or about an hour's drive south of the regional capital, Bata, in continental Equatorial Guinea. Initial data on village social structure and history were gathered during a pilot trip in June 2002 during familiarisation exercises with a focus group of 4-6 people of mixed age and gender over a period of four days (see Keylock, 2002, for details). The exercises were informal and unstructured, based on participatory rural appraisal (PRA) methods (e.g. Bernard, 2002; Guijt & Pretty, 1992; Pretty & Scoones, 1989; Scoones & McCracken, 1989). Amongst these exercises, a village map was drawn, on which all households were coded and the household head named (see appendix 3), a land-use map was drawn of the greater area around Sendje (see appendix 4) and the village history was discussed and displayed on a time-line. A 'household' was defined as a family group living together in one or more neighbouring dwellings and eating from a communal pot. Where a man had more than one wife, secondary wives and their dependants were only included if they lived and ate with the rest of the household. Detail on the history of Sendje and the country as a whole is given in chapter 1.

Since the official formation of the village in 1953, Sendje has seen a number of different foreign companies working in the area, providing local employment. During Spanish colonial times, two Spanish logging companies had concessions to the east of Sendje in the forest as far as and

including Monte Alén National Park. There were also coffee, cocoa and palm-oil plantations in the area, particularly to the west and south of Sendje. Following Independence, the plantations closed, but employment opportunities continued to a lesser extent with sporadic logging operations and, recently, construction companies, building and repairing the bridge over the Río Uoro to the north of Sendje and the road which runs from Bata through Sendje to Mbini and Cogo in the south (see table 1.1 in chapter 1 for details of companies working in the area since colonial times).

3.2.2 Data collection

The main period of data collection in Sendje was from November 2002 to January 2004, with regular household interviews starting in January 2003. Using the household code system devised during the pilot study, I first undertook a complete village census, listing each resident member of the household with their relation to household head, age, gender, level of education and occupation. I included all permanent residents living in the household at the time of the census, but not children living away from Sendje for the purposes of attending school (included in some censuses, e.g. Keylock, 2002; Mba Mba, 1998), as they were neither permanent consumers or producers with respect to the household. The census recorded a total of 317 permanent residents (199 over 18 years of age) within 59 inhabited households, giving a mean household size of 5.4 people (median = 4, SD = 3.84, range = 1-19). It should be noted that this population estimate is considerably lower than those recorded in the latest village general (2000) and electoral (1995) censuses; this could be (a) because of the slightly differing methodology used between surveys as mentioned above, (b) because a large proportion of the village had migrated to Bata in search of work with the current economic boom (see chapters 1 and 2) or (c) a result of previously inaccurate or deliberately misleading census data collection (see Equatorial Guinea section in chapter 1). All Sendje residents were of the Fang tribe, split into 7 different sub-tribes (akin to extended family clans; see chapter 1 for detail on Fang culture and history).

A sample of 48 households was then randomly selected from the list of 59 households, and a repeat sampling system devised of six households per day every day for an eight-day interview cycle, thus rolling forward one day of the week for each subsequent interview with a household. The sample decreased to 42 households during the course of the study due to mortality, emigration or dissolution, so this is the number used for final analyses. Interviews were conducted daily for 52 consecutive weeks from 29/01/03 to 28/01/04 (thus ensuring even coverage of seasons and days of the week) by a local female research assistant from the village, who had completed secondary education.

I conducted the first round of interviews with all 48 households personally, accompanied by the research assistant. During the course of the interview cycle, she learnt interview and data recording techniques by observing me and practising, gradually taking over sole responsibility for the interviews under my guidance and observation. I carried out regular checks of both her interview technique and data quality throughout the study. I wrote CyberTracker programs for data entry via palmtop computers to enable her to input her data from the pre-printed datasheets at periods of the day when not interviewing; I then checked all this data over while in the field so as to be able to raise any queries with her personally. As for all my research assistants, she was rewarded with regular bonuses for good work. In order to counteract interview fatigue on the part of the respondants, we worked hard to maintain a positive relationship with all villagers and thanked those households taking part in the study for their time with gifts of frozen mackerel, rice and other basic foodstuffs every four months or so. I also held parties for the entire village at the end of the first phase of data collection (March 2003) and upon leaving the village (December 2003).

Each interview took only 10-15 minutes once respondents were accustomed to the questions, but the limitation of six households per day was due to the availability of respondents, as they could only be interviewed in the very early morning and late afternoon/evening when they were not in the forest or the fields. Household respondents were usually the wife or wives of the household head, partly because they were responsible for obtaining and preparing food, and partly for the simple logistical reason of availability; whilst the men spent much of their time away from the home in the forest or the bars, when not in the fields the women were more usually to be found in their kitchen, preparing food and looking after the children. If a household was unavailable for interview on a particular day, they were visited the following day; if this was not possible, that interview was excluded from the analysis. The final sample comprised a total of 1607 interviews across 42 households, giving a mean and median of 38 interviews per household (SD = 4.52, range = 14 – 43). This large dataset allows for potential comparison at a number of levels: between households, individuals, major livelihood activity or week/month/season.

Respondents were first asked to list all food consumed by the household the previous day, including its state when acquired (live, fresh, smoked, rotten, dried, tinned, cooked in sauce, etc.), the quantity (kilograms, number, part/proportion of carcass, cup, sack, pile, etc.), the total cost for that quantity if bought (in CFAs: Central African francs), how it was obtained (bought, received as a gift, captured, reared), and from where it was obtained. A 24-hour recall was also conducted for the activities of each member of the household the previous day, from a list of 25 possible activities, including agriculture, fishing, hunting, trading, working in the home, education, working for an employer and resting/partying ('no answer', 'away', 'ill', 'nothing' or 'something else' were also

recorded). Specific gun-hunting and trapping activity for each household member over the last week was also recorded as a check on the hunter interviews and offtake survey (see below). Finally, all income and expenditure were detailed for both the household and each individual member over the past eight days. Income was broken down into wage (with bonuses), item or money received as a gift or borrowed, income from tenants and income from different livelihood activities. Expenditure included items or money received/lent, rental costs, expenditure on consumables such as different types of food, necessities, personal items, alcohol/cigarettes, large expenditures, costs of different livelihood activities, travel, debts and taxes. See appendix 3 for a sample household interview answer sheet. If a household member declined to respond or was absent, and their income or expenditure was therefore unknown to the interviewee, this was marked and accounted for in subsequent analyses.

I based some of the household interview format on those being concurrently conducted across Gabon by Wilkie and colleagues (Wilkie *et al.*, 2002; Wilkie *et al.*, 2005), but with some major modifications and additions. Firstly, whilst they used a three-day recall of household consumption, after piloting of the interview format I found that respondents had difficulty in accurately recalling what they had consumed over a timescale of more than a day. They also became bored by excessive questioning; an important point for a sampling protocol that involved repeat visits every week or so. I therefore only asked for a 24-hour recall. In addition, I recorded actual income over the past eight days (the intervening period since the previous interview), rather than an estimate of the last or a 'typical' month, for each person in the household specified by livelihood activity. Thirdly, I included questions specifically on hunting and trapping activities. These latter two inclusions allowed triangulation with data collected during hunter interviews and the offtake survey, by providing independent information both on who in the village was hunting and what individual incomes were obtained from bushmeat sales.

However, recording income from waged employment during the household interviews proved difficult. As only two wage-earners agreed to state their salaries to my research assistant, we were only able to record occasional waged incomes through the household survey, although we did record who was receiving a wage each week throughout the study period. To correct for this, I visited each wage-earner in the village individually, and whilst alone and assuring complete confidentiality, asked them to point out what code their salary fell into on a sheet of coded monthly salary-scales. In fact, in this situation most people were happy to either tell me or write down their exact salary, and some gave a break-down of bonuses received during the year. For those who were unavailable or still refused to indicate their income, I took the average salary for that type of job from others in the village with a similar job. As bonuses make up an important part of salaries in

Equatorial Guinea, I also discussed the issue of bonuses at length with my local research assistants. The usual practice is for a bonus of half a person's monthly salary to be given on Independence Day, 12th October, and at Christmas, and for double the salary to be paid if a company folds or a person is made redundant. There had also been a rise of approximately 50% in salaries in April 2003 (from an official minimum wage of 67,500 CFA (US $126) to 97,000 CFA (US $181) per month), dictated by the Government. I therefore incorporated the salary increase and bonuses into my final estimate of waged income per individual, across the entire study period.

In addition to recording household income, I assigned households to wealth categories, modifying a participatory approach originally developed by Grandin (1988). I loosely followed the methodology of de Merode (1998). I first separately asked eight individuals of a range of ages, sexes and backgrounds (see table 3.1), who knew the village well, to put all the households into five wealth categories (1 being the poorest and 5 the richest). I chose an odd number of categories to ensure that there was a neutral category available (Bernard, 2002). After discussion with each about why they had assigned households to particular categories, they were then brought together in a group, along with several other new participants again of a range of ages, sexes and occupations (making a total group size of 11), to discuss indicators of wealth and poverty. The initial aim was to get the group to put the households into the same five wealth categories as the individuals had previously done, and then discuss why, but as for wages, household wealth was a sensitive subject. Whilst the individual focus group participants had been willing to discuss wealth with me on a one-to-one basis, it was generally perceived as an inappropriate subject for public discussion, so an attempt at group ranking was abandoned.

Table 3.1 Details of individuals initially asked to put households into wealth categories

Sex	Age	Occupation	Education level
Male	64	Fisherman/trapper	Secondary 1
Female	52	Agriculturalist	Primary 5
Male	49	Village president/bar-trader	Secondary 3
Female	43	Bar-trader/agriculturalist	Primary 5
Male	35	Secondary-school teacher	Pre-university
Male	27	Unemployed	Secondary 1
Male	27	Research assistant	Secondary 4
Female	24	Research assistant	Secondary 5

Whilst there was no gender-split in opinion, two differing viewpoints as to what construed wealth rapidly emerged, depending on the age of participants. Traditionally for the Fang, signs of wealth were many wives (as bridewealth can be very high), many children and high agricultural capacity in

terms of fields and livestock. However, for the younger participants, their modern, westernised view leant more towards material possessions (table 3.2). There was a consensus, however, in terms of house type, secure employment, possession of at least one wife and to some extent material goods, including kitchenware, in that order (table 3.2). From these discussions I drew up a list of wealth indicators for which consensus was achieved. Most important were those based on house type (number of buildings, ownership, size, number of bedrooms, wall/roof/floor type, whether painted inside/out or not, etc.), whether the household had a bar and whether there were wage-earners within the household, but material possessions (type, cost and number of chairs, pots/pans, plasticware, watches/clocks, radios/stereos, mobile phones and generators), number of wives (including bridewealth) and number of children (including place of schooling) were also included. I recorded possession of each by all households in the interview sample during regular household interviews.

Table 3.2 Indicators of wealth as selected by the focus group, according to the sometimes conflicting viewpoints of older ('traditional' viewpoint) and younger ('modern' viewpoint) members of the group. Indicators were chosen if a consensus was reached (shared viewpoint). Indicators are listed in descending order of importance according to the group consensus.

Indicators of a wealthy household	Traditional viewpoint	Modern viewpoint	Shared viewpoint
House type			Concrete floor, built-in ceiling, painted inside and out, brick rather than wood walls
Job			Regular wage and prestige
No. wives	2-3	1-2, personal choice	At least one wife
No. children	8-10 (useful to work in fields and hunt/fish to support you in old age)	3-4 (if too many cost too much to send to school and can't afford necessary medicines so they die)	Some children, well-educated (private better than public school; Bata or Malabo/ overseas better than Sendje)
Possessions		Radios, watches, stereo systems, mobile phones, generators, freezers, cars	Well-fitted kitchen, with pots, pans and plastic-ware (women's suggestion only)
Agricultural capacity	Lots of fields, fowl and goats	Few fields/livestock (fields for poor peasants and number of livestock irrelevant)	No agreement

The majority of the men in the village hunted to some extent. Eighty-three active hunters were recorded during the study period out of a total of 93 adult males (16 years and above) in the village census. I interviewed 72 of these hunters. Interviews were informal and semi-structured (Bernard, 2002) and lasted around 30 minutes. I conducted all interviews personally, in Spanish and Fang, with additional Fang interpretation by a local research assistant where necessary. Participatory rural

appraisal (PRA) methods (Bernard, 2002; Pretty & Scoones, 1989; Scoones & McCracken, 1989), including the use of maps, calendars, pile-sorting, animal picture cards and multiple-choice options, were used to aid understanding of the questions by the hunter (particularly if their knowledge of Spanish was limited) and to maintain interest and enthusiasm during the interview. Hunters were offered cigarettes to put them at their ease during the interview and thank them for their time. Hunters were asked for personal details such as age, education and marital status, whether they had been born in Sendje or elsewhere, previous and current alternative livelihoods, previous and current hunting activity and locations (including number of traps), reasons for hunting, species targeted and why, favoured gear types and why, and costs incurred for different gear types.

All hunter offtake brought back to Sendje was recorded during the study period by a local male research assistant resident in the village. Number of carcasses caught, carcass weights, number sold and sales prices were recorded for all hunters (identified by household). The area they had been hunting in, the time they had spent hunting (in hours or days, which was then scaled up to days per month assuming an eight-hour day) and the gear type(s) they had been using were also recorded for each trip. A total of 9374 animals was recorded, caught by 83 trappers and/or gun-hunters.

I trained the research assistant in recording data from the hunters and in measuring (head-body length and tail length for unusual species where there may be an issues with identification, using a tape measure, following White and Edwards, 2000) and weighing (using a spring balance of 1-10 kg or 1-50 kg for larger carcasses; above this the carcasses weights were estimated) both live and dead animals in November 2002, before leaving Equatorial Guinea because of the Presidential election campaign. He was trustworthy, fastidious and familiar with the purpose of the study and with interview techniques, as he had also worked for me during the pilot trip, and therefore learnt rapidly to accurately and efficiently record the offtake. The vast majority of animals were recorded on Mondays, Wednesdays and Fridays, when the hunters and porters returned from the forest specifically to sell to the bushmeat traders coming from Bata (although offtake at other times was also recorded on an *ad hoc* basis). It was soon revealed that hunters had been paid per completed data sheet in the study by Fa and Garcia Yuste (2001), which subsequently made several hunters extremely reticent about providing information for nothing. In January 2003 we therefore agreed on a token payment per animal recorded (only for those physically observed by the assistant) of 50 CFA (US $0.09), which was insufficient incentive to encourage an increased level of hunting effort, but sufficient reward to encourage them to cooperate with the study. The increase in the number of hunters and animals recorded following this initiative demonstrated its worth. Whilst there still remained a couple of hunters who regularly deliberately avoided having their animals recorded, the animals missed in this way were relatively few. I carried out regular checks of the research

assistant's data collection and recording technique throughout the study. As for the household interviews, I wrote CyberTracker programs for data entry via palmtop computers to enable him to input her data from the pre-printed datasheets whilst in the village and not recording offtake. Both the research assistant and myself made great efforts to maintain good relations with the Bata bushmeat traders, and I thanked them for their patience (which often extended to proactively shouting out prices of carcasses to aid the assistant) with donations of a watch halfway through the study and crockery at the end.

The price of different types of bushmeat was taken from the offtake survey. The price of other meat and fish available in Sendje was taken from the 24-hour consumption recall data and was also recorded separately on an *ad hoc* basis during the study period. The mean price of frozen and tinned meat and fish types did not fluctuate apart from a slight universal increase in May 2003, following the increase in the official minimum wage by the Government (e.g. frozen mackerel increased from 800 to 850 CFA per kg and frozen chicken thighs from 1200 to 1300 CFA per kg). Frozen produce was imported from Bata and its availability increased during the course of the study. At the start of the study frozen produce such as mackerel was occasionally available at the bar/shop of household 36, having been brought from Bata by bushtaxi that morning and sold the same day. There was however a constant supply of frozen mackerel and usually other produce such as chicken or pork available at the shop of a road construction company camp, based in Sendje II 2 km to the north of Sendje. However, following the opening of a new bar/shop in Sendje I in May 2003 (by a relatively wealthy couple from another village), with a generator and chest freezer, permanent frozen storage meant there was a near constant supply of a wider variety of frozen produce in the village from then on. Frozen produce cost on average only 50-100 CFA per kg more than in Bata (e.g. when frozen mackerel cost 800 CFA per kg in Sendje, it cost 750 CFA per kg in Bata).

3.2.3 Data analysis

The number of meals of a particular meat/fish type consumed per day per household was calculated by dividing the total number of meat/fish meals recorded in the 24-hour recall by the number of interviews with that household. Assuming a possible maximum of 45.6 interviews per household per year (365/8), income was scaled up to give annual estimates per household (annual income = recorded livelihood profits/n effective interviews*45.6).

In calculating total household income, several complications with the household survey data became apparent, in addition to the issue of wages as described above. Firstly, nearly a third of all

household members were absent during the interview or declined to respond to questions on income (mean = 0.28, SD = 0.14, range = 0 – 0.51). In order to take their income into account, overall income per household was scaled up to include this proportion of non-responses (this is the number of 'effective interviews' in the equation above). It must therefore be emphasised that the accuracy of estimates of income varies between households, depending on both their level of compliance and availability for regular interviews (it was usually harder to record data on all household members the greater the household size).

Secondly, the costs for each livelihood input (e.g. machetes, nets, prepared food ingredients, items for bar trade) were subtracted from stated income to give overall profit net of costs (hereafter referred to as 'income'). However, a comparison of income from hunting between that reported in the household survey and that recorded in the offtake survey showed that income from this male-dominated livelihood was being severely under-reported in the household interviews (by a factor of nine). This was because either the women household respondents genuinely had no idea about the men's hunting income (and therefore the individual was marked down as 'unknown' under income in the household interviews, thus reducing the accuracy of the total hunting income estimate), or the men had claimed to their wives to have caught and sold less than they actually did in order to avoid having to share the proceeds with the rest of the household (thereby underestimating hunting income). I therefore used hunting income as estimated from the offtake survey in subsequent analyses. As I had no independent estimate of income from fishing, another male-dominated livelihood in which men are known to under-report catches to their wives (pers. obs.), I multiplied income recorded in the household survey by nine to account for the same level of under-reporting as for hunting (as fishing was a minor income-generating activity this in fact made little relative difference to the final results).

Thirdly, in the case of hunting costs, I estimated costs from the offtake survey and from general observation. One 35m roll of wire (costing on average 5000 CFA in Sendje) was enough to set 90-150 traps, about the number set by the average trapper (see chapter 4). However, village-based trappers tended to have fewer or older traps (therefore with wire less frequently changed) than forest-based trappers, overnighting in hunter camps (see chapter 4). I therefore subtracted 5000 CFA from the annual income of forest trappers but only 2500 CFA from the annual income of village trappers. Cartridge price in Sendje fluctuated slightly, depending on source and availability, but was on average 750 CFA per cartridge. For all shot carcasses recorded, I therefore subtracted 850 CFA per carcass, to account for the cartridge cost plus a proportion of mis-hits and dud cartridges due to low quality. Finally, porters were sometimes employed to carry meat from some of the further hunter camps back to the village. During the study, porters were mainly only

employed at one camp, Mabumom, which at 30 km away was the furthest from the village. Two porters were employed on a permanent rolling cycle (one leaving for the forest when the other returned to the village) to ferry offtake from the most prolific hunter in the village, Hunter X. However, they were also used by other hunters at the camp if they had space. As approximately 25% of the proceeds of a bushmeat sale went to the porter, I multiplied each carcass in Hunter X's offtake by 0.8 (to account for the large proportion he also carried himself) and carcasses for other hunters at Mabumom by 0.9 (as they used the porters less than Hunter X).

Fourthly, there was an initially alarming disparity between income and expenditure on bar/shop trade. There were five bar-owning households in my sample, most of which actually reported greater expenditure than income during the survey. However, this is easily explained. Whilst most of them kept accurate records of exactly what they had purchased for their bar (having shop receipts for the number of bottles of liquor, cases of wine and cartons of cigarettes, for example), they were rather more lax in recording what had been taken by the bar over the course of the week (or at least reporting it to my research assistant). The bar-owners of household 36 were an exception in keeping accurate accounts of both income and expenditure (with a ratio of income to expenditure of 2.17). I therefore took the profit margins of household 36's bar/shop as typical profit margins for all the bar/shops in Sendje, and scaled up their income from expenditure accordingly. Although clearly not ideal, this is a reasonable assumption, given that similar items were on sale in all the bar/shops included in the survey.

Therefore, whilst initially certain data were hard to record directly from all household members over the course of all interviews, the fact that supporting information was recorded through a number of different methods and from other sources, in addition to the household survey, enabled the modifications described above. The incorporation of these modifications meant that, overall, a valid assessment of both individual and household income was possible.

In order to calculate effective income per household, some measure of household size is needed. The simplest measure is the number of individuals in the household, but this does not take into account the relative contributions of different members of the household with regard to consumption and production (Sellen, 2003). For consumption, I take a measure of adult male equivalence, in order to account for differing energy requirements according to age/sex. I chose to use Reference Adult (RA) units (ILCA, 1981), which take into account both consumption and production (Sellen, 2003). An adult male (≥16 years of age) represents 1.0 RA unit, an adult female 0.86 RA units, and children 11-15 years 0.96 RA units, 6-10 years 0.85 units and 0-5 years 0.52 RA units. I take the number of potential producers in a household as the number of adult males (≥16

years), as that is roughly the age that hunters and wage-earners become active, and hunting compared to other livelihood options is the focus of this study. I put no upper age limit on consumers or producers because (a) it can be difficult to measure age accurately with no written records such as birth certificates and (b) many men continue to hunt until they are well above the conventionally-accepted age limit of productivity of 60 years (the oldest hunter recorded in Sendje was 80+ years old). Finally, I calculated a dependency ratio (the number of consumers to producers) for each household, as the ratio of Reference Adults to adult males.

However, a caveat should be made here that while the RA index seems a sensible one to use, it is based on east African pastoralist communities, and any measure such as this is likely to be very population-specific (Sellen, 2003). The values for women and children are quite high, so the index may slightly overestimate household consumption needs. Many different adult male equivalent measures have been used in studies of consumption and livelihoods, making direct comparison difficult, particularly when the exact units of measurement are not defined (e.g. de Merode, 1998; de Merode *et al.*, 2004; Starkey, 2004). This said, whilst the differences between these different indices may affect absolute numbers, they should have little effect on general trends. As a check on this, I included four further measures of income in analyses: total household income, household income per RA, household income per capita and household income per adult male.

In order to facilitate comparison with other sites and international development indicators such as the US$1 per person per day extreme poverty line (but see Cavendish, 1999; Homewood, 2005b; UNDP, 2000), I calculated the mean per capita income per household in US$, using a conversion rate of 1000 CFA = US$1.82 (rate on 15/06/03, mid-way through the study period). This gave a mean of US$1.27 or a median of US$0.94 per person per day across the village (range $0.03 – 5.58, SD = 1.31), suggesting that about half the households in Sendje (22/42 in the household sample) are living in extreme poverty. However, this figure is not strictly comparable for several reasons. Firstly, it is measured in current prices and has not been converted to purchasing power parity prices (whereby the $1 a day measure is actually $1.08 at 1993 international prices: for explanation see UNDG, 2003). Secondly, the $1 a day is supposed to include consumption as well as income, so is severely underestimated according to this methodology. Thirdly, without adjusting for local consumer price indices, the international poverty line is meaningless in local terms (UNDG, 2003). Finally, it fails to take into account inequalities within the household. Although useful in producing estimates of poverty at the aggregate level and in allowing comparisons across countries, the $1 poverty line has limited relevance here.

Each household was placed into the modal average wealth category designated by the eight individuals prior to the focus group. However, as categories 1 (the poorest) and 5 (the richest) had only two households and one household in respectively, I used the list of wealth indicators decided upon by the focus group, to reassign 11 borderline households which the eight individuals had originally put in conflicting categories. This resulted in a more even distribution of households among the five categories (figure 3.1) and was therefore used in later analyses (table 3.3). In all cases a household was only moved to an adjacent wealth category if at least two focus-group participants had originally placed it in that category. The single exception to this was household 12, which I moved from category 2 to 5, due to differing perceptions of what constituted this household. The original household was composed of an old (septuagenarian) couple, without a wage or bar, and therefore was justifiably considered to be in a poor wealth category. However, their son-in-law, Ricardo, originally from another village, came to Sendje in early 2003 and set up a very profitable bar. Although he officially lived in household 12, and regularly purchased food for the communal pot, he otherwise did not share his income. I reassigned this household to category 5 based on Ricardo's obvious wealth (with a smartly-furnished bar and possessions such as a generator and DVD player), even though Antonio, the head of the household, still lived very modestly and continued to trap around the village to protect his crops.

Figure 3.1 Assignment of households into each of the five wealth categories, according to the initial classification of 8 individual members of the focus group (conducted separately) and after *post hoc* reassignment according to wealth indicators selected by the group.

Wage-earners and bar-owners were only found in the higher wealth categories (table 3.3). Household income (log US$ per person per day) was highly correlated with wealth category (Spearman's correlation coefficient (two-tailed) = 0.68, n = 42, $p < 0.001$; summarised by wealth category in table 3.3). The correlation was even stronger for non-hunting income (log US$ per person per day) (Spearman's correlation coefficient (two-tailed) = 0.76, n = 42, $p < 0.001$). This

suggests that either measure of income may to some extent be interchangeable with wealth category (partly because measures of wealth are to a large extent based on income). A cluster analysis was performed on income (US$ per capita per day) to divide this quantitative, continuous measure of wealth into five categories (following de Merode *et al.*, 2004). The cluster categories correlated significantly with the categories obtained from the participatory wealth ranking exercise (Spearman's correlation coefficient (two-tailed): r = 0.41, p = 0.007, n = 42), suggesting that these qualitative wealth categories are a good approximation of overall household income. However, as the correlation is stronger when the continuous income variable is used instead of its condensed cluster category, this adds strength to the argument that, regardless of whether overall 'wealth' or monetary income is used, a continuous variable should have stronger predictive power than a categorical one.

Table 3.3 Characteristics of wealth categories 1-5 and number of households in each category.

Wealth category	n households	Mean annual income (CFA)	Mean US$ per RA per day[1]	Mean household size (RAs)[1]	Mean dependency ratio[2]	% commercial hunting	% wage-earning	% with bar/ shop
1	5	132,516	0.22	3.5	2.4	60	0	0
2	7	382,380	0.46	4.0	2.1	43	0	0
3	15	1,225,196	1.30	5.9	3.4	66	66	0
4	10	1,993,314	1.63	7.4	3.1	60	80	10
5	5	3,263,355	4.45	4.4	4.1	0	60	80

[1] RA (Reference Adult) units are a type of AME (adult male equivalent) unit (ICLA 1981)
[2] Mean dependency ratio is the number of consumers (RA units) divided by the number of producers (adult males, defined as 16 years and above)

Finally I ran a series of generalised linear models (GLMs) using the statistical software 'R' to test which variables predict whether a household hunted commercially (as a proxy as to whether the household relies on hunting for income; I defined commercial hunting as the sale of ten or more hunted animals per year), whether they gun-hunted or not (as guns are the gear type with the greatest barriers to entry) and finally the proportion of catch that a household sold (weighted by number caught, by including it as an offset). All income variables were first log-transformed to give a normal distribution. I ran univariate analyses first to test for differences in my measures of non-hunting income (total non-hunting income, non-hunting income per RA, non-hunting income per capita and non-hunting income per adult male). Since all were highly correlated with one another and the differences were minor, I chose non-hunting income per RA to aid conformity with the consumption analyses. The seven final predictor variables entered into each of the three multivariate GLMs were non-hunting income per RA (log-transformed), wealth category, whether or not the household contained a wage-earner, whether or not the household owned a bar/shop, the number of adult males, the dependency ratio and the mean age of adult males. As all villagers were Fang, ethnicity was not likely to be a factor, and other potential explanatory variables such as

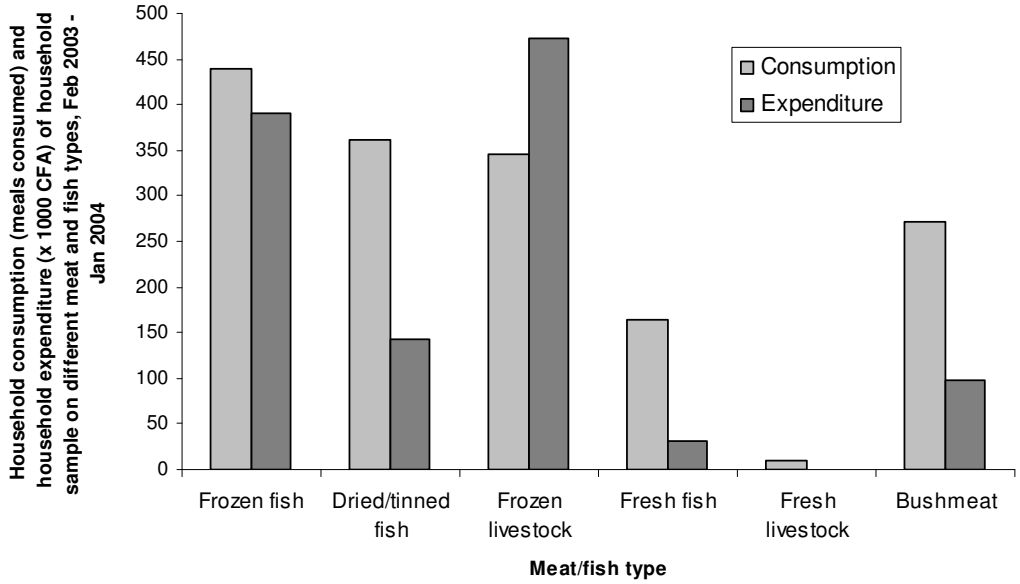
education were individual-specific so inappropriate for a household-level analysis (see chapter 4). For the commercial hunting analysis, both the multivariate and univariate GLMs were run with log non-hunting income per RA as a quadratic variable, as tests indicated that it exerted a polynomial (quadratic) effect (GLM: F = -4.956, p = 0.026).

3.3 RESULTS

3.3.1 What is the role of bushmeat in household production and consumption?

Bushmeat plays a relatively minor role in consumption across all households (figure 3.2). Frozen meat and fish are consumed much more frequently than fresh produce. Frozen fish is the most commonly consumed meat/fish type, followed by dried fish and then frozen livestock (figure 3.2). This order of actual meat/fish type consumption frequency is very similar to that reported in the one-off household survey conducted during the pilot trip, where we asked households about typical consumption patterns (see figure 2.3b in chapter 2). This gives confidence in the other findings of that survey, namely that consumption did not reflect preference (see chapter 2). There was no seasonal pattern to either bushmeat or overall meat/fish consumption by households (Pearson's correlation between number of bushmeat meals consumed per day and rainfall per month = 0.20, df = 11, NS; correlation even weaker for meat/fish).

Figure 3.2 Number of meals consumed of each meat/fish type (n = 1590 meals) and total expenditure on different meat/fish types (n = 923 bought meat/fish meals). The difference between the two samples is significant (χ^2= 220, df = 4, p < 0.001).



Expenditure on different meat and fish types differs significantly from consumption (χ^2= 220, df = 4, $p < 0.001$). Expenditure on bushmeat and fresh fish is proportionally lower than on frozen produce, due to the fact that these wild foods are more commonly captured by the household instead of being purchased (figure 3.3). In addition to frozen foods, both dried and tinned fish are widely consumed, although expenditure per meal is a lot lower than for other meat and fish types (figure 3.2 and table 3.4). In the first case, dried fish in particular is widely perceived as a 'poor man's meal'. It is eaten in smaller quantities per meal as it has a stronger flavour and so provides taste rather than bulk (i.e. less protein per portion). In the second case, tinned fish (sardines) makes up a fairly small proportion of the 'other fish' category, and is more commonly consumed by hunters in the forest. In contrast with meat and fish, the majority of staples, fruit and vegetables were produced by the household rather than purchased.

Figure 3.3 Source of different meat/fish types (bought, received as a gift, reared or captured) as proportion of meals consumed

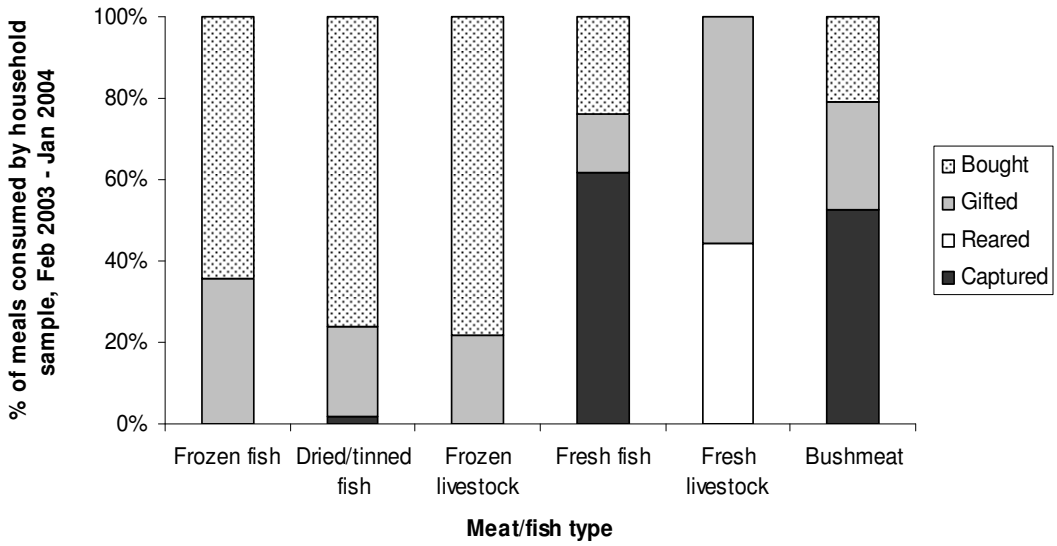


Table 3.4 Number of meals consumed and bought, and expenditure per meal bought, for different meat/fish types

Meat/fish type	Meals consumed	Meals bought	Expenditure per meal (CFA)
Frozen fish	439	283	1377
Dried/tinned fish	361	274	519
Frozen livestock	346	271	1741
Fresh fish*	164	39	804
Fresh livestock	9	0	/
Bushmeat	271	56	1743

* includes crayfish and crabs

Consideration of the difference in price between these meat/fish types helps to explain their relative consumption. Bushmeat and fresh livestock are on average the most expensive food types (although the price of bushmeat can vary considerably, with the cheapest species being the cheapest meat/fish type per kilogram in the village, whilst the most expensive species is nearly four times the price of frozen mackerel; figure 3.4). Most bushmeat (mean 89%) is thus more commonly sold by hunters to earn income (figure 3.5). (As can be seen from figure 3.2, fresh livestock plays a very minor role in household consumption and expenditure, and the same is true for income.) In turn, the household can buy a greater quantity of frozen produce with the profits from selling bushmeat, or use the surplus to buy necessities such as soap, salt, oil or paraffin, or luxuries such as alcohol or cigarettes. However hunters can differ widely in the proportion of offtake they sell. Those hunters who catch a greater number of animals sell a greater proportion, as they are hunting predominately for income (figure 3.5). On the other hand, at the lower end of the graph there is a great deal of scatter; it appears that whilst some households who catch fewer animals are hunting mainly for subsistence (or for some other reason such as crop protection) and so consume the majority of their catch, others are also hunting for the commercial trade.

Figure 3.4 Prices of different frozen and fresh meat and fish types in Sendje during 2003. Prices are the means and 0.05-0.95 percentiles of all types in each category for which price data were available. Prices for bushmeat were taken from the offtake survey of all bushmeat traded and those for the other food types from the household survey. Dried/tinned fish is not included here as due to the drying or tinning (i.e. addition of water/oil) processes, direct comparison with fresh or frozen cuts difficult in terms of price per kilogram.

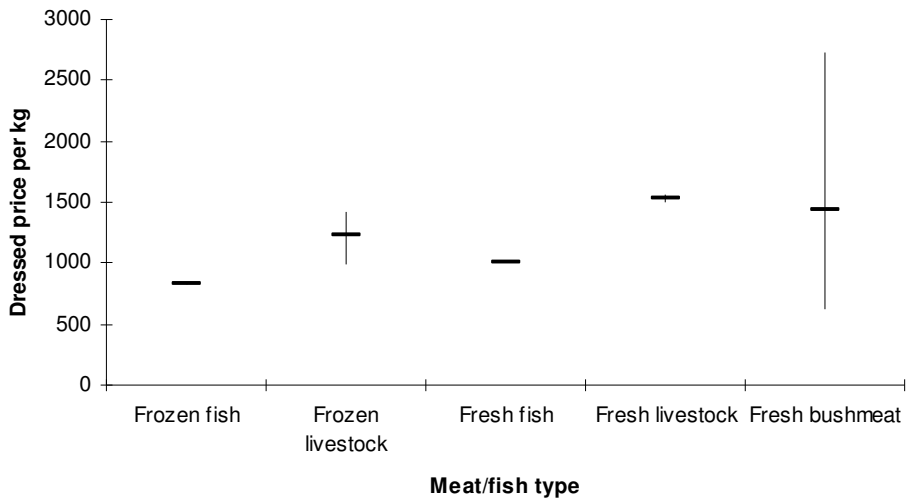
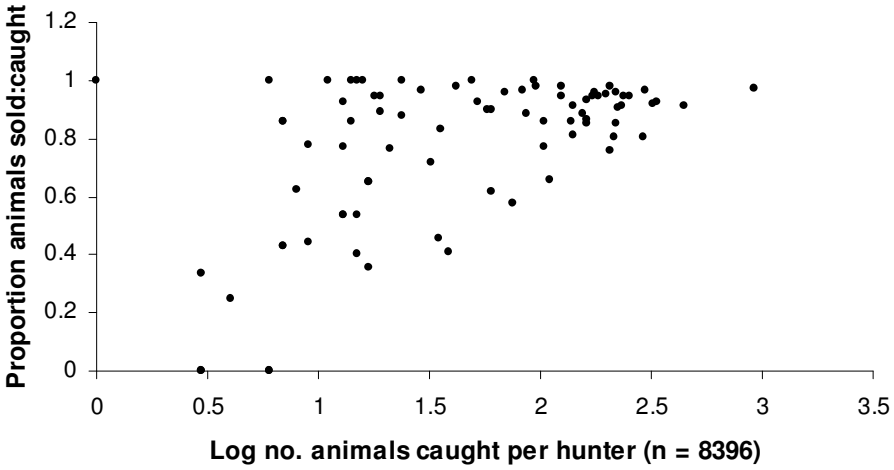
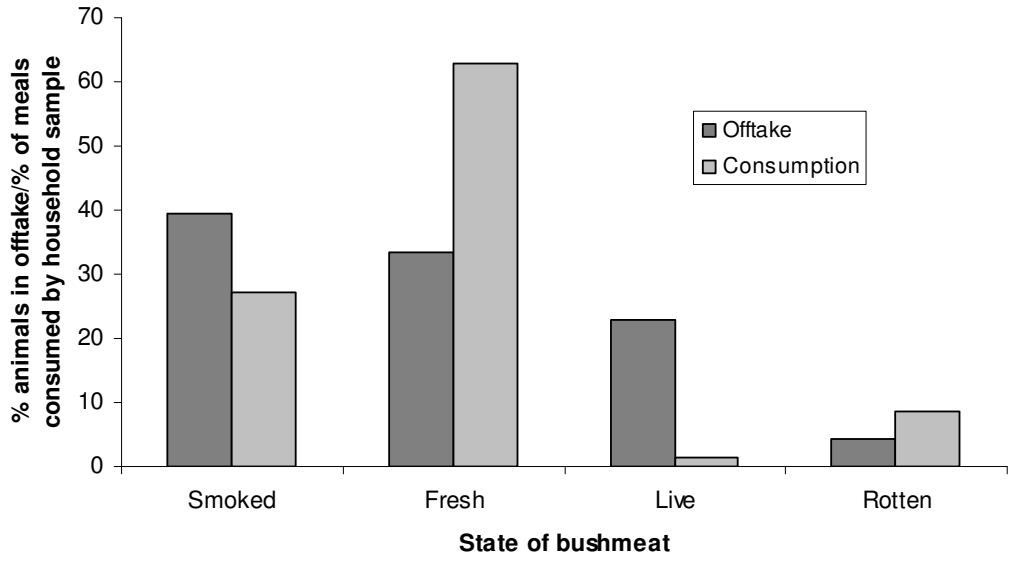


Figure 3.5 Log_{10} number of animals caught by proportion traded per hunter, from Sendje offtake survey during 2003 (n = 8396).



The large disparity in prices for different species of bushmeat (figure 3.4) means that the larger, more marketable types tend to be sold (e.g. medium-large ungulates, pangolins, porcupines and monkeys), usually to the Bata bushmeat traders (see chapter 2), whilst the smaller, less profitable animals are consumed within the household (or in hunter camps in the forest, without even being brought to the village: see chapter 6). It is not just the species that defines profitability, but also the state of the carcass (figure 3.6). Smoked and live animals keep for longer, so are more marketable than rotten or fresh (that may be close to rotten) carcasses; accordingly, the proportion of carcasses that are consumed in Sendje differs significantly from those that are caught (χ^2= 56.9, df = 2, $p <$ 0.001; figure 3.6).

Figure 3.6 Percentage of smoked, fresh, live or rotten animals recorded in the hunter offtake with those in each state consumed by households. The difference is highly significant ($\chi 2$= 56.9, df = 2, $p < 0.001$).



3.3.2 Do hunters hunt through choice or necessity?

It is clear that a large number of hunters sell bushmeat for income, but to what extent do they rely on hunting as a livelihood? At the village level, hunting is a major income-generating activity, falling just below waged employment and above bar trade (figure 3.7). Whilst hunting is a major livelihood in Sendje, agriculture and fishing are not. There is also a clear gender split: men are the main income-earners, earning 83% of all village income. Commercial hunting is a totally male-dominated activity, as is commercial fishing, with nets, traps or line (dam-and-scoop fishing is carried out by women, but solely for subsistence). Agriculture is predominantly for subsistence and purely carried out by women (with the exception of a few weeks in the two annual dry seasons when men burn and clear the fields before planting). Unlike bushmeat, the limited trade in agricultural products was nearly always within Sendje itself, rather than to the Bata market.

However, if we look at the contribution of the top three earning livelihoods, waged employment, hunting and bar trade, at the household and individual level, we see a different picture (figure 3.8 and appendix 3.1). Bar trade is clearly the most profitable livelihood for both households and individuals, followed by waged employment and then hunting. Bar trade is distinct from the other two livelihoods in having prohibitive start-up costs (which create a barrier to entry for most Sendje households) as well as being practised by women as much as men (women tend to be more active in trading in Equatorial Guinea – see also chapter 2).

Figure 3.7 Total annual village income from different livelihoods, separated by gender (estimated by scaling up the 1607 household interviews with the sample of 42 regularly interviewed households, to estimate income of all 59 households in the village per year).

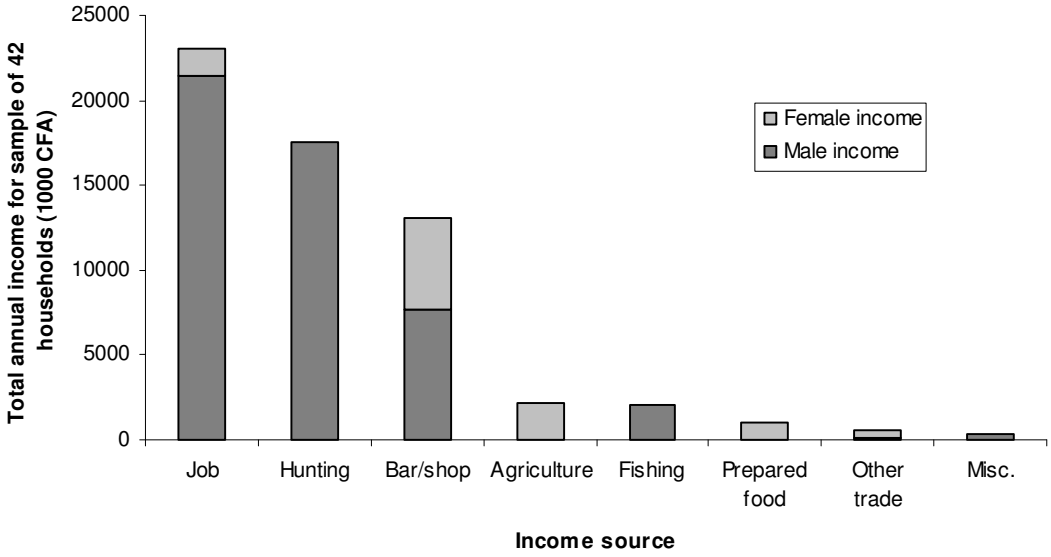
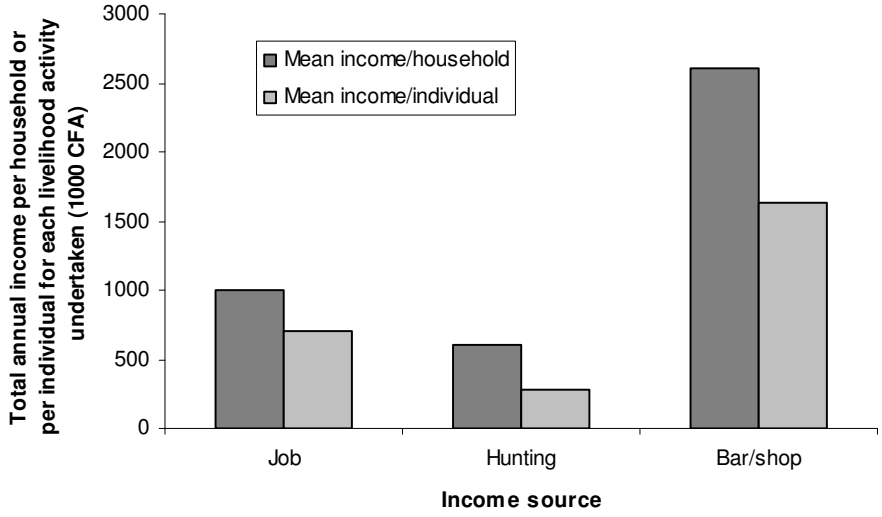


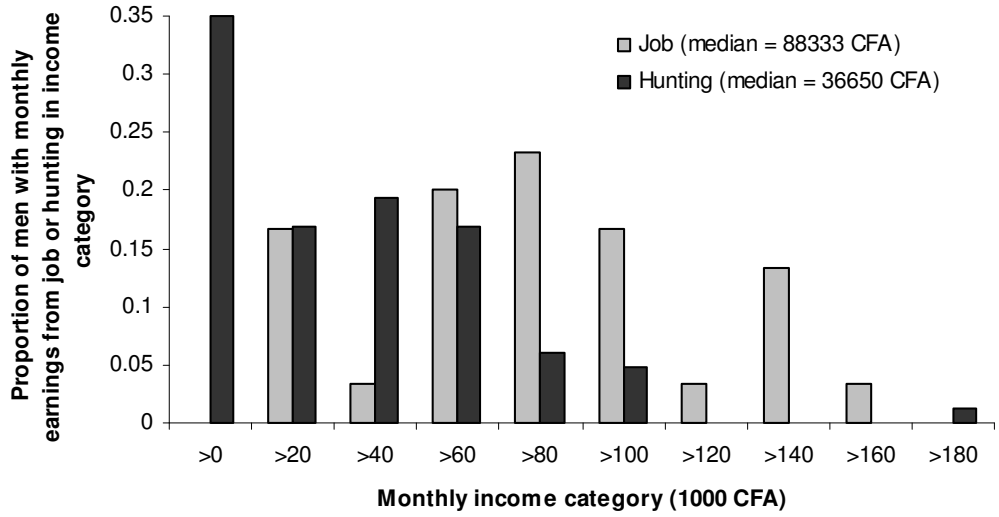
Figure 3.8 Income per household and per individual from the three highest-earning livelihood activities for the village as a whole. Income shown is that solely earned from the particular livelihood.



Hunting and waged employment are the main male income-generating activities in the village, and are commonly carried out by the same individuals at different times (see below; figure 3.9). The average male monthly income from hunting (mean = 43,043 CFA, median = 36,650 CFA; range = 0 – 195,678 CFA; n = 83) is far less than that from waged employment (mean = 88,394 CFA, median

= 88,333 CFA; range = 20,000 – 160,000 CFA; n = 30). The mean from hunting is higher than the median due to the right-tailed skew of the distribution of hunting income; at the extreme, one particularly prolific commercial hunter, Hunter X, had a total catch and total profit that far exceeded any other hunter in the village, and whose monthly income from hunting was greater than the highest wage (figure 3.9). In comparison, the majority of hunter incomes fall into the lowest category, demonstrating that although hunting can be a profitable livelihood, it rarely is. It is possible that some hunters may be supplementing this low hunting income with income from other livelihoods. However, even reducing the hunter sample to those for whom hunting was their only source of income, monthly income was still far less than that of the average wage (mean = 58,743 CFA, median = 56,167 CFA; range = 10,000 – 195,678 CFA; n = 55). Note that hunting is the sole livelihood for the majority of men in the village: 55 out of a total of 93 adult males in the census.

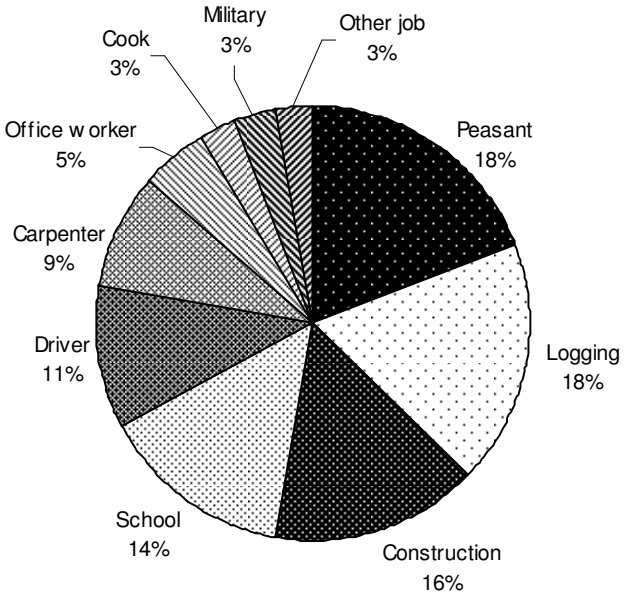
Figure 3.9 Frequency of male monthly mean incomes from hunting (n = 83 hunters) and paid work (n = 30 wage-earners), with medians indicated



So if jobs are so much more profitable than hunting, why doesn't every man earn a wage? Education does not appear to be a barrier to getting a job. There was no significant difference in education codes (0 = illiterate, 1 = primary, 2 = secondary, 3 = pre-university) between male adult hunters (mean = 1.37, SD = 0.73, n = 70; range = 0-2) and male adult wage-earners (mean = 1.43, SD = 0.68, n = 30; range = 0-3) (two-tailed Student's t-test = 0.691, df = 98, NS). Neither did the age of hunters (mean = 45.4, SD = 17.9, n = 70; range = 18-90) differ from that of wage-earners (mean = 43.8, SD = 13.4, n = 30; range = 22-71) (two-tailed Student's t-test = 0.65, df = 98, NS). However, there was some overlap between the 'hunters' and 'wage-earners'; 15 men conducted both livelihoods consecutively during the study period.

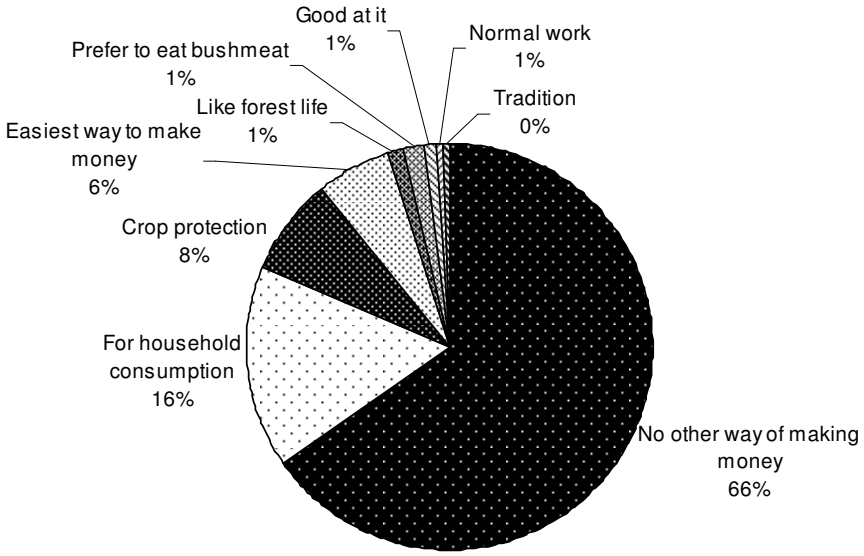
Sendje hunters are certainly not unemployable. The majority (68%) have had a job in the past (figure 3.10). Of the remaining 32%, 14% had either just left school or were trapping in their school holidays with a view to returning (earning money to matriculate for the new year). Of the 18% who had always been peasants (defined here as those practising agriculture, hunting or fishing), some had previously worked on plantations in colonial times whilst many of the others were non-native hunters who had come to Sendje to hunt commercially (see chapter 4). They had mainly been agriculturalists in their home villages in the interior of Río Muni, where agriculture is a more commercial activity than in Sendje. Twelve of the 70 respondents (17%) had previously worked in Libreville (Gabon), many for decades, where some gained qualifications and all earned far higher wages. However most eventually returned because of both official and social persecution (Equatoguineans find it difficult to obtain foreign work permits as they commonly lack formal travel documentation).

Figure 3.10 Occupations of hunters before hunting (n = 70 hunters)



Hunters were asked why they hunted, and presented with a selection of choices written on cards (including the option 'for another reason'). The vast majority (66%) chose 'because there is no other way of making money' (figure 3.11). They distinguished between this and another option presented to them, 'because it is the easiest way of making money' (6% of responses). 'For household consumption' and 'for crop protection' were chosen only 16% and 8% of the time. When asked if they wanted their sons to be hunters, 90% of respondents (n = 72) stated emphatically no.

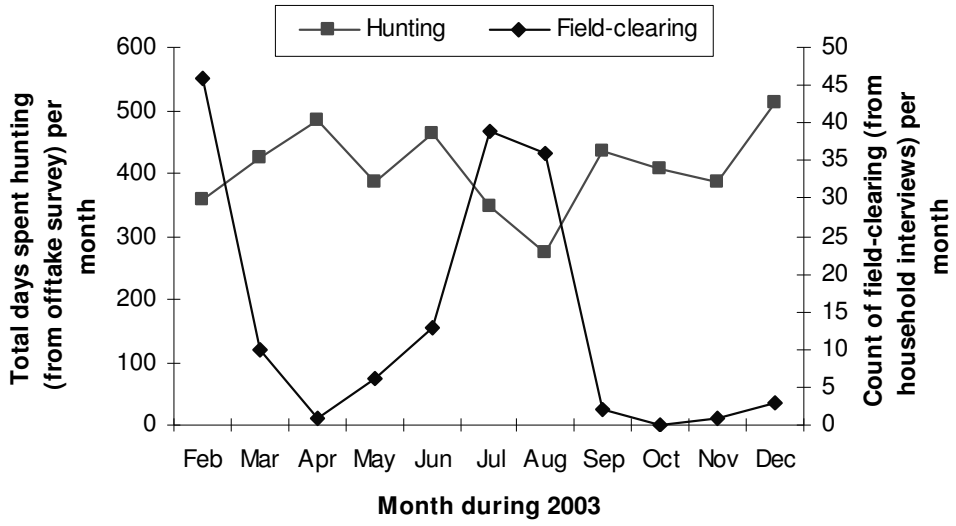
Figure 3.11 Answers to question 'Why do you hunt?' during hunter interviews (n hunters = 72; n responses = 59). Only top-choice reasons (or joint-top reasons, represented proportionally) are presented here, although in many cases a hunter chose several other secondary reasons. Options were written onto cards and laid out in random order in front of interviewees so that they could pick those most applicable. Three other reasons that were presented to respondents as options ('because the women think I'm strong' (i.e. for prestige), 'because I like hunting' and 'for another reason') got no scores.



Many men spend fewer days hunting at the end of each dry season (Feb-Mar and Jul-Aug), when they clear the fields for planting by the women (Pearson's correlation: R = -0.70, p = 0.017, n = 11; figure 3.12). However the drop in hunting effort is not large, as agriculture is not an important male livelihood, and therefore most men spend only a couple of weeks clearing fields per season, whilst still continuing to hunt to a lesser extent. Thus, even though subsistence agriculture is likely to be a considerable contributor to overall household production, as measured in studies such as de Merode *et al.* (2004), this time spent by hunters in clearing fields produced negligible income as defined in this male-focused study, as none of it accrued immediately or directly to them, due to the time-lag between planting and harvesting and the fact that any income from agriculture was accrued by the women.

This serves to demonstrate that hunting can be seasonal, depending on the availability of other livelihood activities. However, the main 'seasonal' effect is the availability of other income-generating jobs. Hunting serves as a temporary or long-term fall-back in times of financial need. Trappers stop trapping when occasional work with construction companies working in the area comes their way, whilst students return to the village to trap in their school holidays.

Figure 3.12 Time spent by men in the village hunting and clearing fields (Pearson's correlation: R = -0.70, p = 0.017, n = 11).



Overwhelmingly, hunters complained that they hated hunting (as one hunter stated, 'It is an example of the misery we have here in Equatorial Guinea'). Certainly there was not much prestige associated with hunting: for example, the general reaction to the reason, 'because the women think I'm strong', was either disgust or hilarity, and in the focus group one woman stated that, 'trappers are the paupers of the village… they sleep in the forest like meat'. Generally, if a man doesn't have to hunt, he doesn't.

3.3.3 How do economic differences between households affect bushmeat hunting, consumption and expenditure?

Linear regressions were performed to understand the effect of increasing income on consumption of and expenditure on both meat and fish in general, and bushmeat specifically. When measured in terms of meals of a particular type consumed (as actual weights of meat/fish were often not available from the interview data), increasing household income per RA caused an increase in daily consumption per RA of meat and fish (adjusted R^2 = 0.130, t = 2.67, b = 0.109, df = 41, p = 0.011) but had no effect on daily bushmeat consumption per RA. Higher household income per RA caused highly significant increases in expenditure per RA on both meat and fish (adjusted R^2 = 0.46, t = 5.99, b = 0.296, df = 41, $p < 0.001$) and bushmeat (adjusted R^2 = 0.168, t = 2.97, b = 0.479, df = 25, p = 0.021) (figure 3.13).

Figure 3.13 Log_e annual household income per RA with (a) $\log_e$ daily meat/fish expenditure per RA and (b) $\log_e$ daily bushmeat expenditure per RA (plus 1). For meat/fish expenditure, the slope is equal to the income coefficient, but not for bushmeat due to adding 1 to allow logging of zero expenditures.

Figure 3.13a

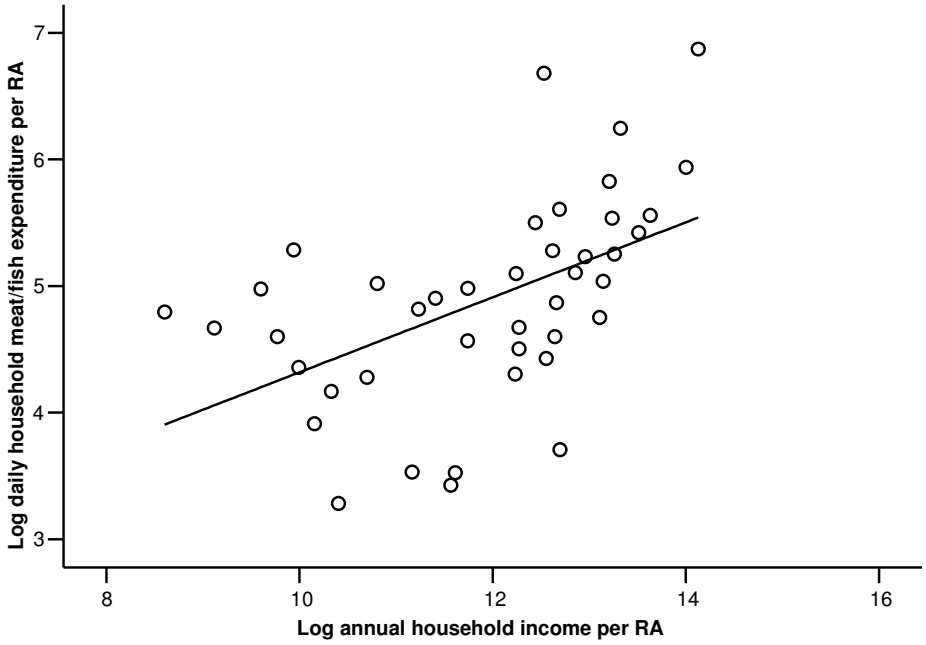
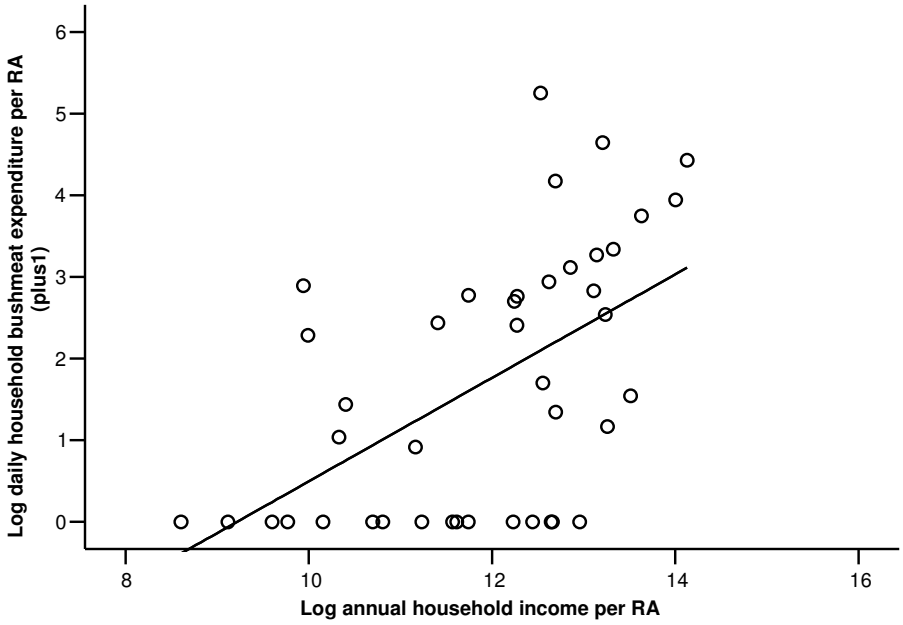


Figure 3.13b



The slope (b) of log-transformed consumption or expenditure against log-transformed income for all households gives the income coefficient, essentially the income elasticity, of that commodity (figure 3.13) (see chapter 2 for detail on income elasticities). The income coefficient for meat/fish consumption is 0.109 and for expenditure is 0.296, suggesting that meat and fish are necessities. In terms of expenditure, bushmeat appears to be a necessity, with an income coefficient of 0.479, but the coefficient for consumption is non significant; however it should be noted that this excludes those households with zero bushmeat expenditure (16 households) or consumption (2 households), as values of zero cannot be log-transformed (hence the lower df than for the meat/fish regression analysis). Many households never buy bushmeat whatever their income (figure 3.13b). This is because richer hunting households can still eat their surplus bushmeat so do not need to purchase it, some families with high status or allegiances to the ruling political party receive bushmeat as a gift rather than having to buy it, and some people just don't like it (see preference surveys in chapter 2).

The importance of hunting income to a household was greater for those households in the lower wealth categories, 1 and 2 (figure 3.14). Those who earned a lot in category 4 but from hunting rather than a job or bar were not considered by the focus group to be worthy of category 5 because of the low status of hunting (figure 3.14). Similarly, some hunting households which were placed in category 1 actually earned more than the non-hunting households of category 2. This emphasises the point that perception of wealth is often blurred with factors such as status and prestige and therefore often represents more than purely financial assets – at least in the short-term.

The results of the GLMs to test whether any household characteristics predicted whether a household hunted commercially (binomial errors), whether they gun-hunted (binomial errors) and the proportion of catch sold (number sold with Poisson errors and number caught offset) are shown in table 3.5. In the multivariate analyses, the number of adult males in the household was the only significant (positive) predictor of whether or not a household hunted commercially and whether or not it gun-hunted. Non-hunting income per RA (with a quadratic function) and the dependency ratio were nearly significant predictors of commercial hunting in the multivariate GLM. However, when tested alone, dependency ratio was not significant, while the quadratic fit for non-hunting income became significant at the 0.05 level (negative), showing that the effects of income were confounded by the number of adult males in the household. The negative quadratic term for non-hunting income indicates an 'inverted-U' response of probability of commercial hunting, with middle-income households being most likely to hunt commercially, whilst higher, and to a lesser extent lower, income households less likely to hunt commercially (figure 3.15).

Figure 3.14 Log_e annual household income for non-commercial hunting and commercial-hunting households in each wealth category. The difference in income between hunting and non-hunting households appears to be greatest in poorer households (those in wealth categories 2 and 3). Note that there are no commercial-hunting households in the top wealth category.

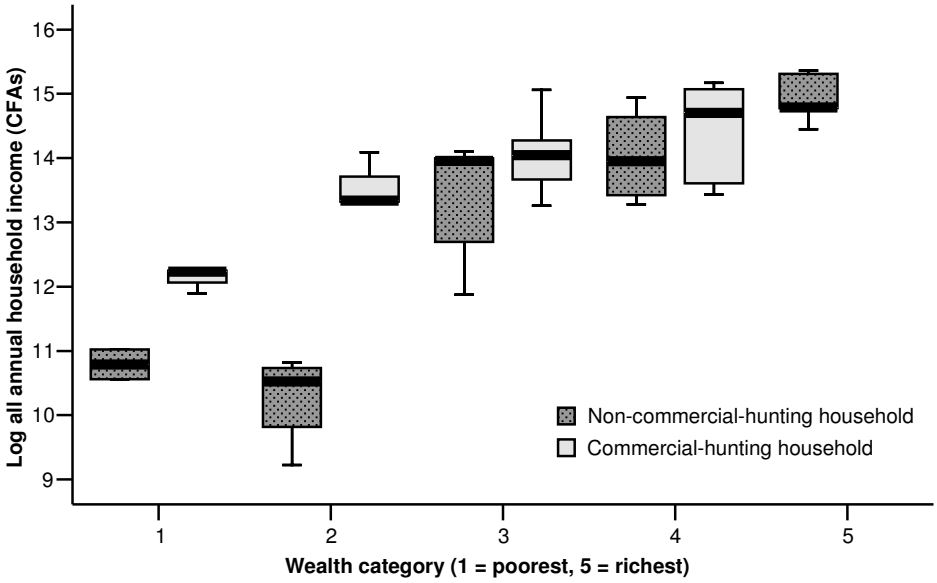
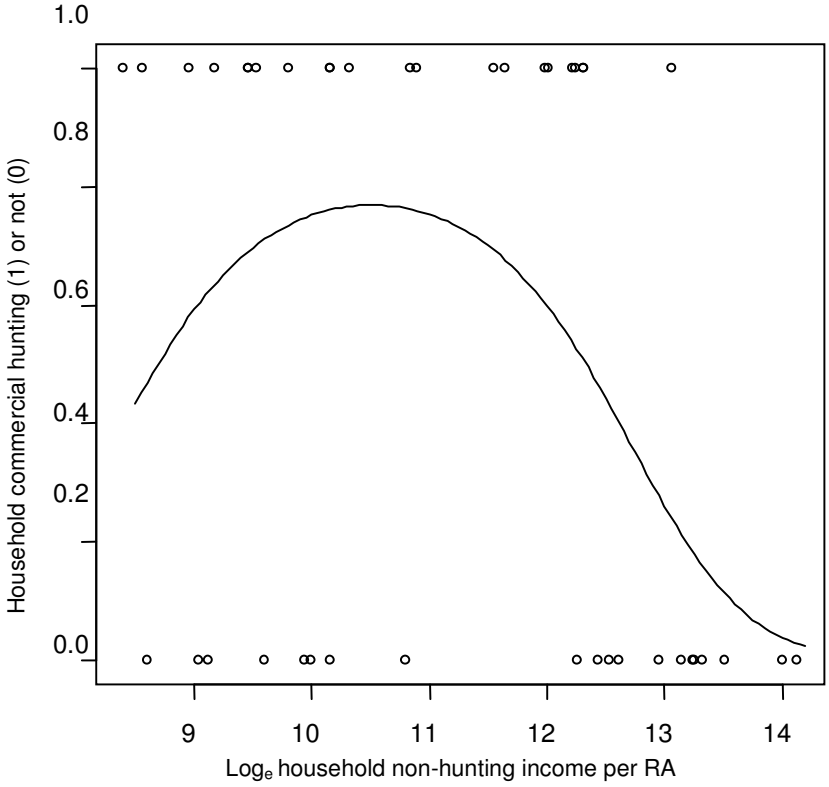


Table 3.5 Results of univariate and multivariate generalised linear models to test which explanatory variables predicted whether a household hunted commercially (n all households = 42), whether a member of the household gun-hunted (using only hunting households, n = 27), and the number of carcasses sold per household (using only hunting households, n = 27, and an offset of log number of animals caught).

Predictor variables	Response variables					
	Commercial-hunting		Gun-using		No. animals sold	
	p	slope	*p*	slope	*p*	slope
UNIVARIATE						
Log non-hunting income per RA	n/a		0.316		0.868	
Log non-hunting income per RA (quadratic)	**0.010**	-ve	n/a		n/a	
Wealth category	0.221		0.560		0.544	
Wage-earning	1.000		0.588		0.532	
Bar/shop-running	0.113		0.879		0.617	
No. adult males	**0.002**	+ve	**0.032**	+ve	0.901	
Dependency ratio	0.366		0.445		0.472	
Mean age of adult males	0.848		0.114		0.468	
MULTIVARIATE						
Log non-hunting income per RA	n/a		0.207		n/a	
Log non-hunting income per RA (quadratic)	**0.069**	(-ve)	n/a		n/a	
Wealth category	0.189		0.839		n/a	
Wage-earning	0.488		0.260		n/a	
Bar/shop-running	0.343		0.944		n/a	
No. adult males	**0.002**	+ve	**0.032**	+ve	n/a	
Dependency ratio	**0.071**	(+ve)	0.174		n/a	
Mean age of adult males	0.722		0.450		n/a	

Figure 3.15 Whether or not households hunt commercially with increasing non-hunting income per RA unit (quadratic curve fitted).



There does appear to be a trend towards households with higher overall incomes (as opposed to non-hunting income as included in the analyses above) being more likely to gun-hunt. When a univariate GLM was performed to see if log-transformed total household income predicted whether a household gun-hunted or not, the result was significant at the 0.10 level ($p = 0.061$, F = 3.509, df = 1, positive slope).

There was no trend between income/wealth and proportion of offtake sold (table 3.5). However wealthier households would appear to be less reliant on hunting for income, as demonstrated by the fact that only one household in wealth category 5 hunted. This was in fact just small-scale trapping around fields, rather than commercial hunting, to control crop pests (the main reason for hunting cited by the hunter when interviewed), and none were sold, so it did not contribute to household income.

3.4 DISCUSSION

Hunting is the major income-generating activity for most men in Sendje, contributing to some degree to household consumption but to a greater degree to household income, a finding which is similar to those of de Merode *et al.* (2004) and Starkey (2004). The finding that bushmeat expenditure had an income coefficient of less than one suggests that like meat and fish in general, it is a necessity rather than a luxury, as found in Bata (see chapter 2) as well as studies in Latin America (Wilkie & Godoy, 2001) and Gabon (Wilkie *et al.*, 2005). Both de Merode *et al.* and Starkey found an 'inverted-U' (quadratic) relationship between wealth and bushmeat income dependence, in that middle-income households benefited most from bushmeat. The results presented here suggest a similar quadratic relationship between non-hunting income and commercial bushmeat hunting, in that only the very poorest and the richer households in the village do not rely on bushmeat for income. The very poorest households tended to have restricted access to hunting, in that they either lacked an adult male or were too old and infirm for intensive forest hunting, whilst the wealthier households had alternative sources of income in the form of a bar or wage. It should be noted that this lack of access of the few, very poorest households was not restricted to hunting; the lack of a healthy, productive male meant they were also unable to capitalise on any other livelihood opportunities.

Agriculture is predominately a subsistence activity, and almost never undertaken by men. The divide between agriculture as a female activity and hunting as a male activity is deeply rooted in Fang hunter-gatherer tradition and can partly be explained by their dependence on cassava (manioc) as a staple. Cassava is easy to store and cultivate, fairly aseasonal and not heavily demanding in terms of time, so whilst the women work in the fields and carry out all the domestic chores, men are free to carry out other activities, such as hunting (Takeda & Sato, 1996). However, cassava has very low protein content (*ibid*), which also explains why meat is such an important part of the Fang diet (see chapter 2). In addition, because such low value is generally assigned to vegetable products in hunter-gatherer societies (de Garine, 1996), and vegetables are perceived as expensive in comparison to meat or fish (pers. obs.; Ruel *et al.*, 2005), meat is a far more valuable market commodity than agricultural products. However, to some extent this appears to be in contrast to other villages in the more populous north-east of Río Muni, where agriculture plays a much larger role in livelihoods (S. Allebone-Webb, pers. comm.); it is not yet clear whether this is due to tradition, a natural evolution of tastes, better agricultural habitat or because the availability of

bushmeat is lower there and people have had to alter consumption and diversify livelihoods accordingly.

It appears that fishing is a relatively minor activity in terms of income earned, for both men and women. This is surprising, given both the proximity to a major river (Río Uoro) and its many sizeable tributaries and streams, and people's liking of fish both within the village and in Bata (see chapter 2). Fish is a common alternative source of protein to bushmeat throughout Río Muni (see chapter 2), but the sustainability of freshwater fisheries across the region is even more poorly understood than that of marine fisheries (Brashares *et al.*, 2004; von Bubnoff, 2005). Thus it may be that fish stocks in the Monte Mitra area have already been overexploited. However, many hunters fish by hook-and-line and lay crayfish traps in the hunter camps to feed themselves, whilst bringing only bushmeat back to the village to sell. It therefore seems more likely that the cheaper price of fish compared to bushmeat makes it a less profitable commodity. It seems that because fresh fish is relatively cheap and available compared to bushmeat in Bata, a coastal town with easy access to marine fish (see chapter 2), like agricultural produce, there is insufficient market demand for it to be a major income-generator in Sendje.

The fact that Equatorial Guinea is now oil-rent dependent like its neighbour Gabon (Yates, 1996) appears to be creating an urban bias with respect to economic development at the expense of the rural sector (Ross, 1999). However, this has not yet caused the significant migration to the towns that have occurred following the decades of Gabon's oil boom: still only about 39% of the population were living in urban areas in 2001 according to the national census (Ministério de Planificación y Desarrollo Económico, 2002), compared to Gabon's urban population of 84% in 2003 (Starkey, 2004). But if the Gabon model follows, this means that domestic producers are likely to find it difficult to compete with cheap imports of (1) fruit and vegetables, and (2) both fresh and frozen meat and fish (see chapters 1 and 2). It therefore seems that bushmeat remains the main commodity with sufficient demand to make domestic trade worthwhile. In addition, traditional dependence on livestock is very low in Equatorial Guinea, which in part explains its almost non-existent role in the household economy; as in many countries in Central Africa, domestic animals were traditionally a sign of wealth accumulation and as a result of this, consumption is often reserved for special occasions such as weddings and religious festivals (de Garine, 1996).

There is no significant effect of seasonality on bushmeat hunting effort, consumption or income (see also chapter 4), and the proportion of catch that hunters sell (89%) does not vary with season. This underlines the overwhelming reliance on bushmeat for income by the large majority of

households; it does not serve as a safety-net in agricultural lean seasons (as found in DRC by de Merode *et al.*, 2004), but a year-round mainstay of the village economy. There are two wet and two dry seasons in continental Equatorial Guinea, but these are not very marked, and usually there is some rain on most days throughout the dry seasons (2003 appeared to be a particularly rainy year; see appendix 1). Whilst cassava is the main staple, villagers also cultivate a wide variety of other starches such as yams, maize, and breadfruit, so there is some staple foodstuff available year-round.

Whilst participation in different livelihood activities at the same time is possible, no man hunted commercially whilst earning a full-time wage. A few men with full-time jobs continued trapping or, if they could afford a gun, gun-hunting close to the village, but working six days a week (in Equatorial Guinea many companies only give Sunday off) was incompatible with the typical type of commercial hunting practised in Sendje, which required long day trips or overnight stays in the forest (see chapter 4). Given the lack of prestige or enjoyment in hunting, most men tended not to do it if they had an alternative source of income. More usually, any traps set by wage-earners were intended to catch the occasional animal for household consumption, or to protect crops, although if something large and particularly profitable like a sitatunga (*Tragelaphus spekei*) or giant pangolin (*Manis tricuspis*) was caught, then it was an added bonus in terms of income. Rather, commercial hunting is better perceived as a fall-back livelihood, carried out when there is no alternative source of income available.

People in Sendje were used to having jobs. The preference for jobs was in part due to the stability and regularity of a monthly wage and in part due to higher status. Whilst hunting did in fact earn more per month than a full-time wage in some cases, and one exceptional hunter earned more than anyone else in the entire village, it was deemed unpleasant and degrading work. Whilst the Sendje-born villagers bemoaned the lack of available jobs, they appeared either unwilling or unable to exploit independent trading opportunities, such as running a bar. In a heavy-drinking and relatively materialistic society such as Sendje (there were 11 bar/shops in the village, of which at least eight were in use at any one time), bar trade earned far more than any other livelihood in the village. However, these opportunities were typically not exploited by those born in Sendje, with three of the four largest, most successful bars being run by immigrants from other villages in the interior of Río Muni, all of whom had come to the village only in the past two years. The reasons for this are unclear and further evaluation was beyond the scope of this study. An apparent lack of entrepreneurial spirit on the part of the native villagers, or their inability/unwillingness to cooperate to counteract prohibitive start-up costs, may also be partly attributable to issues associated with witchcraft (whereby being overly successful risks being accused of witchcraft and 'stealing other

people's luck', and thus requiring them to share their success). This is discussed further in chapter 7.

Sendje is not a remote, subsistence-based community, but has close links to the continental capital, Bata, as well as a strong cash-based economy and a history of formal employment. The country as a whole relies heavily on imported goods, and in Sendje people tend to live hand-to-mouth, spending whatever money they earn on costly luxuries in the bars, mainly cigarettes and alcohol (cf. de Garine, 1996). Indeed, there is a serious alcoholism problem in the village (pers. obs.), and this prevents much income from hunting being re-invested within the household (cf. Solly, 2001, 2004). This was shown to be the case in rural Guatemalan households, where increased male agricultural income was largely spent on male goods, affecting women's ability to purchase food and domestic technology for the family (Katz, 1995).

Households 12 (see data analysis section) and 37 are examples which demonstrate how misleading apparent wealth or calculated income for the household as a whole can be in determining incentives of individuals within the household. Household 37, composed of an old man and his separated, middle-aged son, is the highest-earning household in wealth category 1. The household officially earns reasonable income from hunting, as the son both traps and gun-hunts commercially, but he gives next to nothing to his infirm old father, who lives in a dilapidated kitchen and relies on charity from neighbours to avoid starvation. Hence thoughts of the neglected father were behind the focus group's reasoning for putting the household in the poorest wealth category. Although for many families there is indeed a clear 'safety net' in being in a large household with many active adults, as was recognised in the wealth ranking exercise (being alone without children, a spouse or relatives to support you was a common reason for putting a household in the lowest wealth category), the patterns described here indicate that for many households, consumption and production may often be better measured from an individual point of view rather than at the collective household-level. In this context, the 'intrahousehold competition' model provides an appropriate framework in which to analyse wealth and associated benefits. This model predicts that individuals with more or less overlapping interests compete for control over components of household wealth and that the various benefits of wealth differ among individuals within households (reviewed in Sellen, 2003). Other models found to work for pastoralist societies such as those in east Africa do not appear to fit rural Equatorial Guinea, where men practice individual-based hunting with guns or traps rather than a cooperative activity such as pastoralist herding.

Using overall wealth or total household income to predict the likelihood of hunting can lead to reverse causality if hunting is a large contributor to the household economy. Here, my wealth

categorisation correlates well (although not perfectly) with overall household income, but as expected, does not predict whether a household hunts, as hunting probability is related to non-hunting income. Unfortunately, in the absence of accurate measures of income, many studies rely on general wealth categorisation from PRA methods as a proxy for income. Wealth as measured by participatory methods is a subjective assessment of long-term income, mixed with other factors such as social status (Homewood, 2005a). Thus in a situation where people are hunting purely for income to increase short-term cash flow, rather than for other reasons such as prestige or tradition, wealth may not be a good proxy for income, as these results demonstrate.

It should be emphasized that my measures of income do not take into account non-monetary income, such as gifts, which from the consumption survey can clearly make up a large proportion of household consumption. In particular, given the power exerted by the ruling Partído Democrático de Guinea Ecuatorial political party and its associates, such as the village president-elect and the various other party representatives, a large part of income takes the form of gifts, bribes and unofficial taxes, which went largely unrecorded in my income survey. At the other end of the scale, many of the poorer households also rely on gifts of food and other necessities in order to survive, in the near-absence of any monetary income.

The effect of increasing total household income (from all sources) is two-fold, in that (1) it increases expenditure on bushmeat, and (2) it probably causes a shift by hunting households from trapping to gun-hunting. Both of these effects were predicted in a bioeconomic model of bushmeat hunting by Damania *et al.* (2005), and were found empirically in neighbouring Gabon by Wilkie *et al.* (2005) for the former case and by Starkey (2004) for the latter. However, in this study increasing income is only a weak predictor of gun-hunting, suggesting that either the household sample size here is too low for better statistical certainty (although given that the sample includes most households in the village, this would have been a difficult issue to resolve), or that Sendje may still be at an early point in the expected shift between trapping and gun-hunting.

Sendje was deliberately chosen for this study due to its particularly high level of hunting (Fa & Garcia Yuste, 2001), and its proximity to a large, mainly officially protected area of forest, in order to evaluate the effects of this level of hunting on conservation of the park. From a development perspective however, it therefore may not necessarily be typical of most rural communities in Equatorial Guinea. This criticism has been levelled at studies like this by Starkey (2004), but he also found significant dependence on bushmeat for income in his 'average' villages (i.e. those not near to protected areas, or known for being particular sources of bushmeat) in Gabon. However, given the high forest cover and relatively low, evenly-distributed population density across the

whole of Río Muni, it is likely that much of the rural population is dependent on bushmeat to some extent. To what degree this would also be for income rather than consumption is less clear, as bushmeat from Sendje does make up a large proportion of that sold in the Bata market (chapter 2) and its proximity and ease of access to Bata plays a large part in its substantial commercial trade of bushmeat.

I conclude that while bushmeat is not widely consumed by households in Sendje, whatever their income, it does make a substantial contribution to household income, particularly for the poor- to medium-income households. As these households are probably living below or near the poverty line, it is therefore an important contributor to overall poverty alleviation. At a different scale, there is likely to be an intra-household poverty divide, as incentives and benefits appear to act at the individual- rather than household-level. As men are the main income-earners, in the absence of other livelihood options, they hunt for a living.

Appendix 3.1 Total and mean household income, and mean overall, male and female income, from the top three earning livelihood activities for the village overall

	Livelihood activity		
	Job	Hunting	Bar/shop
Total annual village income (CFA) from livelihood	23,087,600	17,494,452	13,030,390
Mean income/household (CFA) from livelihood	1,003,809	603,257	2,606,078
n households carrying out livelihood	23	29	5
Mean income/individual (CFA) from livelihood	699,624	277,690	1,628,799
n individuals carrying out livelihood	33	63	8
Mean male income (CFA) from livelihood	738,169	277,690	1,924,854
n males carrying out livelihood	29	63	4
Mean female income (CFA) from livelihood	420,175	0	1,332,744
n females carrying out livelihood	4	0	4

Chapter 4

Hunter decision-making and spatio-temporal patterns of trapping

4.1 INTRODUCTION

4.1.1 Why study hunter behaviour?

The hunter is a link between demand and supply of bushmeat, and as such is a critical entry point for research and action to manage the bushmeat trade (Bowen-Jones *et al.*, 2002). While an understanding of what drives a man to hunt in the first place is a crucial first step (see chapter 3), knowledge of his incentives and decision-making processes whilst actively hunting is also needed. Unfortunately, the role of behaviour - of hunter, hunted and the interactions between the two - has been generally underrepresented in studies of exploitation (Sutherland & Gill, 2001).

A study of hunter behaviour is important for two reasons. First, a hunter's personal profile (e.g. his background, skills, income security, number of dependants and physical ability) will exert an influence on the type of hunting he practises and the effort he expends. Second, his decision-making processes with regards to the form this effort takes, such as how far to go, for how long and what sort of prey to target, together with the volume and type of prey he catches, can indicate the level of depletion in an area, and hence the overall sustainability of a harvesting system (Milner-Gulland, in press).

Hunters employ a wide variety of methods to catch their prey, which can be broadly categorised as active pursuit hunting (e.g. with firearms, bow and arrow or blowpipe) or more passive trapping or snaring (Rowcliffe *et al.*, 2003). Pursuit hunting obviously allows a much greater degree of prey choice. Sometimes individual species are targeted preferentially, such as elephant (Bowen-Jones, 1998) or red colobus (Davies, 1987), but more usually prey are selected on the basis of their profitability in terms of weight or economic value, with medium or large prey being selected over smaller prey (Colell *et al.*, 1994; Infield, 1988; Mittermeier, 1987; Peres, 1990). Where hunting is for commercial markets and transport costs are a factor, there is a preference for medium-sized prey that are more economically viable to transport and sell (Fa *et al.*, 1995). In contrast, snaring is the

most widespread method of hunting in use in central African forests and is relatively unselective, although different snares are designed to catch different types of prey due to their particular behaviour, size or weight (Noss, 1998c). The specific location and type of snare can also enable some degree of prey selectivity (pers. obs.).

Most studies of hunting behaviour have concentrated on pursuit hunting, either by traditional methods such as bow and arrow or blowpipe (e.g. Kuchikura, 1988), or by modern shotguns (e.g. Alvard, 1993). However there has been very little work on trapping behaviour (but see work by Noss, 1998a, b, c, 2000). Almost nothing is known about the rules of thumb that determine trapper decisions: for example, when catch reduces with the depletion of prey, do trappers increase the number of snares, move them or switch to a different gear type altogether? An understanding of trapping effort over space and time can give an idea of the sustainability of a system.

The foraging behaviour of animals has been widely studied, but has usually been considered separately from the foraging behaviour of humans. However, optimal foraging theory can give useful insights into determinants of human hunting decisions (Cowlishaw & Dunbar, 2000; Fitzgibbon, 1998). There are four types of optimality model that may be of relevance to hunter behaviour: the prey choice, patch departure, central place foraging and ideal free distribution models. The prey choice model (or the optimal diet model) ranks prey according to their profitability, and whilst the most profitable prey types are always taken, the decision of whether to take the less profitable types depends on the rate at which the more profitable types are encountered (Charnov, 1976a, b). The model is only relevant when there is an element of active prey selection, so has generally only been applied to pursuit hunting (e.g. Alvard, 1995; Alvard, 1993, 1994; Rowcliffe *et al.*, 2003; Winterhalder *et al.*, 1988; Winterhalder & Lu, 1997).

The other three models can be used to explain the spatial pattern of foraging, where prey are dispersed throughout a heterogenous environment, and may be more applicable to trapping. The patch departure model (giving rise to the marginal value theorem) predicts the point at which it pays the hunter to leave a patch (conceptually similar to a hunting zone or camp) and move to a new one, assuming that the marginal gain in leaving should be the same in all patches (Charnov, 1976b). This has been applied widely to natural and experimental animal populations (e.g. European starlings: Olsson *et al.*, 2001; parasitoid wasps: Outreman *et al.*, 2005; and kangaroo rats: Price & Correll, 2001; Tenhumberg *et al.*, 2001) and in real and simulated fishermen behaviour (Dreyfus-Leon, 1999; Sosis, 2001, 2002). Central place foraging models predict an increasing preference for large prey as travel time increases from a central place (e.g. village, hunting camp or market), and a corresponding restriction in optimal diet breadth to fewer, high-value species (Orians & Pearson,

1979). The pattern of depletion around these central places therefore varies according to the value of the prey, with more valuable prey being depleted over a greater distance (Hill *et al.*, 1997; Muchaal & Ngandjui, 1999; Peres, 2000). Thus as prey become scarcer and exploiters have to travel further, they are likely to stay longer in each patch and return with higher loads than they would if travelling short distances (Sutherland & Gill, 2001). Finally, the ideal free distribution uses game theory to explain the distribution of hunters among patches varying in quality (Fretwell & Lucas, 1970). Negative feedback among hunters competing in a patch, in terms of interference or - more likely with regard to trapping - depletion of prey, results in more hunters at better sites and fewer in poorer sites, sharing the same mean hunting success rate.

Some of these optimal foraging models have been combined with population biology models to simulate the dynamic relationships between hunter-gatherers and their prey in a multi-species system, focusing originally on subsistence pursuit hunters (Winterhalder & Lu, 1997) and subsequently incorporating trapping (Rowcliffe *et al.*, 2003). Individual-based models such as a multi-agent system developed by Bousquet and colleagues, which simulates blue duiker persistence in response to trapping under a particular community-based management system, adds a new level of realism to the model's predictions by including spatial data, but is flawed in that it considers exploited species in isolation (e.g Bousquet *et al.*, 2001). A recent model has focused on commercially-driven hunting, by including economic components in order to explicitly consider bushmeat hunting as a component of the household economy (Damania *et al.*, 2005). Such models are a great step forward in our ability to predict the impact of hunters on prey populations under a variety of conditions and constraints, but empirical data, particularly on hunter behaviour, are needed with which to test these predictions (Fitzgibbon, 1998).

The combined use of a global positioning system (GPS) and a geographic information system (GIS) is a powerful tool for assessing spatial hunting pressure, particularly in conjunction with more traditional methods such as hunter questionnaires, interviews and offtake surveys. A recent GIS-based study of the spatio-temporal interactions between hunter and prey in Norway found that areas close to the hunter camp were more heavily hunted than areas further away (as expected under central place foraging theory), but that topography and habitat configurations seemed to have some modulation effect on this pattern (Broseth & Pedersen, 2000). I build upon this using a novel tool for data collection, the CyberTracker, a handheld computer with attached GPS. I used this to record detailed spatial and temporal data on trapping and hunting effort and success of hunters in the Monte Mitra area of Río Muni. Combining these data with a record of hunter offtake and qualitative data on hunter incentives and profiles from interviews, I assess hunter behaviour in response to changes in prey distribution and the wider economy.

4.1.2 Research questions

As trapping is the more common form of hunting practised in the Monte Mitra area, I focus here on the behaviour of trappers rather than pursuit (gun) hunters, and consider gun-hunting in more depth in chapter 5. The two hunting methods also involve different spatio-temporal dynamics, so are best considered separately. The current chapter can be broken down into two parts: the first part explores the intrinsic qualities and characteristics of the individual trapper and their influence on hunting behaviour, and the second part explores the influence of extrinsic factors such as prey distribution, density and behaviour on hunter behaviour.

I concentrate initially on trapper behaviour, evaluating trapping success rates at the level of the individual trapper, the trap and the landscape. I then analyse what factors trigger trapper movement, and whether we can predict this by tracking some measure of catch per unit effort (CPUE). Finally, I compare trapping to gun-hunting, the second most common gear type, addressing why traps currently predominate over guns and under what circumstances hunters may switch from one gear type to another. The chapter is therefore structured according to the following research questions:

1) What determines trapper success rate?
2) What determines trap success rate?
3) What determines camp success rate?
4) What triggers trapper movement, within and between camps?
5) What determines gear type used? What triggers a switch from one gear type to another?

4.2. METHODS

4.2.1 Study area

This study focuses on the village of Sendje in Río Muni, situated 41 km south of the regional capital of Bata by dirt road and a major source of bushmeat for the city. Most data were collected from November 2002 to January 2004, but some information from interviews and other work conducted on a pilot trip in June 2002 is also included. The study area encompassed the zone of trapping and gun-hunting of hunters from Sendje, which spans either side of the village, but particularly to the east into the central third of Monte Alén National Park (the Monte Mitra forest), the border of which is about 10 km away.

In the past, there were human settlements and logging camps throughout the surrounding area of forest, but these are now abandoned and the only permanent settlements are along the main road. Many of these old settlements are now used as bases for trapping and to some extent gun-hunting. There are a number of these hunter camps used predominately by trappers to the east of Sendje, of which 10 were in use from November 2002 to January 2004: Bisun, Bingungun, Etcham, Ebang (Manjana), Evodulu, Etombong, Avindja, Anvila, Enuc and Mabumom. The majority of these camps are situated within Monte Alén National Park. A further five camps (Esuasas, Abeñang, Ongamsok, Tomasi and Churu) were in use in June 2002 but had been abandoned by the time of the main fieldwork season, the latter four due to the installation of new forest guard camps in the southern part of the hunting zone (at Churu and Abeñang) by the ECOFAC project, in charge of park management at the time. Hunters visit the very closest camps, such as Bisun and Bingungun, on day trips from Sendje, spend Monday to Friday in camps at intermediate distance, and remain in Mabumom camp, the furthest camp from the village at 30 km away, for up to two weeks at a time, utilising porters to transport food to camp and meat back to the village (table 4.1).

Table 4.1 Characteristics of hunter camps in use during study period

Hunter camp	Travel distance from Sendje (km)	Length of period spent at camp
Bisun	8.5	Daytrips
Bingungun	9.5	Daytrips
Etcham	11	Daytrips
Ebang (Manjana)	12	Usually Mon-Fri; sometimes daytrips
Etombong	15	Usually Mon-Fri; sometimes daytrips
Evodulu	15.5	Usually Mon-Fri
Anvila	19	Usually Mon-Fri
Avindja	21	Usually Mon-Fri
Enuc	26	Usually Mon-Fri; sometimes 2 weeks
Mabumom	30	Usually Mon-Fri; sometimes 2 weeks

As is the case throughout much of central Africa (Noss, 1997, 1998a, c), trapping is the most common method of bushmeat hunting practised in Río Muni. Levels of gun-hunting have been particularly low in Equatorial Guinea, due to a ban on firearms in the 1970s and guns being subsequently less available and affordable than in other countries in the region (see Butynski and Koster, 1994, and chapter 5). In the Monte Mitra area, most hunters use traps rather than guns (see chapters 5 and 6).

4.2.2 Data collection

4.2.2.1 Hunter interviews

Seventy-two hunters were interviewed out of a total number of 83 active trappers and/or gun-hunters recorded during the study period (see chapter 3 for methodology). Hunters were asked for personal details such as age, education and marital status, whether they had been born in Sendje or elsewhere, previous and current alternative livelihoods, previous and current hunting activity and locations (including number of traps), reasons for hunting, species targeted and why, favoured gear types and why, and costs incurred for different gear types. The presence of other wage-earners in the hunter's household or ownership of a bar/shop by the household was taken from household interviews conducted as part of the study and detailed in chapter 3.

4.2.2.2 Trapper and gun-hunter follows

Hunters were accompanying during their hunting trips to record spatially- and temporally-explicit information on their movements and decision-making in response to prey encounters. Specific data entry templates for both trapper and gun-hunter follows were written for the CyberTracker program (http://www.cybertracker.co.za/) and downloaded onto handheld computers (Handspring Visor Neo/Deluxe) with attached GPS unit (Magellan GPS Companion). Time and geographical position were thus automatically logged for all data points, including start and end points, and the program was also set to log the hunter's position every 15 minutes. The use of CyberTrackers to record data served the dual purpose of ensuring that all fields required were systematically filled in whilst conducting a check on the research assistants' temporal and spatial activities. Trapper and gun-hunter follows were conducted from February 2003 to January 2004.

For trapper follows, data on trap configuration and trapping success were collected. A 'trap group' was defined as a spatially distinct grouping of traps of the same age (i.e. those that had been set on the same day by the trapper). Each trap group was logged, with the number of each type of trap, the age in days of the trap group, and other details such as the presence of fencing between traps and habitat type. For each animal caught in or escaped from a trap, the species (when known), the animal's age, sex and state, whether it was collected, discarded or escaped, the trap type and trap age were recorded. For gun-hunter follows, upon each animal encounter the following data were collected: the species and type of encounter (whether initially seen, heard, smelt or from sign), whether the animal(s) was ignored or pursued by the hunter and the outcome of the encounter (individuals shot and killed).

An attempt was made to follow as many trappers active during the study period as possible; the majority of trappers were followed at least once. Several trappers were followed on more than one

occasion (up to a maximum of four times) to track changes in trap number, position and success over time. Trapper follows were conducted by myself, by one of two expatriate volunteers or by one of two local male research assistants from Sendje, as no particular skills or fluency Fang were required for observing the trappers and recording the data. A total of 77 follows were carried out with 48 trappers, 18 around Sendje and 59 around eight hunter camps.

Gun-hunter follows were conducted opportunistically rather than using a random sampling procedure, because of the limited number of gun-hunters available to follow (only 14 gun-hunters were active in the Monte Mitra area during the study period). Follows were therefore also limited to those hunter camps where the gun-hunters were currently based. In order to reduce the likelihood of the hunt being disturbed by myself or one of the expatriate volunteers due to our inexperience, all gun-hunter follows were conducted by one of the two local male research assistants, one of whom was an ex-gun-hunter and the other who regularly used to accompany his brother on gun-hunts. A total of 48 follows were conducted with 10 gun-hunters, 13 starting from Sendje and 35 starting from five hunter camps.

As Hunter X was the only active gun-hunter in one camp, Mabumom, at the time of the study, a research assistant, an ex-Mabumom gun-hunter adept in the use of CyberTracker, went on daily mock-up gun-hunting trips at Mabumom at the same time as the majority of Hunter X's gun-follows were conducted. He recorded all animal encounters and what he would normally have done on each encounter. His encounter and pursuit rates with potential prey were similar to those of Hunter X, but his 'capture' rate was slightly lower, which appears to confirm Hunter X's ability as an above-average gun-hunter as well as trapper.

4.2.2.3 Recording of offtake

All hunter offtake passing through Sendje (mostly from the forest to the east) was recorded from November 2002 to January 2004. Biological data (species, age class, sex, weight and head-body length) and hunt/trade data (method of capture, state, whether whole or part carcass, whether eaten or sold, where eaten/sold, carcass price) were recorded for each animal caught, as well as information on the hunter (name, household code) and hunting trip (number of hours/days, location, hunting methods used). A total of 9374 animals was recorded, 90% of which was trapped. See chapter 3 for full methodology.

4.2.3 Data analysis

The analyses were run for 34 trappers that had been followed but did not also gun-hunt, as gun-hunting in addition to trapping both compromised an individual's trapping effort and affected his

catch rate. Only those trappers for whom the complete complement of traps had been counted were included in the analysis (several trappers had been followed on only one of two separate trap circuits, and thus were excluded, as it was important to include their total trapping effort; others were first followed whilst still in the process of setting traps in a new location, so were only included if a second follow subsequently recorded a more representative sample of traps). Number of traps recorded during follows was found to be significantly correlated with the number of traps estimated by the trappers themselves during interviews (Pearson's correlation: $R = 0.619$, $n = 46$, $p < 0.001$).

Six trapper profile characteristics, age, married status, number of children, education level (illiterate, primary or secondary), whether or not he was native to Sendje, whether or not he had been employed during the last decade and whether or not his household had an alternative source of income (i.e. owned a bar/shop or contained a wage-earner), were input as the explanatory variables in generalised linear models (GLMs) to see which were the best predictors of different measures of trapping effort. Whether the trapper was married or not was removed from the model as a predictor variable as it was found to correlate highly significantly with both number of children and age.

The different trapping effort variables were: total trap circuit length from village, distance of start of trap circuit from village, days spent trapping per month (proportion of days, arcsine root transformed; for trappers making day trips from the village, eight hours was assumed to be equivalent to one day), number of traps, an 'effective trap index' and a 'total trapping effort index'. The effective trap index (no. traps/sqrt mean trap age) included mean trap age as the denominator, as a surrogate for frequency of moving traps and therefore effort expended, and was found to be predicted better by the GLM explanatory variables than trap number alone (table 4.2). Trap age was square-root-transformed in order to give a normal distribution of the effective trap index. Trap age was not included as an explanatory variable on its own as, *a priori,* zero trapping success would be would be expected from any number of traps at infinite age (i.e. if they were never checked) or from zero traps at any age.

The 'total trapping effort index' was the principal component extracted from a factor analysis combining the two effort response variables that were predicted best by the GLM explanatory variables, days trapping per month (as a proportion, arcsine-root transformed) and effective trap index (as a proportion). Together they formed a single component with an eigenvalue < 1 (0.393), which explained 80.4% of the variance. This compared to 79.9% of the variance explained when trap circuit length from village was included as a third factor to form a single component with an

eigenvalue < 1. A cluster analysis was then performed to group trappers according to their trapping strategy, selecting three cluster types based on the total trapping effort index.

Table 4.2 Results of GLMs of hunter profile variables against different measures of hunter effort

Explanatory variables (hunter profile)	**Dependent variable (hunter effort)**					
	Trap circuit length from village (km)	Trap base distance from village (km)	Days trapping per month*	Number of traps	Effective trap index	Total trapping effort index
Age	t = -4.340, $p < 0.001$	t = -3.740, $p = 0.001$	t = -4.976, $p < 0.001$	NS	t = -3.015, $p = 0.005$	t = -3.013, $p = 0.005$
No. of children	NS	NS	NS	NS	NS	NS
Education level	NS	NS	NS	NS	NS	NS
Non-native to Sendje	NS	NS	NS	t = 3.837, $p = 0.001$	t = 3.464, $p = 0.002$	t = 3.582, $p = 0.001$
Alternative income in household	NS	NS	NS	NS	NS	NS
Job in past decade	t = 2.983, $p = 0.006$	NS	NS	NS	NS	NS
Overall model	Adjusted $R^2 = 0.380$, df = 34, $p < 0.001$	Adjusted $R^2 = 0.282$, df = 34, $p = 0.001$	Adjusted $R^2 = 0.419$, df = 34, $p < 0.001$	Adjusted $R^2 = 0.294$, df = 34, $p = 0.001$	Adjusted $R^2 = 0.488$, df = 34, $p < 0.001$	Adjusted $R^2 = 0.498$, df = 34, $p < 0.001$

* Non-equal errors (Levene's test of homogeneity of variance) mean that results of this model are not meaningful, but are given here for comparison

4.3 RESULTS

4.3.1 What determines trapper success rate?

In order to understand why some trappers caught more than others, I first analysed what determined various measures of trapping effort, and then whether catch was dependent on this level of effort. Of all measures of trapping effort tested, the total trapping effort index was found to be the effort variable predicted best overall by the model's explanatory variables (table 4.2). Trapper age was a highly significant predictor of nearly every measure of trapping effort (effort decreasing with age), while whether or not the trapper was native to Sendje (non-natives expending more effort) was also a good predictor of effort variables that included a measure of trap number (table 4.2). In fact these two hunter profile variables are related: the mean age of Sendje non-natives is much lower than that of Sendje natives, and is thus a younger subset of the trapper sample as a whole (figure 4.1). Those trappers who had had paid employment in the last decade also went on significantly longer trapping trips than those who had been unemployed.

For the cluster analysis of the total trapping effort index, trappers were separated into three clusters representing three different trapping strategies (figure 4.2). Each trapping strategy can be broken down by time, distance and trapping effort, to show the importance of different effort variables in

defining overall effort (table 4.3). Between the three trapping strategies, there is a greater distinction between number of effective traps in each group (splitting clearly into low, medium and high number of effective traps) than days spent trapping and trap circuit distance, which does not differ greatly between strategies 2 and 3. In effect, trapping strategy 1 describes the village trapper group, who stay close to the village, going on only short trips and having only a few traps. Strategies 2 and 3 describe two different types of forest trappers, who all tend to stay overnight at different camps in the forest and spend a similar amount of time trapping. However strategy 2 trappers have either a lot of old traps, or few young ones, whilst strategy 3 trappers have many more effective traps. The three strategies correlate with age, strategy 1 trappers being the eldest and strategy 3 the youngest.

Figure 4.1 Median age of trappers non-native and native to Sendje. The bar represents the median, the box the upper and lower quartiles and the whiskers the maximum and minimum values.

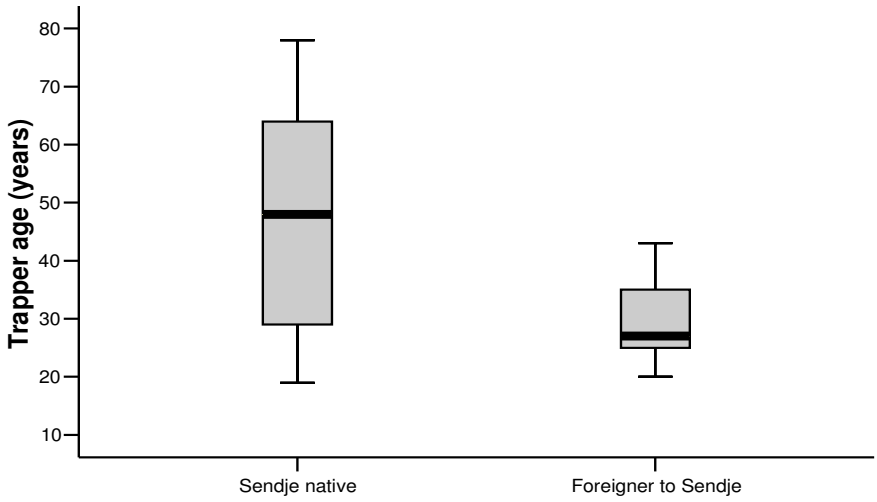


Figure 4.2 Separation of trapping strategies into three clusters by total trapping effort index. Low, medium and high strategies reflect trapping effort. The bar represents the median, the box the upper and lower quartiles and the whiskers the maximum and minimum values.

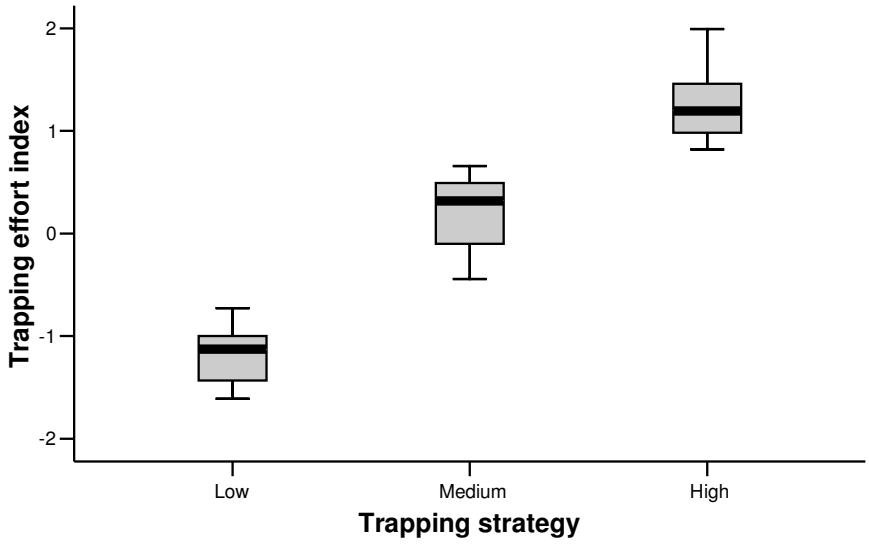


Table 4.3 Trapper cluster types and corresponding trapping strategies, according to the cluster analysis. Proportions (out of 1 for each variable) are in parentheses to enable an easier comparison of values between the three strategies.

	Strategy 1	Strategy 2	Strategy 3
Cluster \ trapping strategy	Low-impact village trappers	Medium-impact forest trappers	High-impact forest trappers
No trappers in cluster (n = 34)	11	15	8
Mean days trapping per month	3.3 (0.11)	13.5 (0.50)	16.4 (0.66)
Trap circuit distance from village (km)	5.5 (0.13)	24.8 (0.57)	32.4 (0.75)
Effective trap index	5.8 (0.16)	14.0 (0.38)	27.3 (0.75)
Trapping strategy summary	Few days per month, close to village, low no. effective traps	Average days per month, medium distance, medium no. effective traps	Average-many days per month, medium-long distance, high no. effective traps

Another set of GLMs were run to identify which trapping effort variables were the best predictors of two measures of individual trappers' trapping success, the average number of carcasses caught per month and the biomass caught per month, for the trapping zone where the follow was conducted. Carcass number and biomass were calculated from the offtake survey, except where trappers were mainly village-based and tended to consume the few animals they caught, where capture rates were estimated from bushmeat household consumption taken from the household survey (see chapter 3). Days trapping per month, total trap circuit distance from village and the

effective trap index were tested together first, and both days per month and the effective trap index were found to be highly significant predictors of both measures of trapping success (table 4.4). As the total trapping effort index was a composite of days per month and the effective trapping index, it could not be included in the GLM, but in a simple linear regression it was found to be a very highly significant predictor of trapping success (adjusted $R^2 = 0.890$, F = 258.718, df = 32, $p < 0.001$, for carcasses per month; table 4.4 and figure 4.3), and more so than the GLM overall or if either days per month or the effective trap index were regressed alone (table 4.4).

Finally, when a linear regression was performed of trapper age against carcasses per month, age was found to significantly predict trapping success (adjusted $R^2 = 0.355$, F = 19.165, t = -4.378, df = 33, $p < 0.001$; figure 4.4). The partitioning of trapping strategies in figure 4.4 shows that these age-determined trapping strategies are responsible for distinct differences in trapping success.

Table 4.4 Results of GLM and linear regression to identify which measures of trapping effort are better predictors of trapping success

Explanatory variables (trapping effort)		**Response variables (trapping success)**	
		Carcasses per month	Biomass per month (kg)
Generalised linear model	Days per month (arcsinrt transformed)	t = 7.530, $p < 0.001$	t = 5.802, $p < 0.001$
	Effective trap index	t = 6.038, $p < 0.001$	t = 3.837, $p = 0.001$
	Trap circuit length from village (km)	NS	NS
	Overall model	Adjusted $R^2 = 0.868$, F = 106.325, df = 33, $p < 0.001$	Adjusted $R^2 = 0.767$, F = 48.836, df = 30, $p < 0.001$
Simple linear regression	Trapping effort index (principal factor from days per month and effective trap index combined)	Adjusted $R^2 = 0.890$, F = 258.718, t = 16.085, df = 32, $p < 0.001$	Adjusted $R^2 = 0.789$, F = 109.372, t = 10.458, df = 29, $p < 0.001$

Figure 4.3 Trapping effort index with number of carcasses per month (n trappers with sufficient data to estimate carcasses trapped per month = 33, out of a total of 34 followed trappers), separated by different trapping strategies

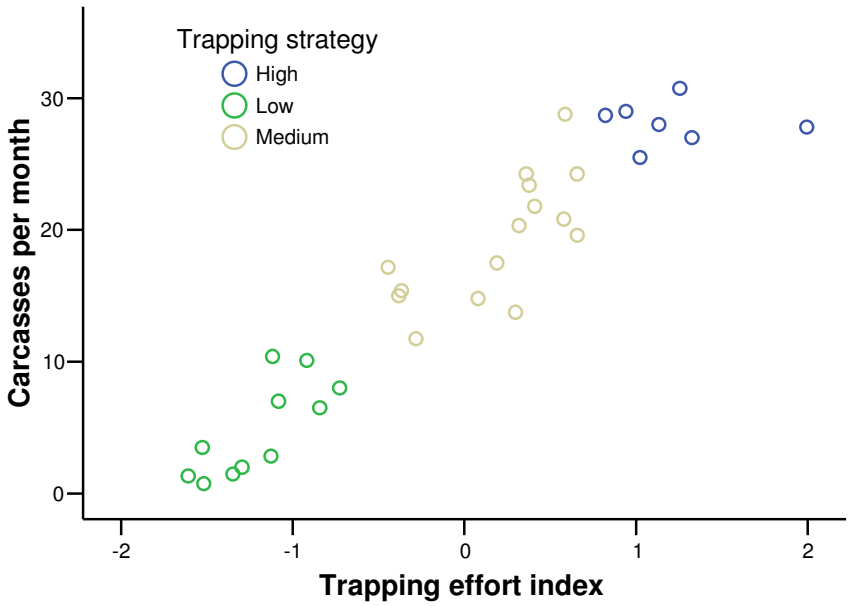
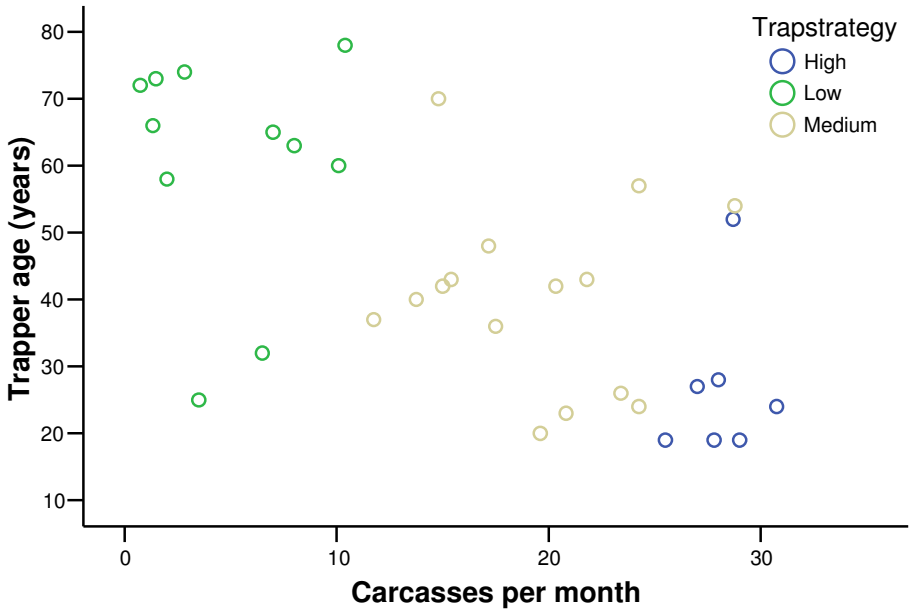


Figure 4.4 Negative correlation between trapper age and trapping success in terms of carcasses caught per month, separated by different trapping strategies

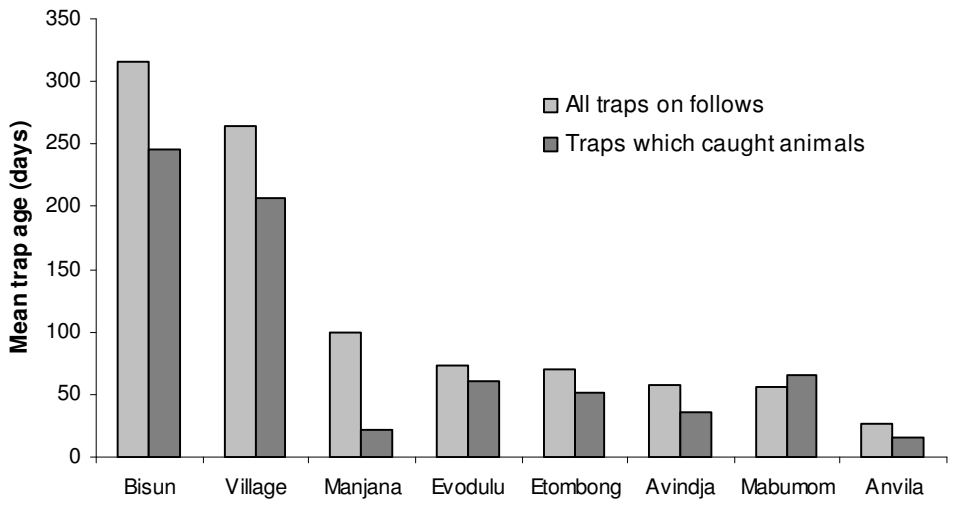


4.3.2 What determines trap success rate?

I will demonstrate later on that certain trappers have above average trap-rates. Therefore in order not to bias general trends of trap and hunter camp success rates through over-representation of individual trappers, I include data from only a maximum of two follows per trapper per camp here and in section 4.3.3. To minimise bias I include data from only one follow of one exceptionally successful hunter, Hunter X.

A trap's age is clearly important in determining its success rate. At every hunter camp where follows were conducted (except Mabumom) the mean age of traps that caught animals was lower than the mean age of all traps recorded (figure 4.5). Overall, the mean age of all traps recorded during the course of 74 follows was 124.9 days, whereas the mean age of successful traps (catching 53 animals) was 70.6 days.

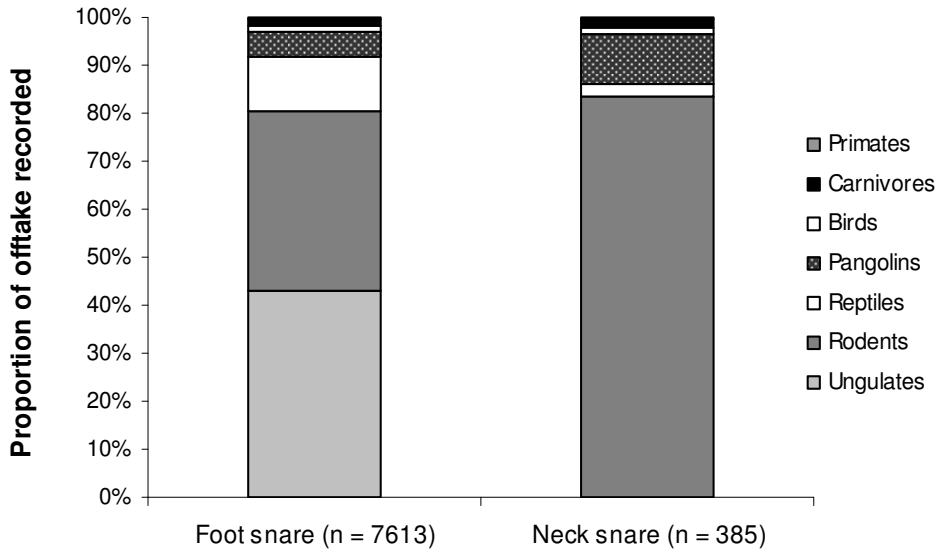
Figure 4.5 Comparison of mean age of traps which caught animals with mean age of all traps recorded on follows, for different hunting zones



Different snare types target and catch very different types of prey. The main distinction between snare types is between neck and foot snares. *Ebeneñong* neck snares, the more common type, are typically set outside burrows or around fields, sometimes in conjunction with fencing, primarily to catch rodents like the giant rat (*Cricetomys emini*) or brush-tailed porcupine (*Atherurus africanus*). *Abenqua* neck/body snares are complicated and time-consuming to set, usually positioned on top of fallen logs, and aimed at preferred species such as pangolins and large rodents. *Nga* foot snares are the most common type of snare; the standard (small) *nga* is set with a single thickness of wire to

catch small to medium prey such as blue duiker (*Cephalophus monticola*) or brush-tailed porcupine, but also larger prey when available. In areas where the trapper believes there is a higher density of larger terrestrial prey such as red river hog (*Potamochoerus porcus*) or sitatunga (*Tragelaphus spekei*), heavy-duty large *nga* snares are often set, using quadruple thickness of wire. Figure 4.6 shows the proportion of different prey taxa caught in neck and foot snares. There is a clear distinction between the prey profiles for the different snare types: foot snares catch mainly ungulates (mostly blue duiker) and rodents (mostly brush-tailed porcupine) in roughly equal proportions, whilst neck snares catch mainly rodents and some pangolins.

Figure 4.6 Proportion of different taxa recorded in Sendje offtake survey caught in foot snares and neck snares, November 2002 – January 2004. Note that very few primates were trapped.



Different snare types have different success rates (table 4.5). Small *nga* snares probably have the highest trap rate (accounting for sample size) and are thus the most popular type; however, they are also found furthest from the village and, as section 4.3.3 will show, distance from Sendje is also a significant determinant of trap rate, so this is a confounding factor. *Ebeneñong* neck snares seem to have a lower than average trap rate; however this may also be confounded by distance from Sendje as they are predominately found close to the village, as well as trapper age, as they are more frequently set by older trappers.

It should also be noted that trap rate *per se* is not a good indicator of trap success when different prey are being targeted. As large *nga* are targeted at large, high-value species, even if the trap rate per capture is half that of small *nga*, they may still reap higher overall profits. It appears that this

gamble for harder to catch but preferred prey is the reason that such snare types still continue to be set.

Table 4.5 Success rate of different trap types, as recorded on trapper follows

Trap type		Animals trapped	No. traps	Trap rate (animals / 1000 traps)	Mean distance from Sendje of successful trap (km)
Neck snares	*Abenqua*	3	233	13.1	19.8
	Ebeneñong	3	714	4.2	2.8
	All neck snares	6	947	6.3	11.3
Foot snares	Large *nga*	4	652	5.4	20.5
	Small *nga*	42	4403	9.4	21.4
	All foot snares	46	5055	9.1	21.3
All snares		52	6002	8.8	/

4.3.3 What determines hunter camp success rate?

Six hunter camps and the village area had large enough sample sizes, with regard to number of traps and animals trapped recorded during follows, to evaluate what factors determine relative success rate of a hunting zone. Linear regressions were performed to see if characteristics of the hunter camp (distance of camp from Sendje and trapping area of camp) or characteristics of the traps at that camp (proportion of foot snares and mean trap age, both shown to be important determinants of individual trap success in section 4.3.2) were the most important predictors of camp trapping success rate (table 4.6). Distance from Sendje (figure 4.7a) and proportion of neck snares (figure 4.7b) were found to be significant determinants of camp trap rate (table 4.6).

Table 4.6 Results of linear regressions to predict trapping zone success rate (animals caught per 1000 traps, sqrt-transformed)

Explanatory variables	Response variable: trapping zone trap rate
Distance from Sendje (km)	Adjusted $R^2 = 0.792$, F = 23.823, df = 6, $p = 0.005$
Prop. neck snares (log-transformed)	Adjusted $R^2 = 0.799$, F = 20.815, df = 5, $p = 0.010$
Camp area (km^2)	NS
Mean trap age (log-transformed)	NS

Hunter X, a 33-year old non-native to Sendje who had been trapping and gun-hunting in Monte Mitra for the past eight years, had exceptionally high capture rates throughout the period of the study (table 4.7). However, his high capture rates were not apparently due to exceptionally high effort. His CPUE was far higher than average for both trapping and hunting, both in terms of carcasses per trap and carcasses per hour spent trapping/hunting. He had no more traps than the average forest hunter (mean of 124 traps over four follows), and his mean age of traps (43.6 days)

was not very different from the mean age of all traps at Mabumom (53.4 days). However his rate of capture per trap was 5.09 times higher than all other trappers together, and 2.49 times higher than the other trappers at Mabumom (table 4.7).

Figure 4.7 Trap rate per camp with (a) distance of camp from Sendje (n = 7 camps) and (b) log-proportion of neck snares recorded per camp during trapper follows (n = 6 camps)

Figure 4.7a

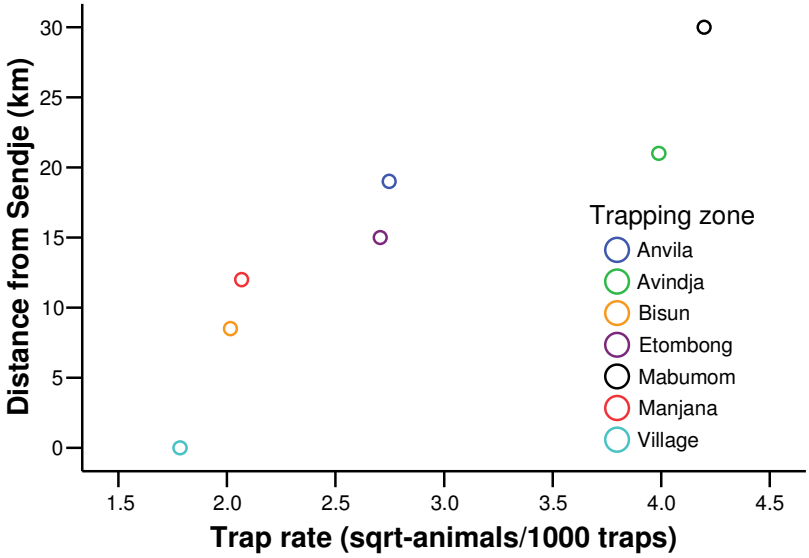


Figure 4.7b

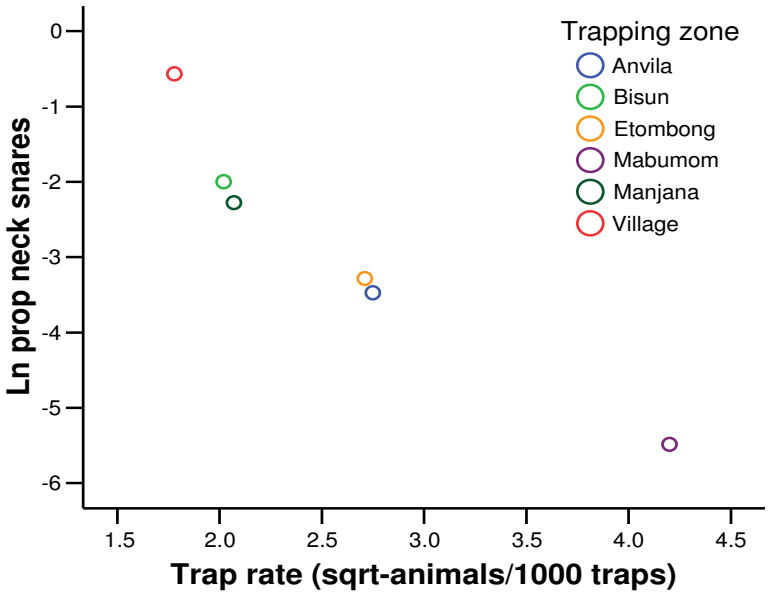


Table 4.7 Measures of catch, effort and CPUE for different trapper and hunter samples

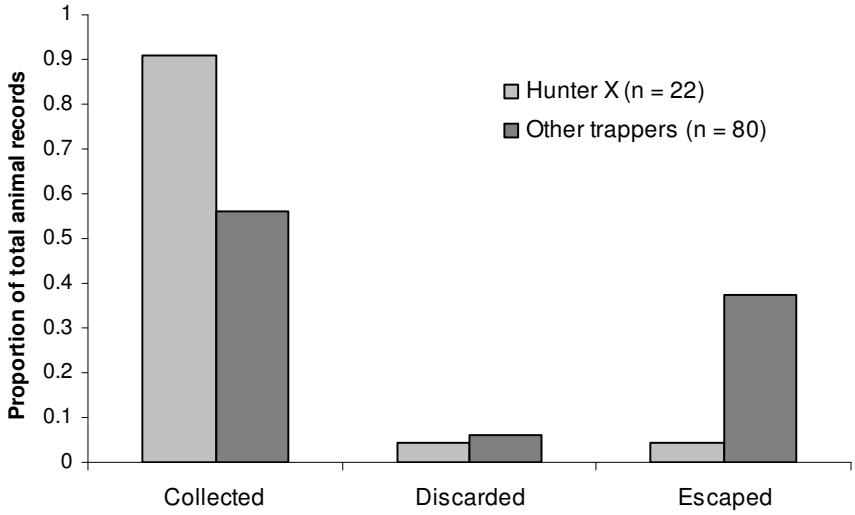
Hunting method and sampling effort	Catch, effort and CPUE (catch per unit effort) measures	All follows	Hunter X only follows	Other Mabumom hunter follows	All non-Hunter X follows
Trapping (48 trappers: 18 village-based follows (23%), 59 camp-based follows)	No. follows	74	4	6	73
	No. animals trapped	53	21	14	50
	No. traps recorded	6024	497	826	5833
	Total trapping hours	376	31	39	417
	CPUE (animals/ 1000 traps)	8.8	42.3	16.9	8.3
	CPUE (animals/ trap hours)	0.14	0.68	0.36	0.12
Gun-hunting (10 gun-hunters: 13 village-based follows (27%), 35 camp-based follows)	No. animals hunted	/	21	(14)*	48
	Total hunting hours	/	37	(34)*	184
	CPUE (animals/ hunt hours)	/	0.57	(0.42)*	0.26

* Estimated from mock hunting trips rather than from real hunter data.

Hunter X's tactic of trapping and gun-hunting together at the camp with the highest trapping and hunting success rate (see also chapter 6) goes some way to explaining his high average offtake of 71.4 animals per month in 2003 (total carcasses/day hunting = 3.628). This compares with the offtake of the next most prolific hunter, Hunter Y, also a gun-hunter/trapper but operating at Etombong camp (which had a much lower trapping rate than Mabumom), whose mean monthly offtake during 2003 was only 39.0 animals (total carcasses/day hunting = 2.168). The greater success rate of Hunter X is not explained by relative usage of different gear types, as the percentage of animals hunted by gun was very similar for Hunter X (31%) to that of Hunter Y (27%).

The exceptional success rate of Hunter X, particularly in trapping, may be explained by a combination of unusual effort, skill and intelligence in setting his traps. He operated no special type of trap, but appeared to be skilled in setting them sensitively enough to capture and retain animals. His rate of collection of animals caught in traps was far above average, as fewer animals were recorded as escaping from the traps (figure 4.8). During one follow, he collected 10 animals in only 53 traps, which he explained thus. Having planned an extended stay of eight days in the village, he unset his traps before leaving camp, and then spent the first trapping trip on his return resetting these traps. Therefore when he checked the traps again three days later, he collected all the animals that other trappers would have left rotting in their traps during a similar period away. It appears he may simply have wasted fewer animals than other trappers, with the result that a larger proportion of animals captured actually appeared in the offtake survey.

Figure 4.8 Comparison of proportion of trapped animals recorded on follows collected, discarded or escaped, between Hunter X (n = 22 animals on four follows) and all other trappers combined (n = 80 animals on 73 follows)



Hunter X also remained in Mabumom, the furthest camp from Sendje, long after all the other trappers had abandoned it, adopting a strategy of moving his traps regularly around the camp (see figure 4.9a). This presumably meant he was constantly encountering new prey from relatively undepleted areas. This compares to the trapping configurations of the two repeat follows of Hunter Y, who barely moved his traps in the three months between follows and kept them much closer to camp (figure 4.9b).

4.3.4 What triggers trapper movement, within and between camps?

The majority of forest trappers (utilising trapping strategies 2 and 3) move camps on a regular basis, every few months to a year or so. During 2003, trappers from Mabumom and Etombong moved to Anvila, although as at least one trapper remained behind in Mabumom and Etombong until 2004, the exact point at which all trappers abandoned these camps is unknown. Figures 4.9c and 4.9d show the movement of two trappers, Hunter W and Hunter Z, initially moving their original trapline further from camp in the same direction, then moving to a different camp and subsequently to a different position altogether around that camp. Figure 4.10 shows the position of all trappers who were followed on their first full follow; the small grey dots demarcate subsequent follows, and thus show the growth of Anvila and Mabumom camps later in the year as again trappers moved their traps either further away in the same direction from camp, or to a new location around the camp.

Figure 4.9 Movement of traps within and between camps during the study period of (a) Hunter X, (b) Hunter Y, (c) Hunter W and (d) Hunter Z. 5 km grid squares are marked.

Figure 4.9a

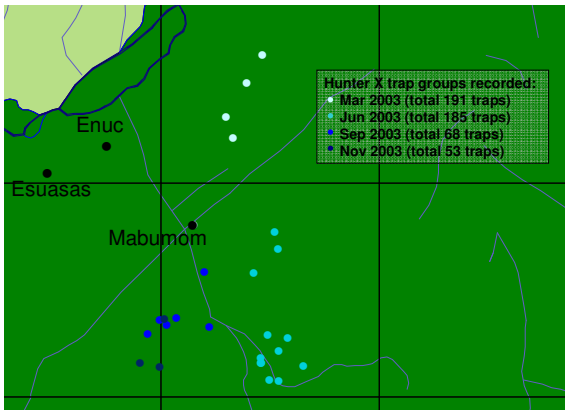


Figure 4.9b

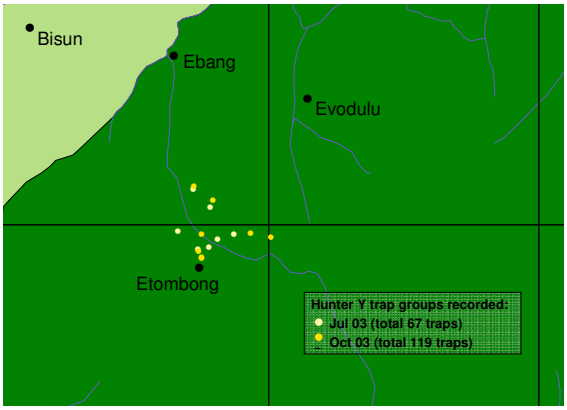


Figure 4.9c

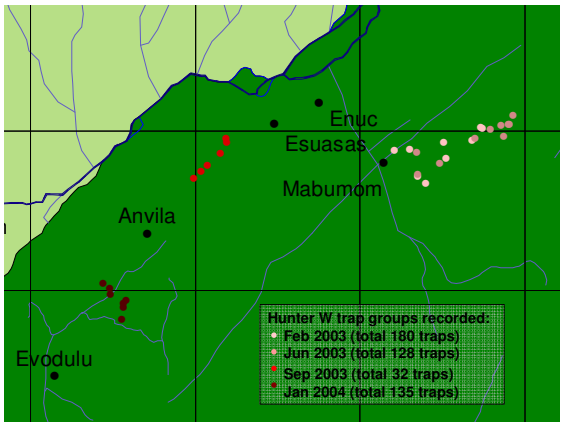


Figure 4.9d

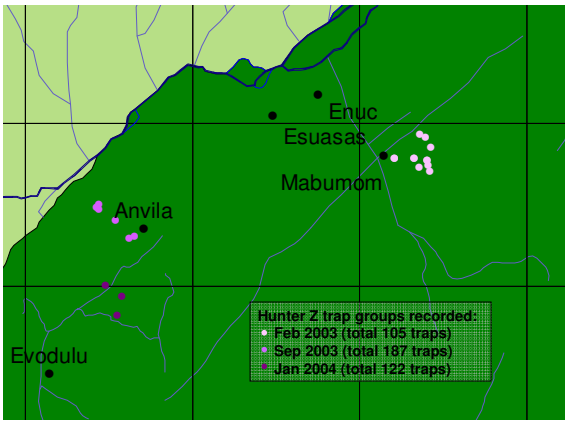
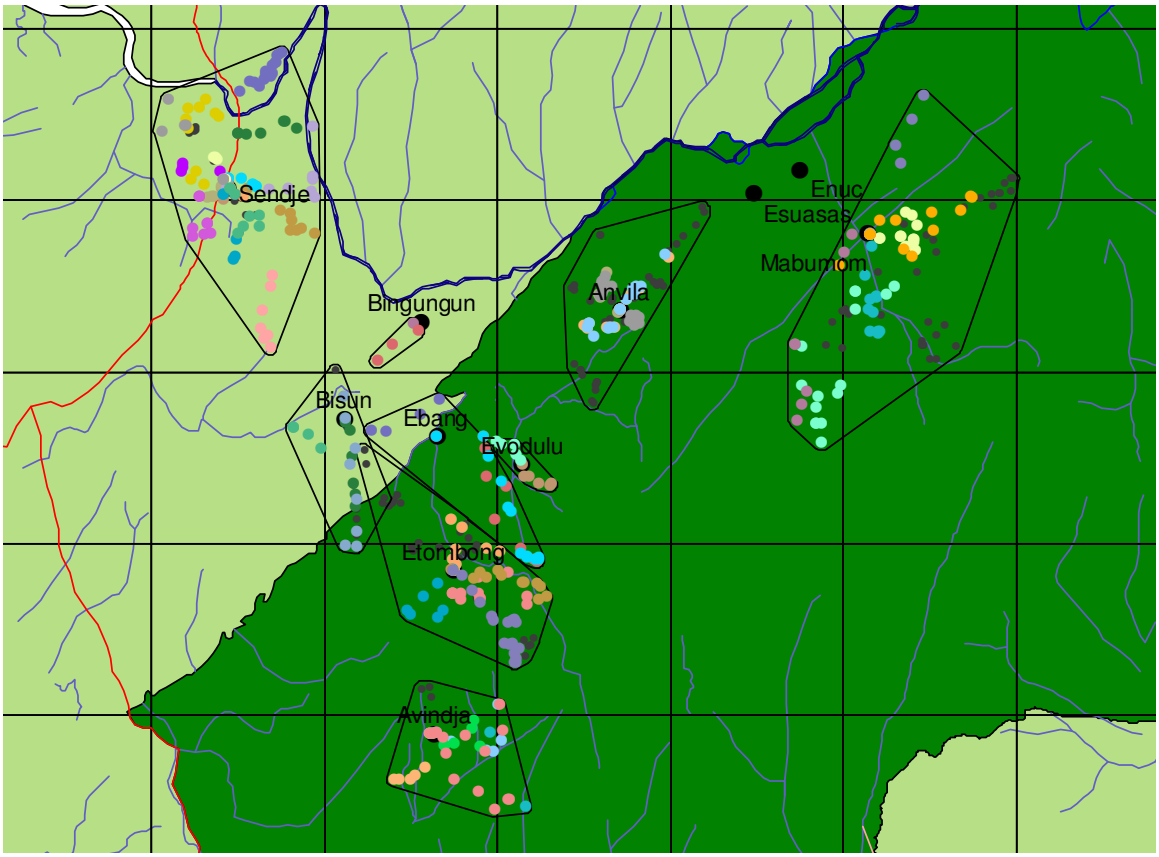
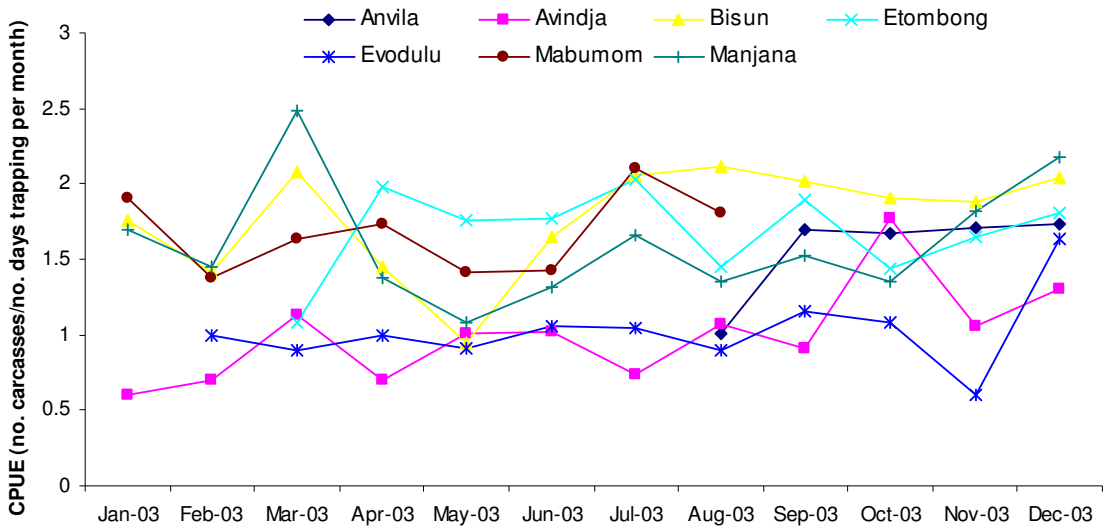


Figure 4.10 Map of Sendje trapping zone showing single follow per trapper and extent of trapping zones around camps. Small coloured spots represent trap groups of different trappers, with a different colour for each trapper. Sendje and individual camps are marked with large black spots. Minimum convex polygons demark the area of trapping around each camp over all trapper follows (shown as small grey spots), with the addition of a 200m buffer to account for the average home range size of blue duiker (*Cephalophus monticola*) of 4ha, which is equivalent to 200m x 200m (Estes, 1991). The dark area represents Monte Alén National Park. 5 km grid squares are marked.



Patterns in CPUE should inform us of when a camp is becoming depleted and at what point trappers will make the decision to move their traps. However, this depends on how CPUE is measured and how closely and accurately it is tracked. Figure 4.11 shows the mean monthly catch per day trapping for all trappers at different camps during 2003. There is no apparent change in CPUE per camp during the course of its usage, least of all the steady drop that would be expected as a camp becomes depleted of prey. This is partly because subtle changes in trapping effort (whether a trapper is increasing the number of traps or moving them as described above) cannot be detected when time alone is taken as the measure of effort. Without regular, repeat trapper follows throughout the period that a hunter camp is in use, the real effort in terms of effective trap number and trapping area, and thus CPUE, cannot be ascertained.

Figure 4.11 Catch per unit effort (CPUE) during 2003 for all non gun-hunting trappers together, at camps for which follows were conducted, measured in terms of number of carcasses per day spent trapping



4.3.5 What determines gear type used? What triggers a gear switch?

At first glance, the CPUE (animals per day hunting) for Hunter X at Mabumon during 2003 appears fairly stable. However, as figure 4.12 shows, upon breaking up his monthly offtake according to method of capture, it can be seen that the number of animals trapped per month reduced over the year while the number of animals shot increased (Pearson's correlation between animals shot and trapped per month = -0.625, $p = 0.022$, n = 13). Thus it might appear that CPUE for trapping was decreasing; but according to the repeat trapper follows, the opposite was true, as the number of traps decreased considerably as the year went on (figure 4.9a), disproportionately to the catch. It is not clear what drove Hunter X to increase the proportion of gun-hunting compared to trapping. A possible explanation is that being alone in the hunter camp, he turned to shooting as it gave quicker returns than trapping for less effort in terms of distance, and required less long-term commitment.

When asked what gear type they preferred, 65% of respondents stated trapping, compared to 33% gun-hunting. Cost and familiarity were cited as the major reasons for respondents stating trapping as the preferred gear type (figure 4.13), suggesting that if guns and ammunition became cheaper and more accessible, there would be less of a barrier to entry to gun-hunting.

Figure 4.12 Carcasses per month caught by Hunter X, split by number trapped and number shot

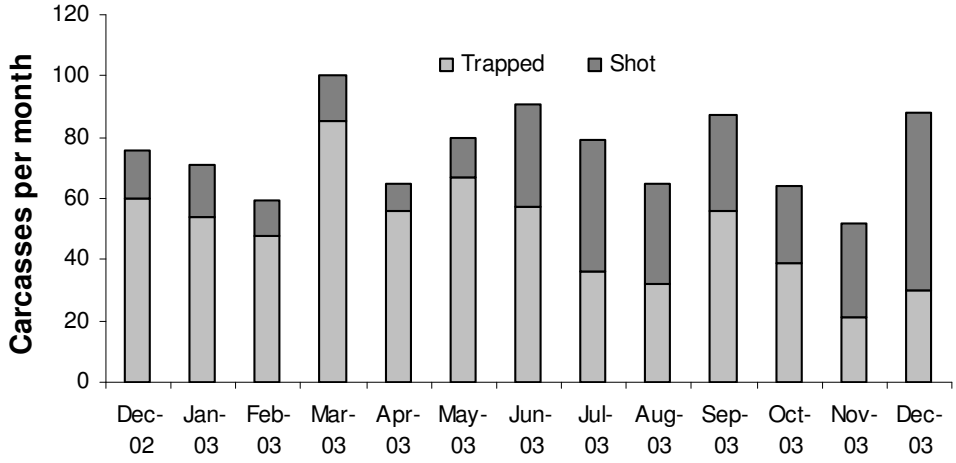
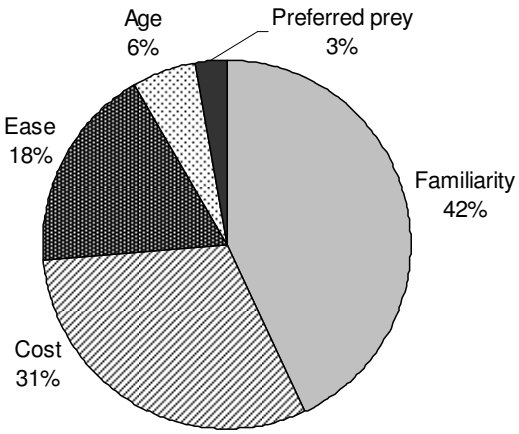


Figure 4.13 Reasons for traps cited as preferred gear type, taken from hunter interviews (n respondents = 36)



However, two respondents did mention that they trapped because it reaped preferred prey. Table 4.8 gives the mean biomass of all carcasses caught and mean price obtained for all traded carcasses, as well as the range of weights and prices, caught by gun, leg-snare and neck-snare. Animals hunted by gun have the greatest biomass, but only a slightly higher price, and when the cost of the cartridge plus wastage due to duds/mis-hits used to kill it is taken into account (estimated as about 850 CFA – see chapter 3), the mean profit is actually less than those trapped (wire is also needed for trapping, but this cost is neglible per animal trapped compared to shot). The wider range of weights

and corresponding prices of trapped animals also shows that more valuable prey *can* be trapped than shot, even if only occasionally. Although most animals trapped by neck-snares are consumed rather than sold, those that are sold (mainly pangolins) are of high value by weight. The majority of animals shot and trapped with leg snares are sold, confirming that these two methods are the main commercial gear types.

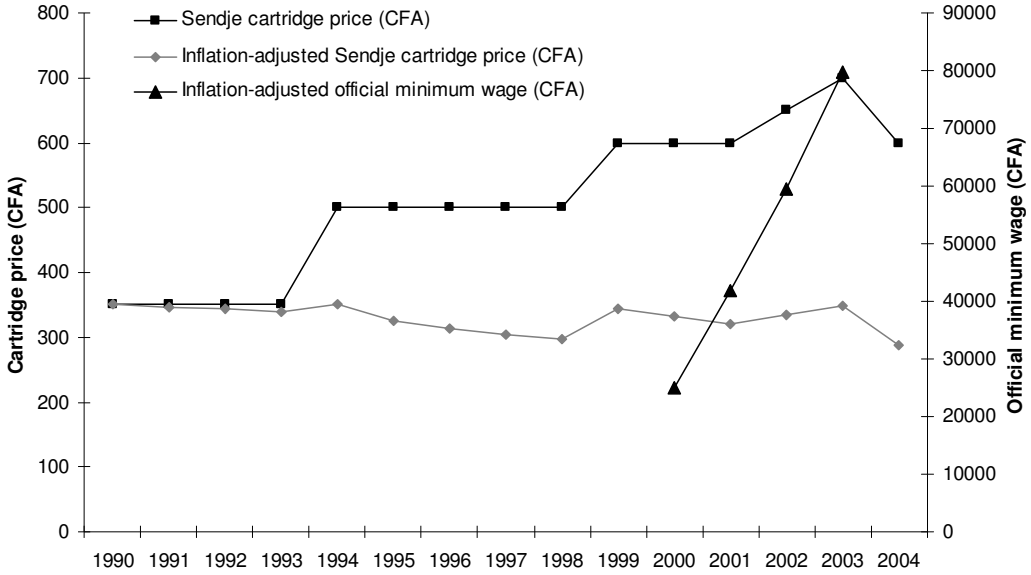
Table 4.8 Relative reward and profit for different gear types, taken from offtake data November 2002 – January 2004

Gear type	Total carcasses caught	Mean biomass per carcass caught (kg)	Proportion carcasses sold	Mean biomass per carcass sold (kg)	Mean price per carcass sold (CFA)	Mean maximum profit per carcass (CFA)*	Carcass weight range (kg)	Carcass price range (CFA)
Gun	623	4.97	0.97	5.05	3746	2896	0.9 - 34	1000 – 35,000
Leg snare	5512	2.77	0.91	2.88	3595	3445	0.2 - 50+	300 – 70,000
Neck snare	274	1.36	0.34	2.08	3427	3277	0.1 - 26	500 – 45,000

* Minus 850 CFA for catridges used

It would thus appear that presently those species most gun-hunted (predominately diurnal primates: see chapter 6) are also those least preferred, and that gun-hunting is less popular and a less important activity than trapping in terms of number of participants, proportion of overall offtake, and relative profit made. However, it appears that gun-hunting is becoming more affordable, at least for those hunters whose household economy is tied to salaried employment. Figure 4.14 shows how the price of a cartridge in Sendje remained fairly constant when adjusted for inflation from 1990 to 2003 – but actually reduced in cost in October 2003 to only 600 CFA each (pers. obs.). This, coupled with an over three-fold increase in the country's official minimum wage in less than four years, even when adjusted for inflation, means that guns and ammunition have suddenly become much more affordable.

Figure 4.14 Actual and inflation-adjusted price of a cartridge in Sendje (pers. obs.), compared with the inflation-adjusted national Equaotoguinean official minimum wage (IMF 2005), 1990-2004



4.4 DISCUSSION

Trappers in Monte Mitra operate under three strategies: low-impact village trappers hunting (strategy 1), medium-impact forest trappers (strategy 2) and high-impact forest trappers (strategy 3), reflecting different levels of effort. Trapping effort depends on trappers' age, in that younger trappers go further, for longer and set a greater number of effective traps. Whether or not a trapper was native to Sendje was also an important predictor of effort and success, in that non-natives tended to adopt strategy 3, but as they were a younger subset of the trapper population as a whole this was hard to separate from the effect of age.

Effort can be perceived in two different ways: the cost to the hunter, and the cost to the wildlife population. For example, a trapper could spend a long time in the forest trapping, but set few or ineffective snares; thus an apparently high level of effort in terms of a trapper's time would have an unexpectedly low impact on prey. Number of traps *per se* was not a good measure of effort, and the age of a trap (i.e. how long it had been in position, which was taken for a proxy for effort in moving traps) was found to be important in modifying the overall effectiveness of a trapper's traps, resulting in an 'effective trap index' measure of effort. Various different measures of trapper effort were tested, and it was found that success was best predicted by a combination of types of effort

(days trapping per month, number of traps and mean age of traps), calculated as a 'total trapping index'.

Although trapping is usually assumed to be a passive process, there is in fact a considerable element of prey choice in terms of the type of snare and where it is set. Different types of trap are targeted at different species, and this is reflected in the offtake recorded from different snare types, as well as their placement on a macro- (e.g. around the village or at a particular camp) and micro- (e.g. on an animal path or outside a burrow) scale. The proportion of neck snares (targeting smaller prey such as rodents) to foot snares (for medium to large prey) decreases with distance from the village, as does overall trapping success and offtake of larger animals (see chapter 6). These trends are both typical of central place foraging, in that once larger, more profitable prey close to the central place become scarce, hunters travel further from camp but target only the larger prey worth transporting back to the village. Secondary (and confounding) explanations are that more neck snares are put out close to the village as crop protection, or that the older village-based trappers are less skilled and/or prefer these less efficient but more traditional snare types, although these effects are likely to be weaker than that of overall depletion.

The prey choice model assumes a 'zero-one' rule, but trappers in this system seem to exhibit partial preferences (Alvard, 1993; Kuchikura, 1988). This reflects between-site variation in prey abundance, resulting from varying degrees of depletion with distance from the village as well as natural variation in prey profiles due to habitat differences (see also chapter 6). Where preferred prey types are scarce and rarely trapped, maximising mean daily meat return rates over the long-term may not be the most suitable measure for determining an optimum foraging strategy, as a regular supply of meat may be equally important (Fitzgibbon, 1998). In this situation, where success rates for larger prey on a daily basis are lower than for smaller prey, hunters can reduce the variance in meat supply by including a proportion of smaller species in the prey profile, such as elephant shrews in Kenya (Fitzgibbon *et al.*, 1995). This would explain why trappers who specialise in setting large *nga* foot snares in areas where there is a higher proportion of large game (e.g. at Avindja camp, in inaccessible and mountainous terrain), never exclusively set this trap type and always include some small *nga* as insurance against the large *nga*'s lower and more irregular capture rates.

Although success rates of trappers were predicted well by the amount of effort they put in, the same pattern is not found if gun-hunter/trappers were included in the analysis, due to one particular individual, gun-hunter/trapper Hunter X, who had a trapping success rate over double that of the next most successful trapper. His exceptional success rate was not explained by any of the effort

measures tested, and seemed to be due to three factors: less wastage of captures, greater skill and effort in setting traps, and behavioural flexibility in terms of being able to change the proportion of effort expended on gun-hunting or trapping. Another theory is that his greater success may partly be related to his age. Walker *et al.* (2002) found that hunting success in the Ache of Paraquay peaked at a later age than physical strength, as experience was required to acquire hunting skills. Although trapping is easier to learn and to become of average ability than pursuit hunting, there is clearly skill required in knowing where and how to set traps. Hunter X was 33 at the time of the study, had never had a job, and had spent at least the last eight years trapping and gun-hunting in Monte Mitra; in contrast many of the other fit, young, relatively successful trappers were fresh out of school or trapped only as a fall-back activity when they were out of work.

The pattern of trappers would appear to agree with the theory of ideal free distribution, as trappers were relatively evenly distributed among camps, at least those which were equidistant from the village. Trappers spent longer in more distant camps, in accordance with central place foraging theory, where transport costs are prohibitive (Sutherland & Gill, 2001; table 4.1). They utilise porters only for the very furthest camps, Mabumom and Avindja, to reduce these transport costs.

Trappers switch back and forth between established camps over time (see chapter 6 for a longer-term analysis of camp-switching). However, there was no apparent decline in catch per unit effort at the point at which trappers switched camps using time spent trapping as a measure of effort. Although the CPUE in terms of days trapping at most camps appeared stable over time, it may actually have decreased in terms of number of traps set, or distance travelled, as the trapper compensated for lower catches by increasing his traps or moving them further away (and therefore consequently increasing the area under exploitation). Unfortunately, low sample sizes for repeat follows precludes further examination of this theory. This again emphasises the importance of selecting the correct measure of effort before making inferences about sustainability (see chapter 6). Unfortunately many of these other measures of effort are much harder and more time-consuming to monitor, and need to be done on a regular repeat basis. This was beyond the scope of this study but is recommended for future research on CPUE.

However, the fact that trappers do make the decision to move, and subsequently return after a 'fallow' period during which prey populations have presumably recovered to some level, is in accordance with predictions of the patch departure model. If CPUE does in fact not appear to reduce greatly before camp-switching occurs, there are two possible explanations for this. Firstly, profitability rankings are likely to vary daily for heterogenous and sparse prey, but this instability is not captured when profitabilities are calculated as a sampled average over a longer time span (Sosis,

2002). Response to prey availability may therefore occur on a shorter time span that is not detected by a monthly analysis. A second and more likely explanation is that that hunters pick up subtle cues of depletion at the scale of the camp that the coarse measure of days trapping is unable to show, finding that they have to walk further from camp and spend longer out trapping over time, as evidenced by the pattern of traps radiating further out from camps (figure 4.10).

A third explanation is that CPUE does not drop markedly at all, and that trappers rotate between camps before over-depletion occurs, allowing populations to recover (Redford & Robinson, 1987). Such a system of management would only work where the number of trappers does not exceed a maximum that the area, and number of camps, can support. This may be an issue with the effective removal of four camps in the southern part of the Monte Mitra hunting zone due to restrictions by the park authorities, ECOFAC, and brings up the issue of whether the area can support the additional pressure of non-native trappers, who have also been shown here to have a greater individual impact than Sendje-born trappers (being full-time professional hunters).

Finally, an understanding of the conditions that may encourage a switch from traps to guns is crucial in gauging future sustainability of hunting in the area. The current preference for trapping may be partly due to the fact that it is the only method of hunting most people know; as use of guns is limited, familiarity plays a large part in determining gear usage. Cost is also clearly currently a barrier to gun-hunting for many Sendje trappers. However, guns and ammunition are rapidly becoming relatively more affordable as a result of Equatorial Guinea's recent oil boom. Whilst the overall effects of changes in household wealth and bushmeat price may be ambiguous in determining bushmeat consumption, results of a model by Damania *et al.* (2005) suggest that increases in hunter income lead to a switch from cheaper, less effective traps to more efficient and expensive guns. If depletion of terrestrial prey is added to the equation, a switch by many trappers to gun-hunting in Monte Mitra, following the example of Hunter X in Mabumom camp during the study period, seems even more likely (see chapters 5 and 6). The resulting effects on prey populations depend on whether any hunting controls are in place; in theory more selective gun-hunting allows rare species to be avoided and may increase the likelihood of sustainable hunting (e.g. Elkan, 2000), whilst in the absence of any controls, the larger-bodied and generally more vulnerable species will be preferentially targeted.

Chapter 5

Effects of gun-hunting on diurnal primates

5.1 INTRODUCTION

5.1.1 The vulnerability of primates

Many African primates are now threatened with extinction (Magnuson, 2005). In west and central Africa, hunting is in many cases thought to be a greater threat to primates than habitat degradation (Brugiere, 1998; Oates, 1996), due to dependence on bushmeat as a food resource (Caspary, 2001). Hunting of wild animals for human consumption is greater in this region than in the south and east of the continent, where pastoralism and livestock rearing is more prevalent (*ibid*).

Species vary in their vulnerability to hunting: in general, large-bodied, slow-reproducing species are more at risk than fast-reproducing species which can sustain relatively high levels of harvesting (Duncan *et al.*, 2002; Gaston & Blackburn, 1995; Kokko *et al.*, 2001). As primates live at relatively low densities and have particularly slow life-histories, and tend to be social, active and therefore highly visible by day, they are particularly vulnerable to overexploitation (Cowlishaw and Dunbar, 2000; Mittermeier, 1987).

Traditionally, primates are a less important component of the diet of African people than that of Amerindians (de Thoisy *et al.*, 2005), probably because they form a lesser proportion of total animal biomass in Africa than the Neotropics (Fa *et al.*, 2002b) and terrestrial prey availability is higher in Africa (Fa and Peres, 2001). Trapping with vine- and now more commonly wire-snares is still the most common type of hunting practiced in the forests of equatorial Africa, generally targeting duikers and rodents as preferred prey (Noss, 1998a, c; Noss, 2000; Wilkie & Carpenter, 1999a). However, by its indiscriminate nature, such trapping endangers terrestrial primates such as apes and mandrills, even if they are not explicitly targeted. Furthermore, the introduction of firearms has contributed to changes in hunting patterns. As the demand for bushmeat increases and terrestrial, trappable prey becomes depleted, arboreal primates are increasingly being hunted with guns, and this now poses one of the greatest threats to the survival of many African primate species.

5.1.2 Assessing the impacts of hunting

The ecological effects of unsustainable hunting have rarely been directly studied (Bennett *et al.*, 2002). Research on the impact of hunting on prey thus far often involves assumptions based on anecdotal evidence or predictions using simple indices of sustainability such as that of Robinson and Redford (1991), based on data from market/offtake surveys or hunter interviews and information on a species' population dynamics taken from the literature. Whilst such predictions are useful indicators of unsustainability (rather than sustainability – see chapter 6), caution must be exercised in interpreting the results. Aside from the biases inherent in such oversimplified indices (Milner-Gulland & Akcakaya, 2001), the use of data which are out of date or from areas with quite different species assemblages and habitat conditions can result in misleading conclusions.

Reliance on indirect data stems from the fact that properly tracking hunter activity over time and space, and gathering accurate data on prey densities, is difficult and takes a substantial amount of time, effort and expense (Surendra Varman & Sukumar, 1995). Carrying capacity (K), which is a fundamental parameter in Robinson and Redford's index, is particularly hard to estimate, given that most areas logistically accessible for research are also accessible to other forms of human disturbance and exploitation, be it of the habitat (logging) or wildlife (hunting), and therefore rarely support natural prey populations undergoing density dependence. However, a reliable estimate of hunting pressure and the subsequent effects this has on targeted prey species is invaluable for predicting the future patterns and sustainability of hunting in an area.

5.1.3 Estimating primate densities

Line transects are the most commonly used survey method in tropical forests, using an index of either direct (sightings or calls) or indirect (nests or dung) animal encounters to estimate abundance (Barnett, 1995; Brockelman & Ali, 1987; Whitesides *et al.*, 1988). Unlike other important bushmeat taxa that are found in this habitat, such as duikers and rodents, daytime sightings of diurnal primates are relatively frequent due to their active, social and visible nature, making it feasible to survey them by direct methods. However, call frequency should only really be used as a relative index of abundance due to factors such as naturally variable call rates between species (Brockelman & Ali, 1987), the similarity of some species' calls (Garcia Yuste, 1995) and the effects of human disturbance on call rates for species such as black colobus (Barnett, 1995; pers. obs.).

Using line transects, population densities can be estimated using the computer program Distance (Thomas *et al.*, 2003). This uses measurements of the perpendicular distance of objects (or clusters of objects in the case of social primates) from the transect to calculate a detection probability

function, which takes into account the fact that objects are more likely to be missed the further they are from the line (Buckland *et al.*, 2001). Distance sampling makes four main assumptions: that transects are placed randomly with respect to the distribution of animals, that animals on the line are always detected, that animals are detected at their initial location, and that measurements of perpendicular distances are exact (Burnham *et al.*, 1980).

Simmen *et al.* (1998) note that 'the transect method (is) a reliable approach to low primate densities overall, but requires that long cumulative distances are walked and does not guarantee that rare species will not be missed'. Distance sampling theory stipulates that a minimum of 40 sightings, and preferably 60 – 80, be obtained per species for reliable estimation of the detection function (Buckland *et al.*, 2001). Frequently the huge survey effort that this number of sightings would require is prohibitive, particularly in hunted areas, and as a result many authors have reported only relative measures of abundance (e.g. Garcia & Mba, 1997) or used alternative transect methods (e.g. Brugiere & Fleury, 2000). However, provided that survey design is rigorous and obeys the above assumptions, as few as 15-20 sightings may enable reasonable estimation of the detection function (Brugiere & Fleury, 2000; Buckland *et al.*, 2001; Peres, 1999).

It should be noted that hunting or other human disturbance often causes behavioural changes in prey, such as freezing, avoidance, fleeing, non-calling, increased nocturnality or altered movement patterns (Fitzgibbon, 1998), potentially making direct comparisons between hunted and unhunted areas far from straightforward. Whilst optimal foraging theory predicts that adults will be selected over juveniles, and males over females when they are larger (Alvard, 1993, 1994), a behavioural bias in susceptibility for adult males protecting the group in disturbed areas may enhance this selection. Such selective hunting can distort age or sex ratios as well as reduce overall group sizes of populations in hunted areas.

5.1.4 Research questions

In this chapter I first report the recently-disturbed, close to 'baseline' composition of diurnal primates for a site of high primate diversity and global importance in continental Equatorial Guinea, the Monte Mitra area of Monte Alén National Park. I then consider the threats posed to these primates by gun-hunting, and finally evaluate the impacts of this level of gun-hunting on the primate community. This is summarised by the following four research questions:

1. What is the normal primate composition in the Monte Mitra area?
2. What is the scale of gun-hunting in the Monte Mitra area?
3. Do gun-hunters operating in the area target certain primates, and if so, why?
4. What effect has gun-hunting had on primate populations in the area?

I then evaluate policies for the conservation of primate populations in the study area, and consider the implications of these findings in the context of Africa-wide primate conservation action plans (IUCN, 1996).

5.2 METHODS

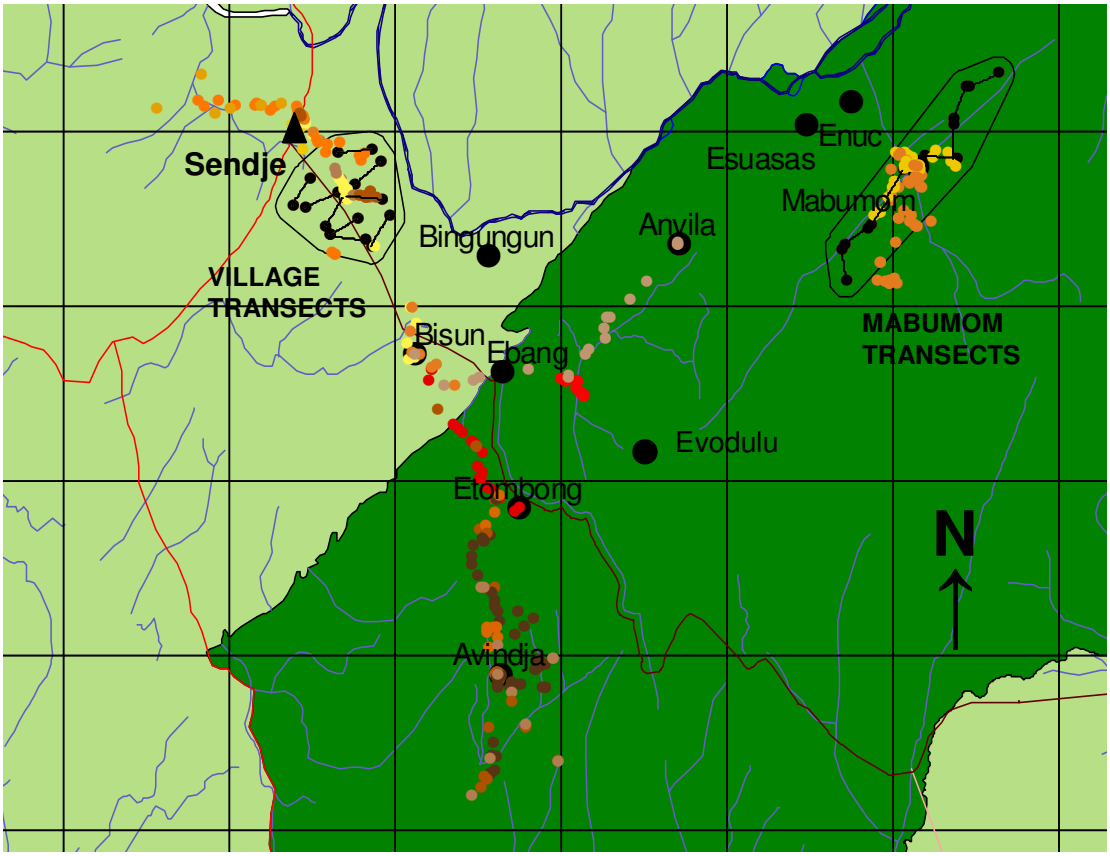
5.2.1 Study area

The study was carried out in the zone of trapping and gun-hunting of hunters from the village of Sendje, encompassing, which spreads to the east and into the central third of the Monte Alén National Park, the border of which is about 10 km away. Hunters either use the village or one of several hunter camps as a base for hunting trips. Many of these camps are inside Monte Alén National Park (see figure 5.1 and chapter 4).

There are two wet and two dry seasons per year in Río Muni, but these are not very marked, and there is usually some rain in most months. Daily rainfall and minimum/maximum temperature were taken at 08:00 each morning by a local research assistant in Sendje (see appendix 1). The period of this study was particularly wet, with 2841 mm of rain falling during 2003, and little distinction between the seasons. The transect periods of roughly 6 months for each site spanned both wet and dry seasons, therefore taking seasonality into account.

Historically, levels of gun-hunting have been low in Equatorial Guinea, due to a ban on firearms in the 1970s by the first President, the dictator Macias. For decades guns were hard and expensive to obtain for the people of one of the then poorest countries in the world, and low human population densities and extensive forest cover meant that trapping reaped sufficient returns. With the advent of the oil boom in the late 1990s, guns and cartridges started to become more available and affordable, being imported from Gabon or the Republic of Congo, but still remain more costly than in other countries in the region. For example, in 2002, when cartridges in Río Muni cost 650 CFA (pers. obs.), they were 500 CFA in neighbouring Gabon (Starkey, 2004).

Figure 5.1 Study area, showing hunter camps and location of transects. The village of Sendje is demarcated by a black triangle, hunter camps by large black dots, the route of hunter follows by small coloured dots (each colour corresponding to a particular hunter, pooled for all trips) and transects by black lines. Only the following hunt zones had active gun-hunters during the study period: Mabumom (two hunters), Avindja (three hunters), Etombong (one hunter), Anvila (one hunter), Evodulu (one hunter) and around the village (most of the camp-hunters already mentioned, as well as all the other remaining hunters out of the total of 14). Transect zones (minimum convex polygons drawn around all transects in each site, including a 500m buffer zone) are circled. Monte Alén National Park is shaded dark green, rivers are in blue, main roads in red and disused logging tracks in brown. 5 km grid squares are marked. Geographical coordinates of Sendje = N 01°32.001' / E 009°49.485'.



5.2.2 Primates in the Monte Alén National Park

The considerable interest in the endemic primate fauna of Bioko Island (Fa *et al.*, 2000; Fernandez Sobrado *et al.*, 2004; Gonzalez-Kirchner, 1996a, b, 1997; Hearn & Morra, 2001; Hearn *et al.*, 2004), has somewhat overshadowed the primates of the continental region. The faunal assemblages are quite distinct, with Bioko classed in the Cameroon rain forest region and Río Muni in the Western Equatorial rain forest region (IUCN, 1996). However there is a great diversity of primates found on Río Muni, including many globally important species.

At least 10 species of diurnal primate are reported to be present in Monte Alén National Park: central chimpanzee (*Pan troglodytes)*, western lowland gorilla (*Gorilla gorilla*), black colobus (*Colobus satanus)*, mandrill (*Mandrillus sphinx*), red-capped mangabey (*Cercocebus torquatus*), grey-cheeked mangabey (*Lophocebus albigena*), southern talapoin (*Miopithecus oguensis*), crowned guenon (*Cercopithecus pogonias*), putty-nosed guenon (*Cercopithecus nictitans*) and moustached guenon (*Cercopithecus cephus*) (Garcia & Mba, 1997; Gautier-Hion *et al.*, 1999). De Brazza's guenon (*Cercopithecus neglectus*) is reported to be north of the R. Uoro but has yet to be confirmed on its southern side, within Monte Alén National Park (*ibid).* Of particular importance for conservation are the two great apes and *Colobus satanus*, classified as endangered and vulnerable respectively in the IUCN Red List (IUCN, 2004). Both apes were given the highest conservation priority rating of '5' and *Colobus satanus* and *Mandrillus sphinx* ratings of '4' by the 1996 African Primates Status Survey and Conservation Action Plan (IUCN, 1996).

5.2.3 Hunter interviews

Seventy-two hunters were interviewed out of a total number of 83 active hunters recorded during the study period (see chapter 3 for methodology). Hunters were asked for personal details such as age, education and marital status, previous and current alternative livelihoods, previous and current hunting activity and locations, reasons for hunting, species targeted and why and costs incurred for different gear types.

5.2.4 Gun-hunter follows

Gun-hunter follows (accompanying gun-hunters whilst out on a hunting trip, collecting data on the hunter's behaviour and potential prey encounters) were conducted opportunistically rather than using a random sampling procedure, because of the limited number of gun-hunters available to follow (only 14 gun-hunters were active in the area during the study period). Follows were therefore also limited to around those zones where the gun-hunters were currently based (five hunter camps and Sendje; see figure 5.1). In order to reduce the likelihood of the hunt being disturbed by inexperienced expatriate researchers, all gun-hunter follows were conducted by one of two local male research assistants, one of whom was an ex-gun-hunter and the other who regularly used to accompany his brother on gun-hunts. See chapter 4 for further details on hunter follows.

A specific data entry template was written for the CyberTracker program (http://www.cybertracker.co.za/) and downloaded onto handheld computers (Visor Neo/Deluxe) with attached GPS unit (Magellan GPS Companion). Time and geographical position were thus

automatically logged for all data entered, including start and end points, and the program was also set to log the gun-hunter's position every 15 minutes. The following data were collected for each animal encounter: the type of encounter (whether initially seen, heard, smelt or from sign), the group structure (number of species and individuals, broken down by age and sex of observed individuals and estimated troop size per species), position (distance from hunter and height from ground, both estimated by eye), whether ignored or pursued by the gun-hunter, pursuit/handling time and the outcome of the encounter (individuals shot and killed).

A total of 48 follows were conducted with 10 gun-hunters, taking a total of 222 hours and resulting in 131 visual primate encounters (0.59 encounters/hour) and 73 kills (0.33 kills/hour). Table 5.1 shows the proportion of different species in these encounters, and the number of times they were observed in monospecific or polyspecific groups.

Table 5.1 Primate encounters during gun-hunter follows

Species	Monospecific groups	Polyspecific groups	Total group encounters
C. cephus	20	15	35
C. pogonias	13	16	29
C. satanus	20	6	26
C. nictitans	14	11	25
M. sphinx	6	0	6
M. talapoin	4	2	6
C. torquatus	1	0	1
L. albigena	1	0	1
G. gorilla	1	0	1
C. neglectus	0	1	1
TOTAL	80	51	131

5.2.5 Recording of offtake

All hunter offtake passing through Sendje (mostly from the forest to the east) was recorded from November 2002 to January 2004. Biological data (species, age class, sex, weight and head-body length) and hunt/trade data (method of capture, state, whether whole or part carcass, whether eaten or sold, where eaten/sold, carcass price) were recorded for each animal caught, as well as information on the hunter (name, household code) and hunting trip (number of hours/days, location, hunting methods used). See chapter 6 for details on the offtake survey. The majority of gun-hunted animals were brought back to the village for sale, so shot offtake is directly representative of the actual number and composition of animals killed.

5.2.6 Primate surveys

Line transects were conducted in two sites to compare species composition and densities in two zones with similar habitat characteristics (forest structure, basic soil type, distance to main river, altitude, etc.) but differing hunting pressure (figure 5.1 and table 5.2). Sites were chosen with as similar as possible habitat characteristics in order to control for confounding factors. Data on habitat structure and altitude was recorded every 100m along each transect (table 5.2). The 'Mabumom' site was in the area of a hunter camp of the same name approximately 35 km from Sendje, with limited but increasing gun-hunting pressure (only two gun-hunters were active at the start of mammal surveys, and had only been there for a few months). The 'Village' site was about 3 km from the village and had had regular and sustained gun-hunting pressure for the last decade or so.

Table 5.2 Characteristics of Village and Mabumom transect areas

Characteristic/variable	Village	Mabumon
Canopy height	Mean 19m (emergents 28m)	Mean 22m (emergents 28m)
Understorey type	Liana/shrub mix; more closed	Shrub/liana mix, relatively open
Soil type	Predominately dry soil; boggy or rocky in some places	Predominately dry soil; rocky in some places
Average altitude a.s.l.	Median 50m (range 15-110m)	Median 460m (range 300-520m)
Distance to village	~3km	~35km
Distance to sizeable river	1-4km	0-5km
Trapping pressure	Heavy, long-term	Sporadic, long-term → heavy, short-term
Gun-hunting pressure	Medium, medium-term	Light, short-term, but increasing
Logging history	Recent past; SOFOGE French logging company selectively logged 1993-1995	Colonial/post-colonial period; IZAGUIERRE Spanish logging company selectively logged ~30 years ago

Eight one-kilometre permanent transects were cut in each site, in two configurations containing four transects each, with 300-500m between the end of one transect and the start of the next. Transects were sited as randomly as possible so as to be representative of the area, but in Mabumom were limited to some extent by inaccessible steep topography to the north and west of the camp. Straight-line transects were cut with the aid of a compass and tape measure, and marked with luminous tape every 20m. After cutting transects were left to rest for at least one day before starting surveys. Study periods of roughly 6 months (~200 km of transects) for each site spanned both wet and dry seasons, therefore taking seasonality into account (table 5.3).

Table 5.3 Village and Mabumom transect survey details

Survey details	Village	Mabumom
No. transects x length (km)	8 x 1km	8 x 1km
Total no. km surveyed	200	208
Direct survey area (km^2)[1]	10.5km^2	14.4km^2
Study period	Jul. 2003 – Jan. 2004	Feb. – Jun. 2003

[1] The survey area was the area of a minimum convex polygon encircling the group of transects in each site, including a buffer of 500m to account for typical *C. satanus* home range size of at least 30ha (Gautier-Hion *et al.*, 1999).

Transect surveys were carried out according to the methodology of White and Edwards (2000) and Davies (2002a). A team of usually two (on occasions three or four) observers, at least one of whom was a local research assistant skilled at wildlife observation and identification, walked the transects at a mean speed of 57 minutes per kilometre. Each transect configuration (4 x 1 km) was walked between the hours of 06:30 and 11:30, with at least one day left between subsequent surveys of a particular configuration, so that animals could recover from potential disturbance. Transects were not conducted in heavy rain, and if morning transects had been disrupted by rain, if possible one or two transects were conducted between 15:00 and 17:00. Observers noted weather conditions at the start of the survey, start and end times for each transect, and the following data for each primate group encountered:

- Species and whether seen or heard (if heard only, approximate distance and compass direction from observer)
- Transect code, time, location along transect and specific habitat
- How first perceived (e.g. branch moving, alarm call, smell)
- Height and stratum of first individual observed for each species
- Perpendicular distance from transect, direct distance from observer (both measured with tape measure, to the nearest 0.1m) and sighting angle from observer, to group centre (measured separately for each species if polyspecific group encountered)
- Number of individuals seen (broken down by age class and sex) and total number of individuals estimated (groups were not followed due to time constraints, therefore this figure was estimated as accurately as possible from the transect line) (noted separately for each species if polyspecific group encountered)
- Reaction to observers and behaviour when encountered.

Data were then analysed using the Distance 4.1 computer program (Thomas *et al.*, 2003; http://www.ruwpa.st-and.ac.uk/distance/), using minimum AIC criteria for model selection.

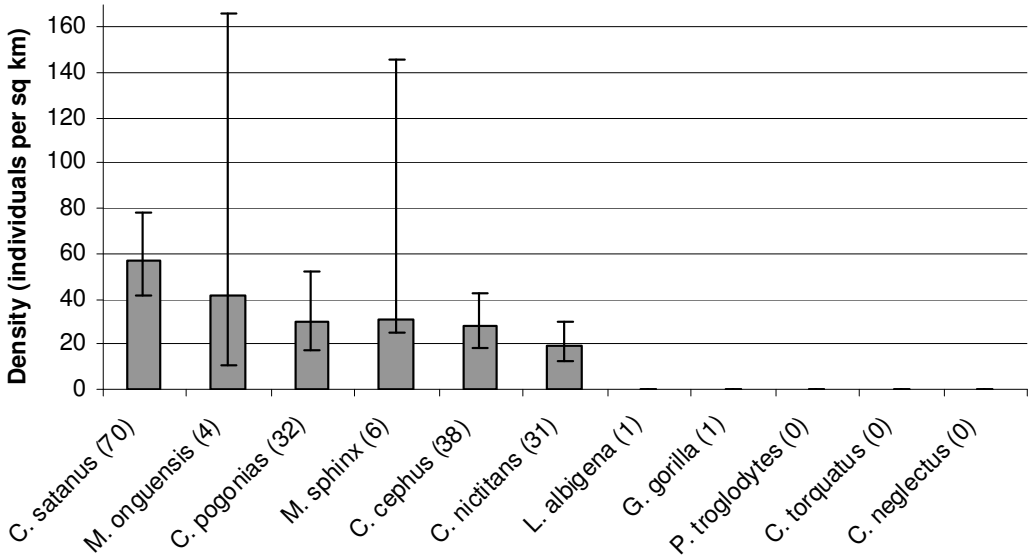
5.3 RESULTS

5.3.1 Normal primate community in the Monte Mitra area

A total of 11 diurnal primate species was recorded throughout the study area, but only nine of these were confirmed in the Monte Mitra area of Monte Alén National Park. Eight primate species were recorded as visual encounters during the transect survey at Mabumom (figure 5.2), and *P. troglodytes* calls and sign were also recorded. *Cercocebus torquatus* and *Cercopithecus neglectus* were recorded to the west of Sendje (in lowland, swampy habitat) in the offtake survey and hunter follows respectively. It seems that *C. torquatus* is restricted to such riparian habitat in the coastal zone (Gautier-Hion *et al.*, 1999; Matthews & Matthews, 2002), and although we have recorded *C. neglectus* south of the Río Uoro near Sendje (although from a single encounter during a hunter follow, so unconfirmed by a specimen), it may not inhabit certain parts of Monte Mitra. Some hunters reported that it was present further into Monte Alén National Park, or used to be, in the 'mountainous zone' (presumably around Río Laña), but this has still to be confirmed.

The density (individuals/km^2) of different primate species in the Mabumom study site, as estimated through Distance with upper and lower 95% confidence levels indicated, is shown in figure 5.2, with detail for the four most common species, *Colobus satanus, Cercopithecus cephus, C. nictitans* and *C. pogonias* in table 5.4. These were the only species with a sufficient number of encounters to allow for accurate density estimation through Distance. Even though sample sizes are below the recommended 40 sightings for line transect methodology for all three guenon species, good detection probability curves enable a good model fit even at these low sample sizes (see appendix 5.1 for comparison of detection probability functions for large and small sample sizes, showing how the favourable data distribution of *C. pogonias* detection distances enables a good model fit with only 25 sightings).

Figure 5.2 Primate densities at Mabumom (individuals/km^2), estimated through Distance, with 95% confidence intervals marked. Total number of encounters per species during 208 km transects are in parentheses.



Given the very small sample sizes for *M. sphinx* and *M. talapoin* (6 and 4 encounters respectively), these estimates have very large confidence intervals, but densities are quite high due to a combination of short sighting distances giving small effective strip widths and large group sizes.

At 57 individuals/km^2, *C. satanus* density at Mabumom was very high compared to the limited number of previous surveys in other sites that have been conducted on the species (2-8 times higher: table 5.5). However, the number of sightings was high (70) and the shape of the detection curve provided a good fit to several models using the Distance program (appendix 5.1a), and the confidence level around the estimate of density is quite small, allowing confidence in it. In addition, our mean cluster size of 13.4 was slightly lower than other studies' (15.1: Brugiere, 1998; 15.3: Brugiere & Fleury, 2000; 17: Gautier-Hion *et al.*, 1999), so this is not contributing to such high individual density estimates.

Table 5.4 Distance density estimations for four most common primate species at Mabumom and Village transect sites. [1]Model used: a = half-normal cosine, b = uniform simple-polynomial, c = uniform cosine

Site	Village			Mabumom			
Species	*C. pogonias*	*C. nictitans*	*C. cephus*	*C. pogonias*	*C. nictitans*	*C. cephus*	*C. satanus*
Total n	24	13	20	32	31	38	70
Encounter rate per km (n/L)	0.12	0.07	0.1	0.12	0.13	0.14	0.28
Indivs / km^2 (D)	18.3	8.8	15.6	30.2	19.3	28.1	57.2
D upper 95% conf. level	30.9	17.3	26.6	52.1	30.4	42.6	77.7
D upper 95% conf. level	10.8	4.4	9.1	17.6	12.2	18.5	42.1
Clusters / km^2 (DS)	1.71	0.82	1.43	2.25	1.83	2.36	4.26
DS upper 95% conf. level	2.74	1.43	2.37	3.63	2.79	3.47	5.65
DS upper 95% conf. level	1.07	0.47	0.86	1.4	1.19	1.6	3.21
Effective strip width (ESW)	35.1	39.7	35.1	26.7	36	29.6	32.7
Cluster size	10.7	10.7	10.9	13.4	10.6	11.9	13.4
SE cluster size	1.28	2.2	0.98	1.83	0.93	0.95	0.8
Model used[1]	a	b	a	a	b	c	c

Table 5.5 Comparison of density estimates of black colobus found in this study with other studies/areas with similar primate assemblages

Study site	Mabumom, Monte Mitra, Río Muni	Monte Alén, Río Muni	Makandé, Gabon	Lopé, Gabon	Douala-Edéa, Cameroon
Authors	*This study*	Garcia & Mba, 1997	Brugiere, 2000	White, 1994	McKey, 1978
No. km	208	225 / 20	249	780	?
N[1]	70	8 / 5	23	125	?
n/L[2]	0.28	0.04 / 0.3	0.09	0.30 – 0.98	?
D[3]	57.2 (42.1–77.7)	n/a	7.3 (± 1.4)	10.8 (4.3 – 13.6)	30 (26 – 41)

[1] Number of visual encounters
[2] Encounter rate (groups encountered per km of transect walked)
[3] Density (individuals/km^2)

5.3.2 The scale of gun-hunting in the Monte Mitra area

Trapping is currently by far the most commonly practised method of hunting by Sendje villagers (see chapters 4 and 6). Those men who gun-hunted did so nearly exclusively by day, with primates being by far the most commonly shot prey type. Out of a total of 9374 animals hunted by any method by Sendje hunters (excluding elephants), 949 or 10.1% were primates, 902 or 95.0% of which were hunted with a shotgun. The majority of gun-hunting was for primates; only 60 animals in other taxa were recorded as hunted with a shotgun. See appendix 5 for species offtake list.

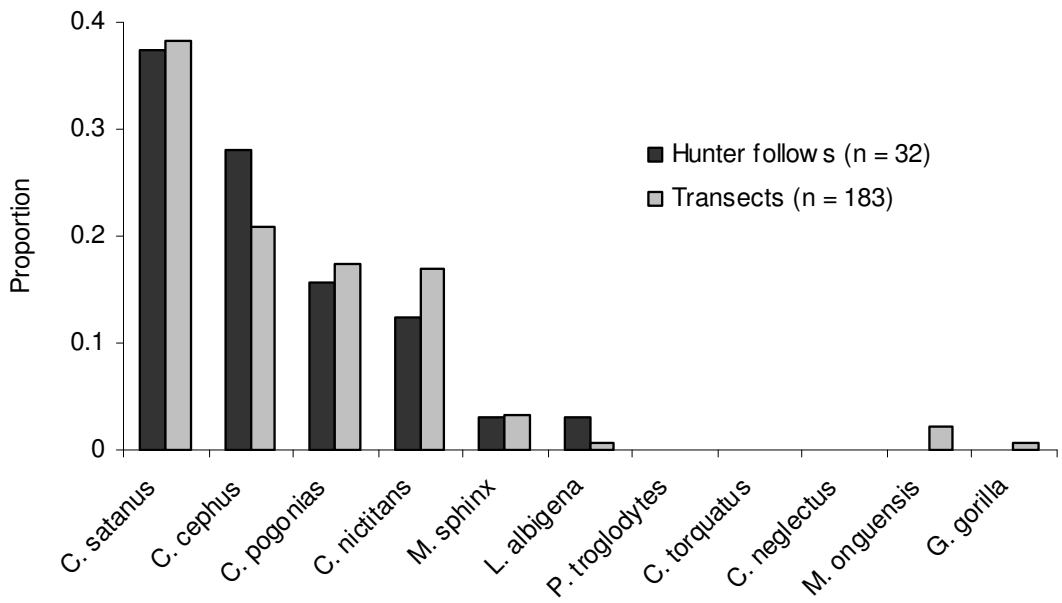
Only 14 out of 83 hunters were recorded as hunting with a gun, and the majority of those also trapped, usually gun-hunting opportunistically whilst out checking their traps. Those that gun-hunted exclusively tended to do so around the village as a secondary activity to another livelihood. Gun-hunting at Mabumom, the furthest camp recorded during this study, appeared to have started only recently on a regular basis (a few months before the study started). When asked which method of hunting they preferred, most hunters stated trapping over gun-hunting, due to lower barriers to entry (costs of gun and cartridges, which are relatively harder to obtain and more expensive than other countries in the region), and the fact that trapping was less effort and required less skill. However, the cost of gun-hunting appears to be decreasing; a single cartridge in Sendje cost 650 CFA in June 2002 compared to 600 CFA in October 2003 (chapter 4).

5.3.3 Do hunters target certain primates?

5.3.3.1 Can we use transect encounter rates as a proxy for hunter encounter rates?

Excluding those species with sample sizes of less than 5, there is no significant difference in the proportional encounter rate per species for hunter follows (n = 32) and transects (n = 183) at Mabumom (χ^2 = 4.06, df 10, NS; figure 5.3). However, although the proportion of different species seen was very similar, overall encounter rates were very different between transects (0.93 groups/km) and follows (0.57 groups/km). This is because the mean sighting distances were much shorter for follows (16.3m) compared to transects (27.3m). When encounter rate is divided by the sighting distance, an index of 0.034 and 0.035 results for follows and transects respectively, suggesting that detection distances vary between survey methods (for some reason hunters only register encounters at much closer distances; perhaps linked to shooting range), but baseline primate density and richness is the same. I therefore take the relative encounter rate from transects as representative of the relative encounter rate from hunter follows, and use it in further analyses due to the larger sample size.

Figure 5.3 Visual encounter rates at Mabumom with different primate species on hunter follows (n = 32) and transects (n = 183)



5.3.3.2 Do hunters choose certain species over others?

There is a significant difference overall between the number encountered per species and the number killed per species ($\chi^2 = 83.66$, df 3, $p < 0.01$; figure 5.4). When post-hoc chi-squared tests (Siegel & Castellan, 1988) were conducted to find out where the differences lay, encounter rate/offtake for each species was found to be either highly significantly (*C. satanus, C. cephus* and *C. pogonias*) or significantly (*C. nictitans*) different. It would appear that *C. satanus* is being positively selected by hunters, whereas the three guenons are not.

Figure 5.4 Proportion of carcasses in Mabumom offtake by species (Nov. 2002 – Jan. 2004; n = 352) with proportion of encounters on Mabumom transects by species (n = 183), for four most common primate species

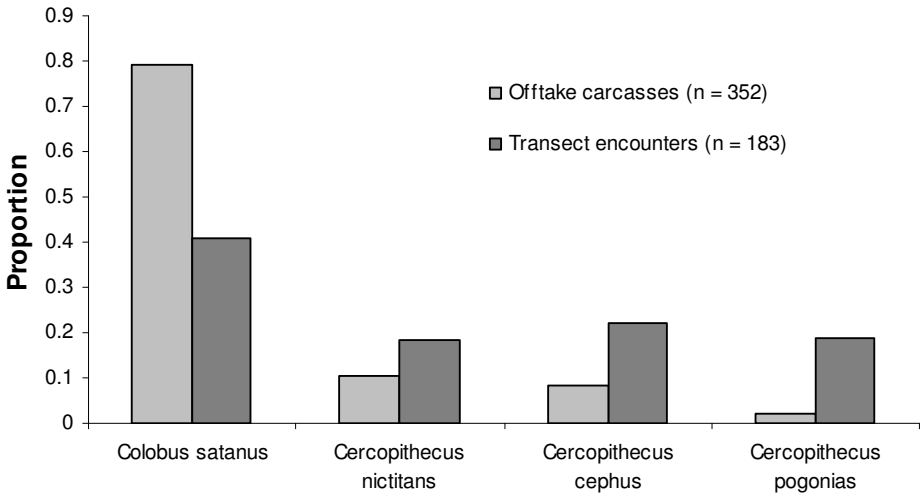
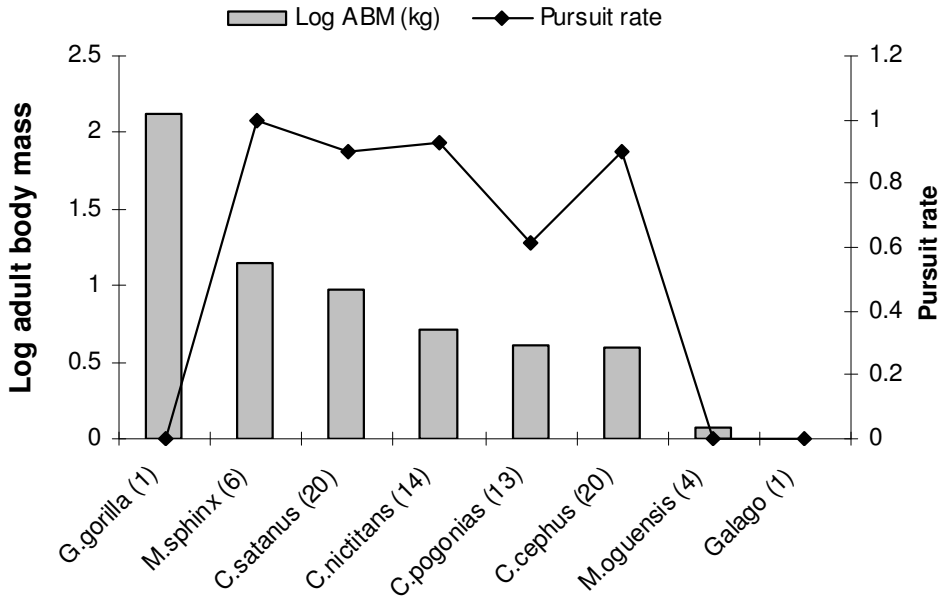


Figure 5.5 shows pursuit rate by hunters for different primate species, listed in descending order of log mean adult body mass (taken from the offtake survey). This limited dataset suggests that body size is a determinant of pursuit probability, in that the largest (*G. gorilla*) and smallest (*M. oguensis* and *Galago sp.*) species are ignored, whilst medium-sized species are nearly always pursued on encounter – seeming to support the 'zero-one' rule of the prey choice model (Stephens & Krebs, 1986). Partial preferences (Krebs & McCleery, 1984) appear to be expressed for *C. pogonias*, possibly due to other factors such as alternative prey availability at the specific location of encounter, previous success on the hunting trip if the hunter is 'attack limited', or the species' innate 'catchability' (Cowlishaw & Dunbar, 2000); however as *C. pogonias* is found at similar densities and has a similar body mass to *C. cephus*, it seems likely that the reason for these partial preferences is because it is traditionally a taboo species.

Figure 5.5 Pursuit rate per species from hunter follows (defined as the proportion of times a monospecific group is pursued upon visual encounter) and $\log_e$ adult body mass (ABM) taken from offtake survey, Nov. 2002 – Jan. 2004. Number of monospecific encounters per species is given in parentheses.



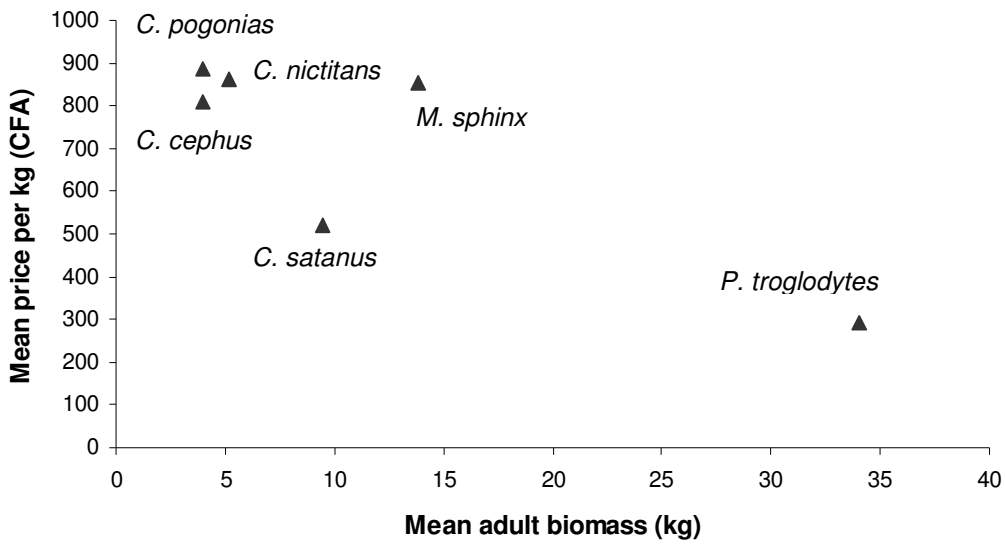
Although encounter and pursuit sample sizes are for many species low (indicated in parentheses next to the species name), the pursuit rate shown in figure 5.5 would appear to reflect real differences, as backed up by anecdotal evidence. On the whole apes are not specifically targeted by hunters, partly due to their large body size making them difficult to transport unless very close to the village, but also because of tribal taboos against both *P. troglodytes* and *G. gorilla* (East *et al.*, 2005; Sabater-Pi & Groves, 1972), expressed by all the Fang sub-tribes in Sendje. Similarly the majority of hunters stated in interviews that they would not shoot something as small as *M. oguensis*, as they are not worth the cost of a cartridge (there are no data available for carcass value as none were sold in the village during the study period, but extrapolating from the price per kg of other primate species would value *M. oguensis* at less than 1000 CFA per carcass, combined with a cartridge cost of 600-650 CFA and a less than 100% capture rate).

Generalised linear models were carried out to test for differences in pursuit and capture rates between *M. sphinx, C. satanus, C. nictitans, C. pogonias, C. cephus* and *M. oguensis* (Crawley, 2002). *M. oguensis* was found to have a significantly lower pursuit rate to *C. pogonias* ($\Delta\text{Dev}(\chi^2)$ 6.185, $p = 0.013$), and both had significantly lower pursuit rates than the other species ($\Delta\text{Dev}(\chi^2)$ 4.962, $p = 0.026$). Similarly, the capture rate of *C. pogonias* was significantly lower than the other species ($\Delta\text{Dev}(\chi^2)$ 12.696, $p < 0.001$) (it was not possible to test the capture rate of *M. oguensis* as it

was never pursued). Being difficult to catch may in part explain why *C. pogonias* is less preferred as prey – theorised as the reason behind some taboo species (Yost & Kelly, 1983).

Figure 5.6 shows the price per kilogram against adult body weight of different primate species recorded in the Sendje offtake survey. *P. troglodytes* meat is the cheapest of all bushmeat species sold in Sendje, and *C. satanus* fourth cheapest (excluding elephant meat, which cannot be fairly compared as its low price is due to the glut of meat available when an individual is killed); the mean price for all primate species was less than the mean price for bushmeat overall (1,076 CFA/kg). The particularly low price of *P. troglodytes* may be biased due to the low sample size (from a single individual, a solitary old male caught about 2 km from the village), but does corroborate anecdotal reports from villagers (*pers. obs.*) and market surveys (see chapter 2) that ape meat is cheap, with little specific demand for it. This would be an alternative explanation for the apparently low pursuit rate of apes. However, price per kilogram does not explain why *C. satanus* has a high pursuit rate; in this case it seems likely that the carcass price, which is comparable to that of the guenons even though it is considerably heavier (the average *C. satanus* carcass is 4,948 CFA and weighs 9.48 kg, whereas *C. nicititans* is 4,452 CFA and weighs 5.16 kg), is sufficiently high to merit it being pursued. Factors such as easy 'catchability' may also be important (Brugiere, 1998). Interestingly, there is no significant difference between the price of *C. pogonias* meat and that of the other guenon species, suggesting that the market does not observe the same taboos against it as Sendje villagers.

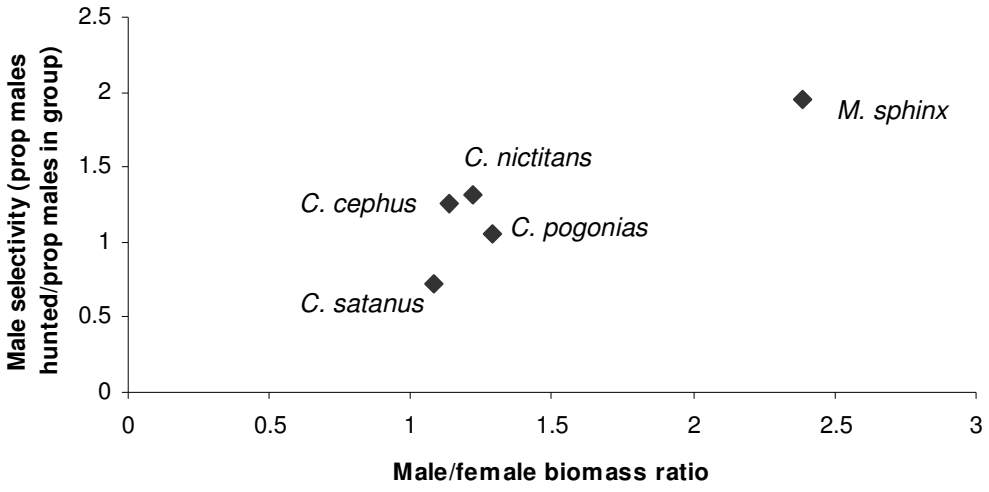
Figure 5.6 Mean price per kilogram for different primate species against mean adult body mass. Data are taken from Sendje offtake data, Nov. 2002 - Jan. 2004 (n whole, fresh primates = 479). Note the mean price of bushmeat sold in Sendje during this period was 1076 CFA/kg (n transactions for fresh bushmeat = 4470).



5.3.3.3 Do hunters select particular individuals on the basis of sex/age group?

Of the commonly hunted species, only *M. sphinx* exhibits marked sexual dimorphism (appendix 5.2; figure 5.7). Although species vary in their social structure, from male-dominated harems for the guenons to multimale-multifemale groups for *M. sphinx* and *C. satanus* (Rowe, 1996), the overall proportion of males per group does not vary greatly between species (for those species shown in figure 5.7, the proportion of males spans from 0.27 for *C. nictitans* to 0.36 for *C. cephus*) when group size is taken into account. Where there is considerable sexual dimorphism, as for *M. sphinx*, there does appear to be some degree of male selection by hunters, as evidenced by a correlation between the male:female weight ratio and the proportion of males hunted (Pearson's correlation; r = 0.886, n = 5, $p = 0.045$; figure 5.7). The correlation disappears when *M. sphinx* is removed from the analysis. Beyond this there is no evidence of marked sexual selection by hunters. The fact that slightly more males are hunted than are available in the case of the guenon species may also be a result of the males' territorial behaviour making them an easier target, particularly for *C. nictitans* (Gautier-Hion *et al.*, 1999).

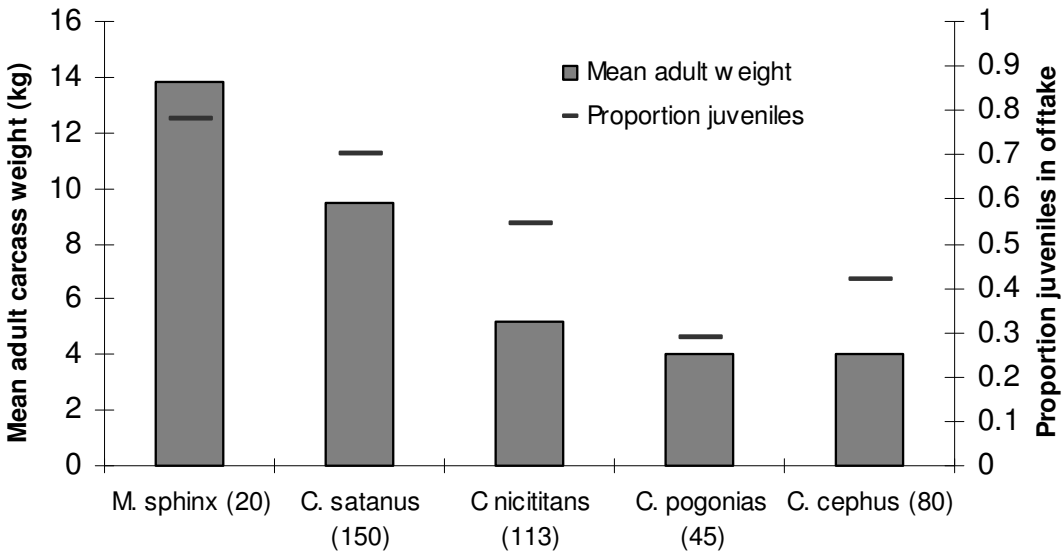
Figure 5.7 Male selectivity (proportion of males hunted/proportion of males in group) with male:female biomass ratio. Socionomic sex ratios for *C. satanus* taken from (McKey, 1978), for other species from (Mitani, 1991) and adult female weight for most commonly hunted species taken from Sendje hunter offtake data.



Adult body mass is correlated with proportion of juveniles hunted: the larger-bodied the species, the more juveniles are hunted (Pearson's correlation; r = 0.91, n = 5, $p = 0.033$; figure 5.8). This is the opposite result to what would be found if there was no prey selectivity, as faster-growing, more

short-lived species such as the guenons should have higher proportions of juveniles. Rather, it seems that for large-bodied prey such as *M. sphinx* and *C. satanus,* even juveniles are of sufficient value to be worth hunting. However, this finding could also be a result of overhunting, as juveniles become more dominant in the prey profile of recovering populations, particularly of species with slower life histories (Milner-Gulland & Mace, 1998). Without data on life histories and group structure, it is hard to disentangle these two potential causal factors.

Figure 5.8 Proportion of juveniles in Sendje offtake with mean adult body weight (taken from fresh carcasses only recorded in Sendje offtake survey, Nov. 2002 – Jan. 2004) for most commonly hunted primate species. Sample sizes for weights are in parentheses.

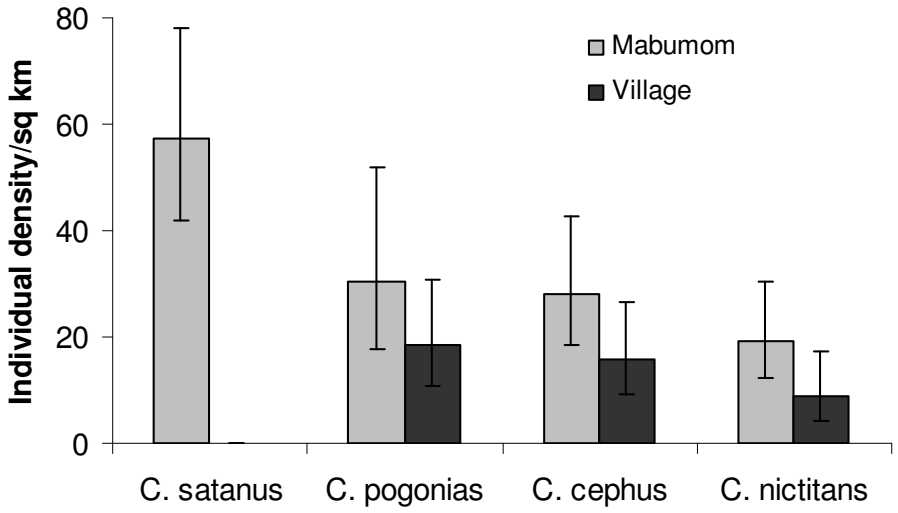


5.3.4 What effect has hunting had on prey populations?

The densities of the four most common primate species found at Mabumom differ considerably to those at the Village site (figure 5.9 and table 5.4). No *C. satanus* groups were detected during the Village transect survey (covering an area of 10.5 km^2); the species has nearly been entirely wiped out from the area around Sendje (pers. obs.). The three guenon species are still present, but at reduced densities compared to Mabumom. Plumptre (2000) warns that differences of less than a 10-30% change in the population if using direct methods are unlikely to be detected between two surveys; as the mean differences recorded here exceed this for all four species, we can be relatively certain that the difference in densities is real, despite the overlapping ranges. A *caveat* should be attached to direct comparison between the two sites, due to potential differences in habitat and other variables (no thorough quantitative botanical survey work has been done in the two areas and this

was beyond the scope of this project). However, villagers confirm that *C. satanus* used to be present around the village and has been decimated by gun-hunting.

Figure 5.9 Density of the four most common primate species at Mabumom and Village transect survey sites (individuals/km^2). Upper and lower (95%) confidence levels are marked.



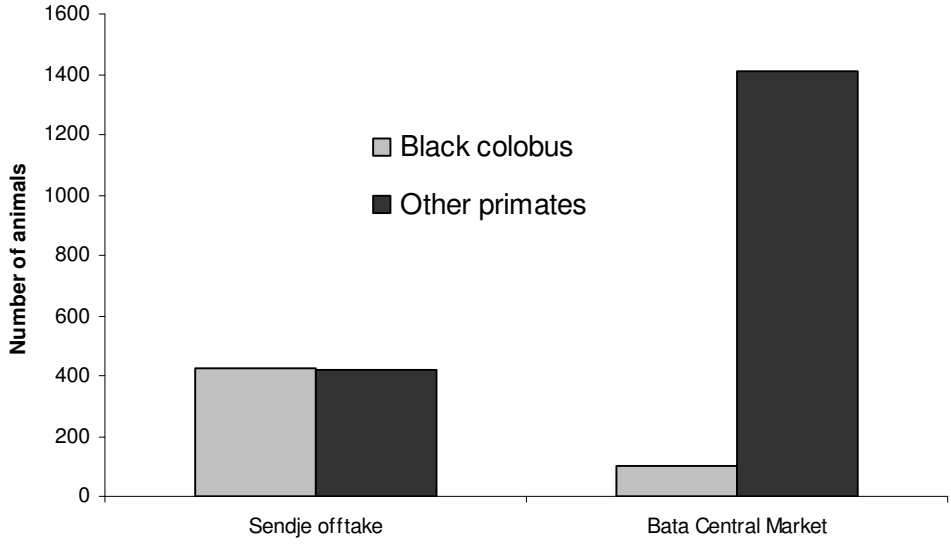
Some *C. satanus* do still remain around the village as they have been recorded during hunter follows and in the offtake survey, therefore another explanation for the lack of encounters during transects is that they, as well as the guenons, have altered their behaviour in response to hunting pressure, thus reducing their detectability. Primate groups at Mabumom showed little fear and often inquisitiveness in response to humans, and calls of many species were frequently heard. Around the village *C. satanus* no longer call and tend to freeze on contact with humans, making them very hard to spot, and other species are also less conspicuous. However, this is unlikely to have affected our transect surveys to a large extent, as the research assistants were very vigilant and effective strip widths for the guenons were similar between the two transect sites, suggesting the detection probability of monkeys is not significantly different (table 5.4).

Group sizes for the guenons do appear to be slightly smaller in the Village transect site, possibly another indicator of hunting pressure (appendix 5.3), but this is within the margin of error expected. Further analysis is not possible as group sizes were estimated rather than accurately counted.

C. satanus made up just over half of primates recorded in the offtake survey during 2003, whereas it was only a fraction of this in the primate sample recorded in Bata's Central Market the same year (figure 5.10). The Central Market is one of the two main bushmeat markets in Bata, and sources

bushmeat mainly from the south of Bata, but also from villages along a logging road to the east, which runs along the northern border of Monte Alén National Park. The fact that *C. satanus* make up only a small proportion of primate carcasses overall in the market (the majority of primate carcasses are of *C. nictitans* and *C. cephus*) suggests that Sendje is an important source of *C. satanus* compared to other areas in this region of Río Muni. Gonzalez Kirchner (1994) reports *C. satanus* being limited to Monte Alén National Park and two small areas in the south-west and north-east of Río Muni. Whether this range is correct, and whether *C. satanus* historically has been absent from other areas or has been exterminated through hunting, is unclear. It is also worth noting that the proportion of primates in the Central Market sample (21.3%) is much higher than in the Sendje offtake sample (10.1%), suggesting that there is proportionally more gun-hunting compared to trapping in other villages that supply the Central Market.

Figure 5.10 Comparison of number of black colobus (*Colobus satanus*) carcasses compared to other primate species carcasses pooled, in Sendje offtake (n = 844) and Bata Central Market sample (n = 1512) during 2003



5.4 DISCUSSION

Equatorial Guinea has the fourth highest primate diversity in Africa (Chapman *et al.*, 1999). Monte Alén National Park is nationally important for primate conservation, containing many primate species at high densities. In particular the Monte Mitra area currently harbours exceptionally high numbers of *C. satanus* compared to other study areas in the species' limited range.

The survey was necessarily limited in that it concentrated on a relatively small area (14.4 km^2 in the Mabumom site), limited topographically to valley floors and slopes which could be physically accessed by the transect team; however this is standard practice in survey design and other than this transects were located randomly. This area does seem to be representative of the central zone of Monte Alén National Park, and as *C. satanus* home ranges have been estimated at 30-500 ha (Gautier-Hion *et al.*, 1999), the survey area was large enough to cross over several groups' home ranges. The same cannot be said for wide-ranging species such as *M. sphinx*, which with home ranges of up to 50 km^2 (Estes, 1991) are less easily surveyed in a study limited in time and area such as this.

The Mabumon area also has very high primate biomass, exceeded in west and central Africa only by Tiwai in Sierra Leone and Kibale in Uganda (table 5.6). As there is a strong positive correlation between total colobine biomass and total primate biomass, driven by colobine biomass (Fashing & Cords, 2000; White, 1994), the high density of *C. satanus* may explain this, even in the absence of red or black and white colobus species in the area.

It is also unclear why *L. albigena* is present in Monte Mitra at such low densities. Kingdon (1997) hypothesises that this may be due to competition with other species, causing it to retreat to swampy areas, Gautier-Hion *et al.* (1999) suggest that densities may be low in secondary forest and Matthews and Matthews (2002) propose that it may be particularly susceptible to hunting as it is vocal and easy to catch. *L. albigena* may have disappeared from the Niefang area of Monte Alén National Park due to overhunting (Garcia & Mba, 1997).

Critics may suggest that this unusually large primate density, particularly that of *C. satanus,* could be a result of poor survey design or experimental error. Brugiere and Fleury (2000) suggest that their line transect methods overestimated density compared to home range methods. However, this was because the uneven topography of their study site led to errors in estimating distance; as all our distances were measured this problem was avoided. Low sample sizes for some species can also

lead to large confidence intervals; however due to good detection probability curves and the use of a pooled detection function across sites in one instance where the number of sightings was particularly low (for estimation of density of *C. nictitans* at the Village site, where n = 13; see table 5.4), our estimates are robust (Brugiere & Fleury, 2000; Peres, 1999, 2000). In addition, Brugiere and Fleury (2000) state that the transect method tends to underestimate group size (and our group sizes were indeed lower than other authors'); this should therefore, if anything, result in an underestimate of individual density.

Table 5.6 Comparison of diurnal primate community of Monte Mitra with those of other African forest sites, broken down into eco-taxonomic groups (adapted from Chapman *et al.*, 1999, p.17)

Site	Annual rainfall (mm)	Primate biomass (kg/km^2)	Number of diurnal species per group				Total diurnal species number[2]
			Terrestrial cercopithecines	Arboreal cercopithecines	Colobines	Apes	
Monte Mitra, this study	*2841*	*>883*[1]	*1(-2)*	*5(-6)*	*1*	*2*	*9-11*
Tiwai	2708	1379	1	3(-4)	3	1	8-9
Taï	1800	802	0	6	1	1(-2)	8-9
Douala-Edéa	4000	409	0	6	1	1(-2)	8-9
Lopé	1505	319	2	4	1	2	9
Makokou	1755	-	2	6	1	2	11
Salonga	1774	-	0	4	2	(1)	6-7
Ituri	1802	710	4	5	3	1	13
Kibale	1662	2710	1(-3)	3	2	1	7-9
Budongo	1495	545	1(-1)	2	1	1	5-6

[1] Excluding nocturnal species (pottos and galagos), and species for which no density estimate was available through Distance (e.g. apes and mangabeys – see figure 5.2), therefore underestimating total primate biomass
[2] Ranges are given where the exact number of species is unconfirmed

It could also be argued that the survey area of Mabumon may not be representative of the Monte Mitra area as a whole. Given the lack of previous thorough botanical or topographical surveys of the area there is a possibility that food or some other resource is particularly abundant in Mabumom; however, given the general similarity (at least structurally and topographically) of the entire Monte Mitra forest, this seems unlikely. More probable is that the combination of the camp's inaccessibility, coupled with an only recent uptake of sustained gun-hunting, has led to the relative protection of particularly vulnerable species such as *C. satanus* from human disturbance and exploitation. (This therefore is at odds with the theory that *L. albigena* has been affected by hunting in the area.) High densities of *C. satanus* have also been recorded to the south-east of Monte Alén National Park, where gun-hunting has also historically been light (J. Rist, pers. comm.).

Interestingly, Bioko Island may be another stronghold for *C. satanus* populations, where encounter rates in the Gran Caldera de Luba protected area are similar to Mabumom at 0.23 groups/km^2

(Hearn *et al.*, 2004). However, the species has been recorded as declining in the markets of Malabo, the capital, suggesting overhunting (Hearn & Morra, 2001).

Recent studies suggest that selective logging often increases overall primate densities (e.g. Oates *et al.*, 1990 - Tiwai Island; Plumptre & Reynolds, 1994 – Budongo Forest Reserve, Uganda; White, 1994 – Lopé), although the effects vary by species: whilst some increase, others remain stable or decrease. Figs and other preferred fruiting trees are found more commonly in exploited forest and selective logging may increase the diversity of trees in many forests (Davies, 1994; Plumptre & Reynolds, 1994). Some authors have stated that colobines in general prefer primary forest; while this may well be true for red colobus (Oates, 1996), evidence now supports the fact that *C. satanus* in fact prefers secondary regrowth, where the forest canopy is broken and the density of colonising shrubs, trees and lianas - which invest less in chemical defence - is greater (Davies, 1994). Brugiere (1998) states that logging in Lopé 'neither removed important food trees nor induced a major change in the forest composition and structure', and suggests that the reported inability of *C. satanus* to live in disturbed forests may be more related to hunting pressure than to ecological constraints.

Monte Mitra appears to currently be a stronghold for a species that is commonly at low densities or absent throughout its restricted range (western Cameroon, Equatorial Guinea, central and northern Gabon and northwestern Congo: Wolfheim, 1983). Fleury and Gautier-Hion (1999) found that *C. satanus* at Makande probably suffer from both regular food shortage in the dry season and episodic severe bottlenecks in food supplies due to the interannual variations in fruiting cycles of Caesalpiniaceae, resulting in low densities. Bourliere (1985) recorded it as absent from both the M'Passa Plateau and the Liboy River in Gabon, although all other species in the assemblage found in Monte Mitra were there. The species has not been recorded by any studies in the Campo-Ma'an Region of south-west Cameroon, although it is possible it may be present at very low densities (Matthews & Matthews, 2002).

Hunter prey choice appears to mainly be a result of body size, with hunters ignoring very large and very small prey, in accordance with optimal foraging theory (Stephens & Krebs, 1986). In the past *C. satanus* used not to be hunted by the Fang because its meat was said to be dry and have a bitter taste (Sabater-Pi & Groves, 1972). However, tastes change and taboos break down with the arrival of migrants (Refisch & Kone, 2005) and a market economy (Bowen-Jones, 1998). Brugiere (1998), studying the species in Lopé, Gabon, stated that 'hunters often report that it is not their favourite species because its meat tastes bad, but when other species become rarer due to hunting pressure, black colobus is heavily hunted'. He suggested that *C. satanus* is 'easy game' due to its relative

inactivity and large body size. This may explain why *C. satanus* was positively selected above all other species in our study of Mabumom hunters, even though its meat is one of the cheapest available and substantially cheaper by weight than that of guenons. Its vulnerability to hunting seems clear given the fact it has very nearly been extirpated from areas close to Sendje where gun-hunting pressure is high.

A study in the Campo-Ma'an region of Cameroon found that guenons had been relatively unaffected by hunting compared to other species, but that *C. nictitans* was likely to suffer in the long term as it was preferred to *C. cephus* and *C. pogonias* by hunters (Matthews & Matthews, 2002). This may well also be the case in Monte Mitra, as *C. nictitans* is the largest and most visible of the three guenons, may be slightly preferred by hunters over the other two species, and was also found at the lowest densities of the three species at the Village site.

At present gun-hunting is very much a secondary activity compared to trapping for Sendje hunters. This is partly because of the greater start-up and running costs involved in gun-hunting (purchase of a shotgun and cartridges, compared to wire), greater skill involved, and presumably because returns on trapping effort are still sufficiently high to make it worthwhile. However, there are a large number of trappers active in the area, and catch per unit effort is likely to decrease if this effort is sustained or even increased (see chapters 6 and 7). Given this scenario, it is likely that trappers will turn to gun-hunting to earn a living, particularly if guns and cartridges continue to become more affordable (see chapter 4), and the price of bushmeat rises due to growing demand from a wealthier urban population (East *et al.*, 2005). This seems to have already happened in other areas of Río Muni, as evidenced by the fact that a greater proportion of primates were recorded in Bata's markets (particularly Mundoasi Market, which is fed by a more heavily populated catchment area to the north, east and south-east of Bata – see chapter 2) than in the Sendje offtake.

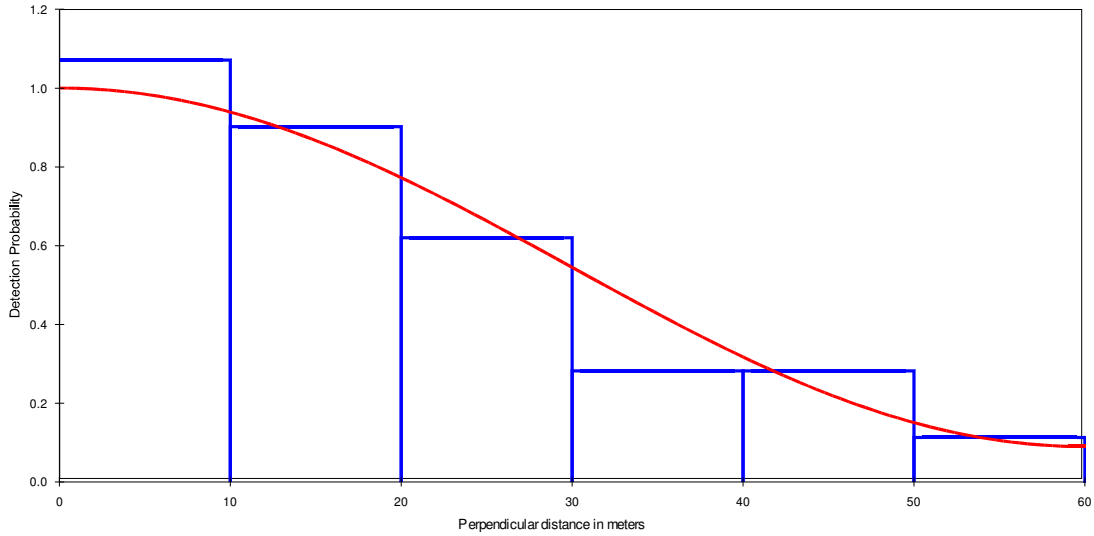
The threat of extinction faced by apes as a result of hunting for bushmeat has been the focus of much recent conservation concern (e.g. Petersen, 2003; Walsh, 2003; http://www.unep.org/grasp/). However Wright and Jernvall (1999) warn that the loss of the folivorous colobines may exert even greater changes in ecosystem processes (Oates, 1994). Aside from playing a crucial role in ecosystem function, this study demonstrates that the loss of the population of *C. satanus* in Monte Alén National Park is likely to impact heavily on the species' global conservation prospects.

At present there is virtually no active enforcement of protected areas in Equatorial Guinea, or control of the trade in illegal species for bushmeat. Hunting and the bushmeat trade is a mainstay of the economy and demand for the resource is only likely to increase with the current economic boom

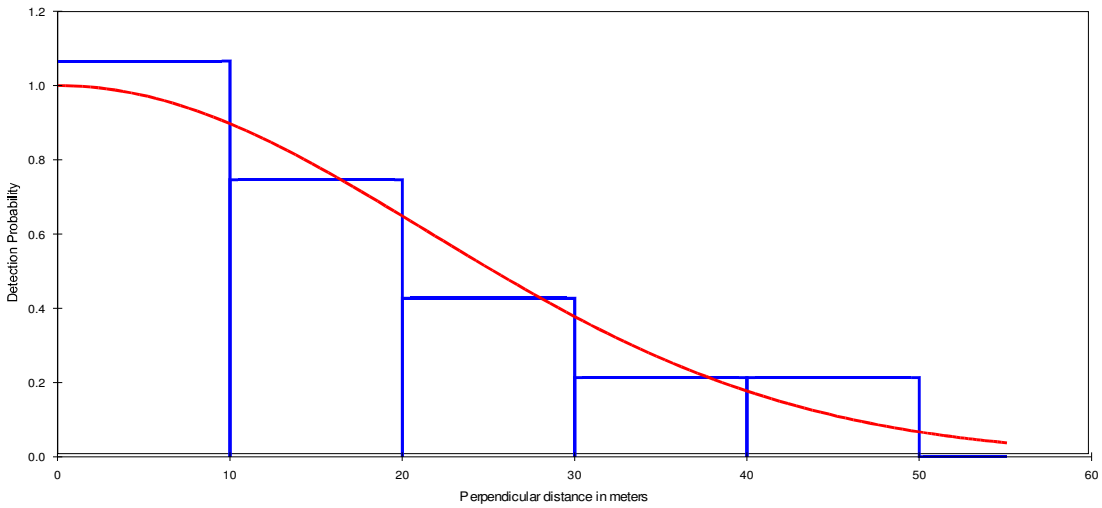
(chapter 2). There is an urgent need for effective management of the country's protected area system (as well as monitoring of protected areas other than Monte Alén National Park to evaluate threats and their conservation worth) and an effective ban on hunting and trade of particularly vulnerable species such as apes and *C. satanus.* These are the most pressing and urgent needs if the biodiversity of the country is to be maintained, or at the very least, its demise reduced. However, in the long term, development of acceptable alternative animal protein sources for urban consumers and income-generating activities for rural hunters should be a priority, in order to address both the demand and supply for bushmeat.

Appendix 5.1 Comparison of detection probability curves at Mabumom for a) *Colobus satanus* (effective n = 58; data grouped into 6 categories, truncated at 60m, and fitted to the uniform cosine model) and b) *Cercopithecus pogonias* (effective n = 25, data grouped into 6 categories, truncated at 55m and fitted to the half-normal cosine model). Distance is along the x-axis and detection probability on the y-axis.

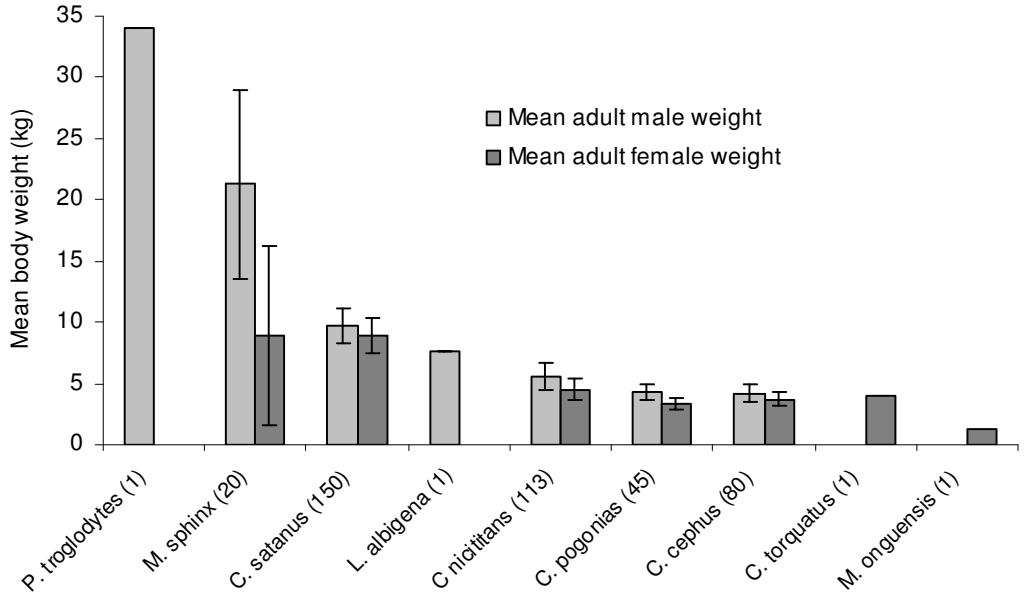
a)



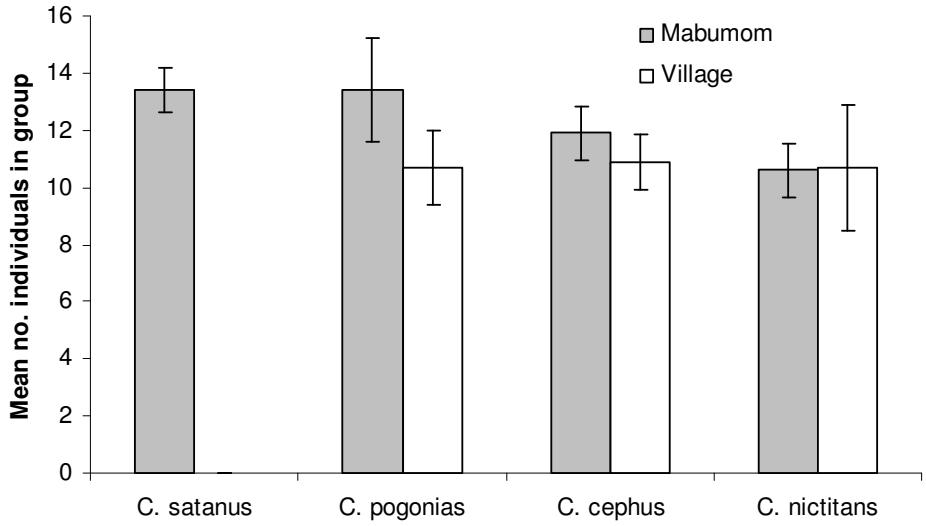
b)



Appendix 5.2 Mean adult body weights for different primate species, from offtake data Nov. 2002 – Jan. 2004



Appendix 5.3 Comparison of species group size in Mabumom and Village sites (with one standard error indicated)



Chapter 6

Patterns of sustainability of hunting in the Monte Mitra area

6.1 INTRODUCTION

Levels of bushmeat hunting in West and Central Africa are thought to be becoming increasingly unsustainable (e.g. Bakarr *et al.*, 2001), with bushmeat harvest from the Congo basin alone estimated at 1-5 million tonnes per year (Fa *et al.*, 2002b; Wilkie & Carpenter, 1999a). However, it is important to define what we mean by sustainability. Robinson & Redford (1991) state that 'sustainable harvest requires both the maintenance of the resource so that it can be exploited for human welfare, and the conservation of the species being exploited and the biological community in which it lives'. But sustainability from a human livelihoods perspective may not result in sustainability from a biodiversity perspective (Redford & Stearman, 1993). Cowlishaw *et al.* (2005) describe a mature bushmeat market in Ghana where vulnerable species have disappeared, leaving apparently sustainable harvests of the remaining robust, short-lived species, which continue to contribute to local livelihoods. In less disturbed areas which still contain high levels of biodiversity, even low levels of harvesting necessarily reduce a prey population below its carrying capacity, and this may have unforeseen, long-term consequences on the ecosystem as a whole (Fitzgibbon, 1998), for example when the loss is of seed-dispersers (Wright *et al.*, 2000) or prey for top-level predators (Hart, 2000).

If sustainability is hard to define, it is even harder to measure. Biological sustainability basically means harvesting a population at a lower rate than its maximum natural rate of growth (Clark, 1990). Assuming simple logistic population dynamics, growth and harvest offtake depends on the population density, with the maximum sustainable yield (MSY) occurring at 0.5 carrying capacity (K), when per capita growth multiplied by density is maximised. A frequently used definition of biological sustainability uses MSY as a reference point to mark a tipping point, giving rise to simple indices for assessing whether harvest of a species is sustainable. Most commonly used is the

Robinson and Redford index (Robinson & Redford, 1991), a quick and simple algorithm that uses the carrying capacity and maximum rate of increase (r_{max}) to calculate potential population production at around MSY. It has been widely applied to assessments of bushmeat harvest sustainability (e.g. Fa *et al.*, 1995; Fitzgibbon *et al.*, 1995; Muchaal & Ngandjui, 1999; Noss, 2000). Robinson and Redford concluded that their index worked well as a first assessment of sustainability for their sample of well-studied neotropical mammals, but warned that as changes in density and r_{max} have a big influence on productivity, the index may not be conservative enough where these parameters are uncertain (as is the case for central African fauna). An alternative is the Bodmer method, which uses fecundity rates rather than r_{max} to calculate population production (Robinson & Bodmer, 1999).

However, experimental simulations of sustainability indices as management tools have indicated that neither the Robinson and Redford nor Bodmer methods are precautionary enough, and therefore both are likely to overestimate sustainable levels of offtake, allowing rapid population extinction (Milner-Gulland & Akcakaya, 2001; Slade *et al.*, 1998). Milner-Gulland (2001) found that a similarly simple method developed for fisheries management, the National Marine Fisheries Service (NMFS) index, worked much better. This index uses an estimate of the current population abundance instead of carrying capacity, and includes a correction factor for bias and uncertainty, and thus reduces the risk of overoptimistic assessments of sustainability compared to conventional sustainability indices. It has recently been suggested that a combination of the Robinson and Redford and NMFS indices could be used as a crude rule of thumb to gauge maximum and minimum limits of sustainability respectively (Anon., pers. comm.).

That said, the difficulty of estimating the parameters needed for such indices is a major drawback, particularly where rare and little-studied tropical rainforest fauna are concerned (Milner-Gulland, in press). Estimating absolute population densities is time-consuming, difficult and expensive. At very low population density (as in a heavily hunted area), a great deal of effort is required to collect enough sightings of a particular species in order to make a reasonably precise estimate of density (Monkkonen & Aspi, 1997; Plumptre, 2000). In many populous areas, an unhunted area with similar ecological characteristics to a hunted area may simply not exist, making direct estimates of carrying capacity impossible. Biological data on the reproductive rates and life histories of many central African species are also scant. Often allometrically-derived data have to be substituted in the absence of knowledge of a species' basic biological traits (e.g. Rowcliffe *et al.*, 2003). All these uncertainties make the simplified indices developed so far only useful as a first indication of possible unsustainability, alerting managers to the need for further monitoring and evaluation of the harvest (Milner-Gulland, 2001b).

Another approach is to look at changes in the species composition (prey profile) of harvested offtake (Colell *et al.*, 1994; Eves & Ruggiero, 2000; Fa, 2000; Fa *et al.*, 2000; Rowcliffe *et al.*, 2003). Medium to large-sized animals are preferred prey and thus targeted first by hunters according to optimal foraging theory (e.g. Alvard, 1993; Newing, 2001; Peres, 2000). Such large-bodied species are also usually the most vulnerable to harvesting. Therefore offtake in relatively undepleted areas tends to contain a higher proportion of larger species, in particular ungulates, and primates where they are targeted, whilst reductions in the proportion of these species could act as a warning signal of depletion. This has more usually been considered when looking at bushmeat markets (e.g. Fa *et al.*, 1995; Fa *et al.*, 2000), but is better applied at the village level as the complications of spatial heterogeneity and market dynamics are minimised (Milner-Gulland, in press).

Trapping with wire snares is the most widespread method of hunting in use in central African forests (Noss, 1997, 1998a, c), due to low barriers to entry in terms of skill, effort and cost (see chapter 4). Snares tend to catch medium to large mammals, in particular duikers (Hart, 2000; Newing, 1994; Noss, 1998c). Duikers made up 55% of the animals snared in the Western Dja Reserve, Cameroon (Muchaal & Ngandjui, 1999) and 49% in Korup National Park, Cameroon (Infield, 1988). Noss (1998c) reported that 75% of captures in Central African Republic forests were made up of three duiker species and the brush-tailed porcupine. Although some snares are designed to catch different types of prey due to their particular behaviour or size (chapter 4; Noss, 1998c), on the whole, trapping is relatively unselective. It is an efficient method of hunting even when densities are low and can lead to greater depletion of populations than other methods targeting the same prey, such as net-hunting (Hart, 2000). It can also be very wasteful: Noss (1998c) estimated that up to a quarter of animals that are successfully trapped are lost to decomposition or scavenging, and over a third more may escape from traps, many with debilitating injuries.

In order to evaluate the impact and sustainability of current levels of hunting in the Monte Mitra area, I address four key questions. I look at overall hunting offtakes and also focus specifically on the impacts of trapping, as it is the most common type of hunting practiced in the area. Firstly, I evaluate whether the prey profile has changed over time, either during this study in 2002-4, or since 1998-9 when an equivalent study was carried out (Fa & Garcia Yuste, 2001). As this prey profile approach assumes that effort and technology remain constant over time, I then assess whether trapping effort or technology has changed over time. Thirdly, I look for evidence of greater depletion of individual species closer to the village. Finally, I compare the overall harvest rate with other studies of bushmeat harvest sustainability.

6.2 METHODS

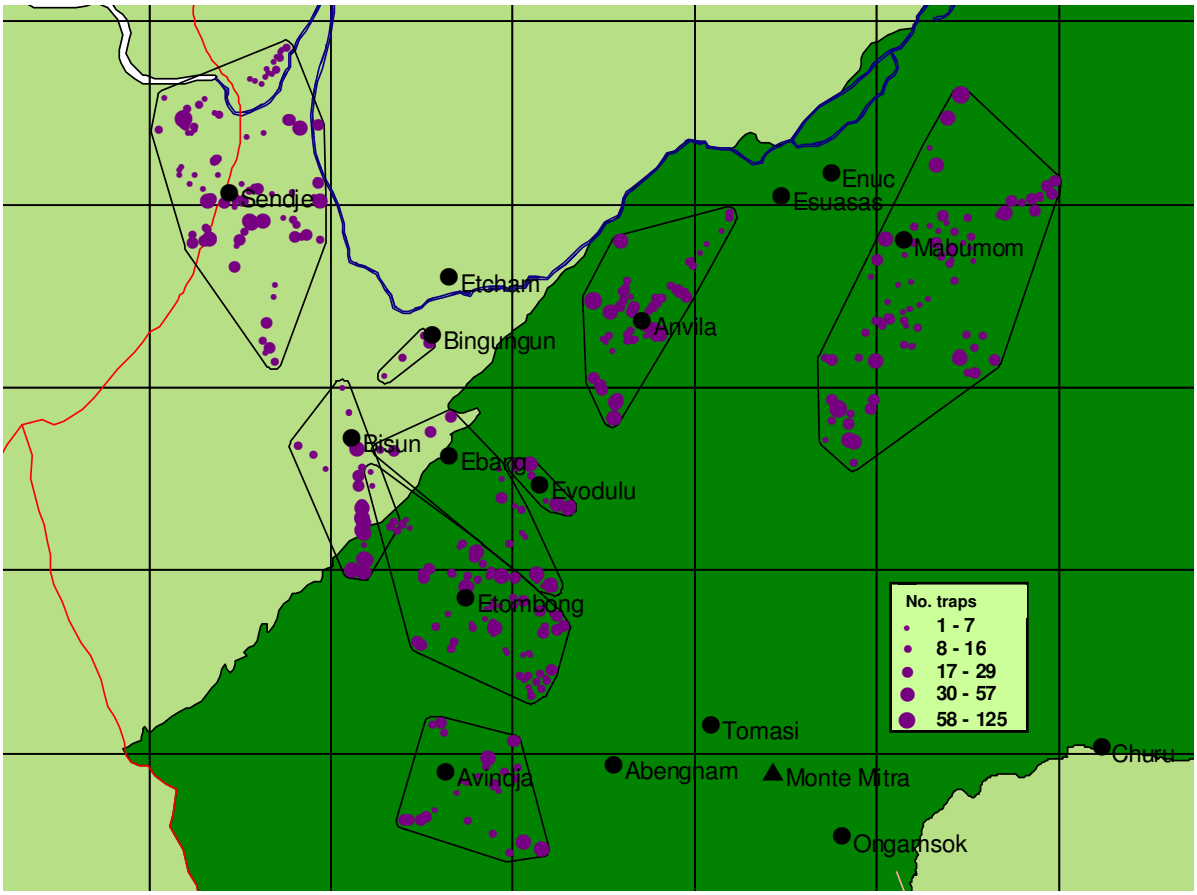
6.2.1 Study site

This study focuses on the village of Sendje and the zone of trapping and gun-hunting of hunters from Sendje, spanning mainly to the east and into the central third of Monte Alén National Park (hereafter the Monte Mitra forest), the border of which is about 10 km from the village. Most data were collected from November 2002 to January 2004, but some information from interviews and other work conducted on a pilot trip in June 2002 is also included.

There are a number of hunter camps used predominately by trappers to the east of Sendje, of which 10 were in use from November 2002 to January 2004: Bisun, Bingungun, Etcham, Ebang (Manjana), Evodulu, Etombong, Avindja, Anvila, Enuc and Mabumom. The majority of these camps are situated within Monte Alén National Park. A further five camps (Esuasas, Abengnam, Ongamsok, Tomasi and Churu) were in use in June 2002 but had been abandoned by the time of the main fieldwork season, the latter four due to the installation of new forest guard camps in the southern part of the hunting zone (at Churu and Abengnam) by the ECOFAC project, in charge of park management at the time. See figure 6.1 for layout of camps, Sendje and Monte Alén National Park. Trapping is the most common method of bushmeat hunting practised in the area.

Sendje was selected as a site for this study following the publication of a survey of the offtake of 42 predominately commercial hunters over a 16 month period from January 1998 to April 1999 (Fa & Garcia Yuste, 2001). The authors recorded the movements of the hunters between camps, and documented a dramatic drop in both catch and effort (in terms of days hunting) over the period of the study. They concluded that offtake of six species (*Cephalophus dorsalis, C. callipygus, C. silvicultor, Mandrillus sphinx, Colobus satanus, Cercopithecus nictitans* and *Atherurus africanus*) was unsustainable in at least one camp each, and that of *C. dorsalis* in all camps. A total of 3053 animals of 58 species were hunted during 1914 hunting days. This work builds on that of Fa and Garcia Yuste, in an attempt to address whether these predictions of unsustainability hold true.

Figure 6.1 Map of the study area showing trapping zones around camps and increasing trapping intensity with distance from camps. Sendje and hunt camps are marked with large black dots. Minimum convex polygons with a 200m buffer zone to account for the home range of the commonly trapped *C. monticola* (2-4ha) show the extent of traps around each camp during the study period. Purple dots represent individual trap groups, with larger dots signifying more traps in the group (see key on map). The dark green area is Monte Alén National Park. 5 km grid squares are marked.



6.2.2 Data collection

Seventy-two hunters were interviewed out of a total number of 83 active hunters recorded during the study period. See chapter 3 for detail on interview methodology. I asked trappers where they were based at the time of the interview (at which forest camp or the distance and direction from the village if based in Sendje) and how many traps they had there. I then asked them to recall where they had been based before that (to the nearest month and year), with the number of traps, and then before that, and so on, as far back as they could reliably remember.

Trappers were accompanied on trips to check their traps both around the village of Sendje and from hunt camps throughout the Monte Mitra forest area (see chapter 4 for detail on trapper follow

methodology). An attempt was made to follow as many trappers active during the study period as possible, in order to estimate the extent of trapping in the Monte Mitra area at an effective 'snapshot' in time. A total of 77 follows were carried out with 48 trappers, 18 around Sendje and 59 around eight hunt camps, from February 2003 to January 2004. The position of all trap groups (defined as a set of traps of the same age, in a geographically distinct group), with details of the number, type and age in days of traps in the group, was logged using a CyberTracker (http://www.cybertracker.co.za/). The data were downloaded onto a personal computer and manipulated using GIS (Geographic Information Systems) software (ArcView 3.3).

All hunter offtake passing through Sendje (mostly from the forest to the east) was recorded from November 2002 to January 2004 by a local research assistant (see chapter 3 for details). Biological data (species, age class, sex, weight and head-body length) and hunt/trade data (method of capture, state, whether whole or part carcass, whether eaten or sold, where eaten/sold, carcass price) were recorded for each animal caught, as well as information on the hunter (name, household code) and hunting trip (number of hours/days, location, hunting methods used). In several of the analyses the data for 2003 only are used, as the 15th December 2002 Presidential election and the run-up campaign to it during November and December 2002, and the illness of my offtake research assistant's wife during January 2004, meant that data on both catch (carcasses) and effort (days hunting) are slightly incomplete during these periods.

Identification of rarer species can be problematic in studies such as these, given limited capacity for training of local research assistants, variation in the specificity of the local Fang name to Latin classification, and the general difficulties of identifying specimens which are often regionally variable and poorly known to science, with limited availability of field-guides. I used Kingdon (1997) for mammal identification and van Perlo (2002) for birds. For those carcasses that I was not there to personally identify, or photograph and take notes on for subsequent expert consultation, I used the animal's weight, head-body length, tail length and assistant's notes where available to identify an animal (e.g. some red duikers and mongooses). However, there were many cases where identification to species level was not possible (e.g. most squirrels).

Two factors meant that it was possible to record the vast majority of the animals being brought back from the forest with relatively little effort. Firstly, nearly every hunter in the village timed his hunting trips to coincide with the days that the Bata traders came to the village to buy to bushmeat, so it was easy to predict when to wait for them, and secondly, there was only one main thoroughfare east into the forest, at which the traders and the offtake research assistant were able to sit and await the return of the hunters (household 1 on appendix 3). The payment per animal also helped to

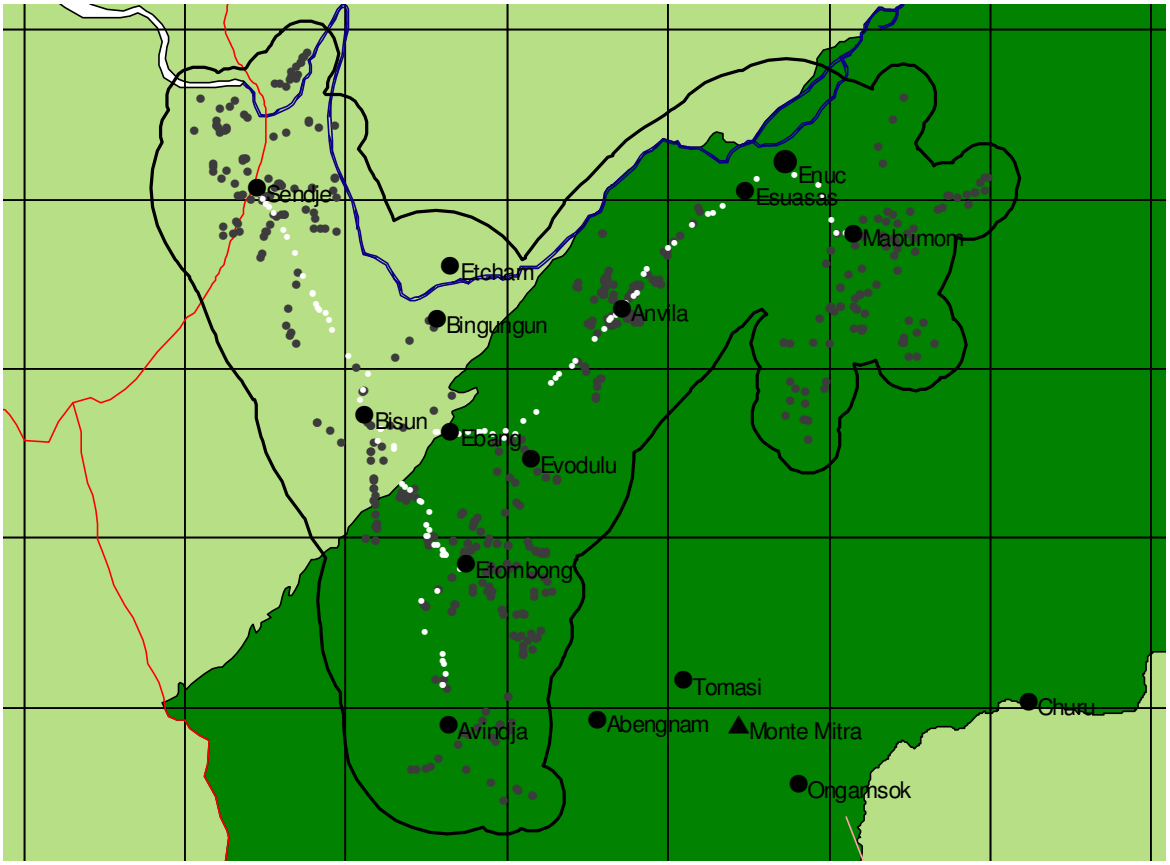
ensure that even small carcasses, such as birds or snails (which are at very low densities in Monte Mitra, unlike other areas of Río Muni, so rarely collected) were recorded.

The village offtake survey did not record animals that were not brought back to the village, either having been consumed in camps by the hunters or found rotten in traps and therefore discarded, as due to the incentive offered to hunters of a small payment per carcass, there was a risk of them inflating this number (which we could not corroborate) in order to claim extra payments. In order to include an estimate of camp consumption, I trained trusted, popular and literate hunters from two camps to record the animals consumed in their camp every day by the hunters. These camp diaries included the animal's age and state and by whom it was eaten, and were recorded over a period of 4 and 4.5 months for Anvila and Etombong camps respectively. Proportions of animals wasted (found rotten in traps or discarded) were taken from the hunter follow data (see chapter 4).

A concerted attempt was made to survey and compare terrestrial wildlife populations in two forest sites in the study area, a long-term heavily-trapped site just beyond the field zone, about 2 km from Sendje, and an intermittently heavily-trapped site at the furthest forest camp, Mabumom, 30 km from Sendje (figures 6.1 and 6.2 and chapter 5). About 200 km of diurnal line transects were conducted in each site (see chapter 5 for detail on methodology) but sightings of all non-primate species were too few to permit abundance estimates. Night-time transects, which are better for censusing species such as duikers (Lahm, 1994),were not conducted due to time constraints and the reluctance of local research assistants to work in the forest at night where there were high densities of elephants. Sightings of sign such as dung on the permanent transects were also low, and in any case the difficulty in estimating the rate of dung decay or track renewal (Barnes *et al.*, 1997; White, 1995) means that density estimations can be highly inaccurate unless decay rate is monitored over the course of the survey period (Plumptre & Harris, 1995).

Net drives (Davies, 2002a; Hart, 2000; Noss, 2000; White & Edwards, 2000) were also conducted in both sites: 16 and 20 drives of 0.5ha each over the course of a week at the village and Mabumom sites respectively. For each drive, a quadrat 50m wide and 100m long was cut in advance and left for at least one day to account for potential disturbance to wildlife. A team of 13 people and two dogs then conducted each drive, 7 first moving silently around the cut quadrat, swiftly putting the 1.5m high nets into place, followed by the remaining four beaters and dogs making their way through the quadrat, shouting, beating vegetation and blowing whistles to chase all wildlife towards the nets and attendant observers. Unfortunately, in terms of common bushmeat species, only two blue duikers (*Cephalophus monticola*) were recorded in each of the two sites, so density comparisons were again not possible.

Figure 6.2 Map of the study area, showing the total trapping zone (307 km^2). White dots demarcate points along hunting trails (old logging roads), the grey dots trap groups and the large black dots trapper camps. The area contained within the grey line is the total potential trapping zone (calculated by merging minimum convex polygons of a 3.23 km buffer zone around the main hunting trails, a 3.23 km buffer zone around trapper camps in use during the study period and a 1 km buffer zone around any individual trap groups that extended beyond the camp/trail buffer zone). The camps outside the total trapping zone were in use by hunters in mid-2002 but not during the main study period. The dark green area is Monte Alén National Park. 5 km grid squares are marked.



6.2.3 Data analysis

The reliability of the trapper interviews was tested to see if the number of the traps recalled by the trapper tallied with the number recorded when he was followed. There was a highly significant correlation between the number estimated by the trapper and the number he actually had (Pearson's correlation (two-tailed): R = 0.619, n = 46, $p < 0.001$), and the error structure was normal, with no particular bias towards over- or underestimation.

Triangulating records from the hunter interviews, trapper follows, offtake record and verbal reports from my village research assistants, at least 78 trappers were active at some point during 2003 (38

of whom were operating from forest camps rather than the village). However, many of these were trapping temporarily: for example, at least six school pupils spent their summer holidays trapping, four new non-Sendje commercial trappers arrived in April to trap in Mabumom camp and left around six weeks later, and several men trapped from time to time inbetween jobs. The mean number of trappers active during any one month in 2003 was 55, 23 of whom were forest-camp trappers (those staying overnight at hunt camps). During 2003 trappers operated a mean of 92 traps each overall (range 2 - 247), or 116 if they were based in a forest camp (range 30 – 247).

The position of all trap groups per trapping zone (area being trapped around a forest camp or Sendje) recorded during the trapper follows was overlaid onto a map of the study area, and minimum convex polygons were drawn around the traps in each trapping zone (figure 6.1). In order to calculate the maximum area being trapped during the study period, those traps not surveyed, as well as other reachable areas which could potentially be trapped, also had to be taken into account. The mean maximum diameter of trapping zones around the camps used most during 2003 (Mabumom, Anvila, Ebang, Etombong, Avindja, Bisun and Sendje) was measured as 6.46 km, giving a mean maximum distance of traps from camp of 3.23 km. A buffer of 3.23 km was therefore added to each camp. As some traps were also set leading off from the main hunting trails (see figure 6.2), a buffer of 3.23 km was also added to the trails. Finally, as some trapping zones were substantially larger than average (e.g. Mabumom and to some extent Sendje), the area of actual recorded trap groups was included, with a 1km buffer added on to allow for trap area extension beyond the follow period. The buffered camp, trail and trap zones were merged together using GIS software and a 'total potential trapping zone' of 307 km^2 was calculated (figure 6.2).

A total of 9374 animals of 49 species (not including a single elephant killed by a Government-licensed elephant-hunter) were recorded in the village offtake survey between November 2002 and January 2004, captured by a mean of 40 hunters per month (median 40, range 35 – 48; this however does not include some of the village-based hunters who tended to capture only very few animals and consume them within the household, which is why the figure here for trappers actually recording offtake differs from the total number of trappers above). 8267 of these animals were recorded during 2003 (table 6.1), and this subset was used for subsequent analyses. A total of 187 animals of at least 25 species were recorded as being consumed in camps in the hunter camp diaries (table 6.2); two of these taxa (a francolin and two hornbills, of unknown species) were not recorded in the village offtake survey. The majority of the animals eaten in camps were small rodents, small carnivores and birds; of the more profitable species eaten such as brush-tailed porcupine (*Atherurus africanus*) and blue duiker (*C. monticola*), the majority were rotten or juveniles (table 6.2).

Table 6.1 Annual number of carcasses and biomass of all species captured by Sendje hunters. Total carcass number and biomass for 2003 was calculated by adding an estimate of carcasses consumed in hunt camps to those carcasses brought back to the village

Taxa	English name	Latin name	Recorded village offtake (carcasses)	Village offtake (% carcasses)	Estimated camp consumption (carcasses) [1]	Estimated total offtake (carcasses)	Total offtake (% carcasses)	Mean biomass per carcass (kg) [2]	Mean biomass per adult carcass (kg) [2]	Total biomass (kg) [3]	Total biomass (% kg)
Ungulates	Blue duiker	*Cephalophus monticola*	2517	30.4	113	2630	28.1	4.7	4.8	12492	33.9
	Bay duiker	*Cephalophus dorsalis*	201	2.4		201	2.2	17.0	17.6	3417	9.3
	Red river hog	*Potamochoerus porcus*	15	0.2		15	0.2	29.4	30.5	440	1.2
	Sitatunga	*Tragelaphus spekei*	14	0.2		14	0.2	38.7	39.3	542	1.5
	Water chevrotain	*Hyemoschus aquaticus*	10	0.1		10	0.1	9.0	9.0	90	0.2
	Yellow-backed duiker	*Cephalophus silvicultor*	8	0.1	3	11	0.1	36.5	36.5	402	1.1
	Peter's duiker	*Cephalophus callipygus*	8	0.1		8	0.1	17.8	19.7	142	0.4
	Western tree hyrax	*Dendrohyrax dorsalis*	3	0.0	12	15	0.2	2.8	2.8	41	0.1
	Dwarf antelope	*Neotragus batesi*	3	0.0	6	9	0.1	2.3	2.9	20	0.1
	White-bellied duiker	*Cephalophus leucogaster*	2	0.0		2	0.0	17.5*	/	35	0.1
	Black-fronted duiker	*Cephalophus nigrifrons*	1	0.0		1	0.0	16.0*	/	16	0.0
	Bushbuck	*Tragelaphus scriptus*	1	0.0		1	0.0	29.0	/	29	0.1
	Sub-total		**2783**	**33.7**		**2917**	**31.2**			**17666**	**47.9**
Rodents	Brush-tailed porcupine	*Atherurus africanus*	2334	28.2	122	2456	26.3	3.2	3.2	7739	21.0
	Giant pouched rat	*Cricetomys emini*	415	5.0	325	740	7.9	1.1	1.1	834	2.3
	Cane rat	*Thryonomys swinderianus*	15	0.2		15	0.2	4.4	4.7	66	0.2
	Small squirrels	n/a	1	0.0	6	7	0.1	0.1	0.1	1	0.0
	Giant squirrels	n/a	1	0.0		1	0.0	0.4	/	0	0.0
	Beecroft's anomalure	*Anomalurus beecrofti*	1	0.0		1	0.0	0.5	/	1	0.0
	Small rats	n/a	0	0.0	6	6	0.1	0.5**	/	3	0.0
	Sub-total		**2767**	**33.5**		**3226**	**34.5**			**8644**	**23.4**
Primates	Black colobus	*Colobus satanus*	416	5.0		416	4.5	9.2	9.5	3840	10.4
	Putty-nosed monkey	*Cercopithecus nictitans*	136	1.6	12	148	1.58	5.0	5.2	745	2.0
	Moustached monkey	*Cercopithecus cephus*	134	1.6	12	146	1.56	3.6	4.0	527	1.4
	Mandrill	*Mandrillus sphinx*	81	1.0	29	110	1.18	8.8	13.8	964	2.6
	Crowned monkey	*Cercopithecus pogonias*	55	0.7	12	67	0.72	3.7	4.0	250	0.7
	Grey-cheeked mangabey	*Lophocebus albigena*	3	0.0		3	0.0	4.2	7.6	13	0.0
	Chimpanzee	*Pan troglodytes*	1	0.0		1	0.0	34.0	34.0	34	0.1
	Red-capped mangabey	*Cercocebus torquatus*	1	0.0		1	0.0	3.9	3.9	4	0.0
	Northern talapoin	*Miopithecus onguensis*	1	0.0		1	0.0	1.2	1.2	1	0.0

	Sub-total		**828**	**10.0**		**893**	**9.6**			**6379**	**17.3**
Pangolins	Tree pangolin	*Phataginus tricuspis*	387	4.7	17	404	4.3	1.9	2.0	785	2.1
	Giant pangolin	*Smutsia gigantea*	12	0.1		12	0.1	20.4	21.0	245	0.7
	Sub-total		**399**	**4.8**		**416**	**4.5**			**1030**	**2.8**
Carnivores	Servaline genet	*Genetta servalina*	32	0.4	110	142	1.5	1.7	1.7	247	0.7
	African palm civet	*Nandinia binotata*	27	0.3	29	56	0.6	2.4	2.4	136	0.4
	Flat-headed cusimanse	*Crossarchus platycephalus*	11	0.1	35	46	0.5	1.1	1.1	52	0.1
	Marsh mongoose	*Atilax paludinosus*	6	0.1		6	0.1	3.0	3.1	18	0.0
	Mongoose sp.	*?Herpestes naso?*	3	0.0	17	20	0.2	3.0	3.0	60	0.2
	Leopard	*Panthera pardus*	2	0.0		2	0.0	23.0	/	46	0.1
	Black-legged mongoose	*Bdeogale nigripes*	2	0.0		2	0.0	2.0	2.0	4	0.0
	African civet	*Civettictis civetta*	1	0.0		1	0.0	6.0	6.0	6	0.0
	Sub-total		**84**	**1.0**		**275**	**2.9**			**569**	**1.5**
Reptiles	Hinge-backed tortoise	*Kinixis erosa*	901	10.9	46	947	10.1	1.7	1.7	1571	4.3
	Dwarf crocodile	*Osteolaemus tetraspis*	144	1.7		144	1.5	4.4	6.0	639	1.7
	Nile monitor	*Varanus niloticus*	27	0.3	6	33	0.4	3.8	4.2	127	0.3
	Nile softshell	*Trionyx triungus*	1	0.0		1	0.0	7.8	7.8	8	0.0
	Sub-total		**1073**	**13.0**		**1125**	**12.0**			**2344**	**6.4**
Birds	African grey parrot	*Psittacus erithacus*	228	2.8		228	2.4			0	0.0
	Black guineafowl	*Agelastes niger*	50	0.6	76	126	1.3	0.9	0.9	116	0.3
	Plumed guineafowl	*Guttera plumifera*	33	0.4	52	85	0.9	1.0	1.0	88	0.2
	Nkulengu rail	*Himantornis haematopus*	4	0.0	17	21	0.2	0.5	0.5	10	0.0
	Great blue turaco	*Corythaeola cristata*	4	0.0		4	0.0	1.3	1.3	5	0.0
	Pigeon/dove spp.	n/a	1	0.0	6	7	0.1	0.6	0.6	4	0.0
	Hornbills	n/a	0	0.0	12	12	0.13	1.0**	/	12	0.0
	Francolins	n/a	0	0.0	6	6	0.06	0.5**	/	3	0.0
	Sub-total		**320**	**3.9**		**489**	**5.2**			**238**	**0.6**
Amphibians	Goliath frog	*Conraua goliath*	12	0.1		12	0.1	1.9	2.1	23	0.1
	Sub-total		**12**	**0.1**		**12**	**0.1**			**23**	**0.1**
Molluscs	African giant snail	*Achatina sp.*	1	0.0		1	0.0	0.5	/	1	0.0
	Sub-total		**1**	**0.0**		**1**	**0.0**			**1**	**0.0**
TOTAL			**8267**			**9354**				**36896**	

[1] Animals consumed in camps estimated from diaries kept at Anvila and Etombong hunt camps over a total of 8.5 months

[2] Carcass weights calculated from offtake survey, Nov. 2002 – Jan. 2004; n whole non-smoked carcasses = 5142; n whole adult non-smoked carcasses = 4814. For those species with no weights recorded in offtake survey, * = average adult biomass from Kingdon 1997 and ** = estimated biomass

[3] Total biomass calculated from mean carcass weight, not adult weight

Table 6.2 Animals recorded as being eaten in camps

Taxa	State of carcass				Total
	Alive	Fresh	Smoked	Rotten	
Rats and squirrels	0	53	1	4	58
Civets, genets, mongooses	0	32	0	3	35
Birds	0	28	0	1	29
Pangolins and porcupines	0	6	0.5	17.5	24
Small duikers	0	7	1	12.5	20.5
Monkeys	0	8	0	3	11
Tortoises	1	7	0	0	8
Monitor lizard	0	1	0	0	1
Yellow-backed duiker	0	0	0.25	0.25	0.5
Total	1	142	2.75	41.25	187

A mean of 6.25 hunters were recorded per month at Anvila and 5 hunters per month at Etombong during the course of the camp diaries. Scaling this up to estimate total camp consumption, for a mean of 23 forest-camp hunters per month over the 12 months of 2003, gives a total of 1087 animals, or a mean of 3.9 animals per hunter per month. This is 11.6% of the total captured offtake. When this is added to the village offtake, the total estimated captured offtake during 2003 is 9354 animals (table 6.1). Multiplying the number of animals of each species with its mean fresh carcass weight (taken from a sample of 5142 whole, non-smoked carcass weights recorded over the entire village offtake survey), gives an estimated biomass of all captured offtake of 36,896 kg during 2003: a mean biomass of 3.94 kg per carcass.

From the trapper follows, 9.4% of all animals caught in traps were discarded, and therefore not included in either the camp consumption or village offtake surveys. This was usually due to the carcass being rotten, but some species were discarded as they were regarded too small or were taboo to capture. For example, many species of snakes are commonly caught in traps, but as there are many taboos against eating them and they are generally perceived as bad luck, they are often simply killed and thrown out of the trap. This in part explains why no snakes were recorded in the offtake survey. Factoring in this proportion of wastage gives a total minimum estimated offtake of 10,236 animals caught in traps during 2003 (about 850 animals per month), or a biomass of 40,377 kg.

However, it must be emphasised that even this considerable amount is an underestimate, as on rare occasions some hunters were reluctant to allow their offtake to be recorded and, as mentioned, the offtake of some small-scale village hunters was also missed. The trapper follows also registered 36.1% of trapped animals actually having escaped or been scavenged from traps. As most escapees would have been left with some sort of injury, (in many cases a severed limb was left behind), commonly causing subsequent death due to blood loss, infection, increased risk of predation or reduced ability to forage or interact socially, the real impact of

trapping on wildlife is even higher than these estimates suggest, although hard to accurately quantify. The presence of many three-legged animals recorded in the offtake survey is evidence that a surprising number of animals survive even these considerable injuries – or at least survive to be trapped another day.

I reviewed the offtake data recorded by Fa and Garcia Yuste (2001) from January 1998 – April 1999. Using my own first-hand experience, interviews with hunters and anecdotal hunter reports, I modified their species list slightly to account for (1) incorrect nomenclature (e.g. helmeted guineafowl, *Numida meleagris,* is out of range and is likely to be the plumed guineafowl, *Guttera plumifera*), (2) possible mis-identification of species (e.g. I had no confirmed reports either present or historic of *Genetta tigrina* so amalgamated all genet species together, and the relatively common species, African palm civet, *Nandinia binotata*, was not recorded during their study and was likely mistakenly included as the rarer, taboo species, African civet, *Civettictis civetta*, thus I also amalgamated all civet species together) and (3) inaccurate carcass weights (e.g. dwarf crocodile, *Osteolaemus tetraspis,* was listed as having an adult body mass of 31.8 kg, compared to a mean of 6.0 kg found in this study). As Fa and Garcia Yuste took adult body masses from the literature rather than directly measuring them as in this study, I recalculated their biomasses using the mean weighed fresh adult carcass biomasses presented here where I had data on species they had recorded (33 species), keeping theirs as stated for those remaining species for which I had no biomass data. This gave a substantially lower total biomass of 7,966 kg per year, compared to their published figure of 11,376 kg.

As Fa and Garcia Yuste recorded a dramatic decrease in offtake after the first month of their survey, I looked at the catch registered during this month (January 1998) in isolation. Extrapolating from their published data suggests that around 750 animals were caught that month. They state that there was an average of 21 animals per hunter, suggesting that 36 hunters were active that month. This harvest rate and number of active hunters was very close to that observed during this study.

6.3 RESULTS

6.3.1 Changes in the prey profile

A comparison was made between the offtake recorded during my study and that of Fa and Garcia Yuste (2001), to see if biomass and biodiversity had changed. They recorded exactly the same proportion of animals wasted in traps and a slightly lower proportion consumed by hunters

in camps, but the overall number of carcasses and biomass recorded in this study was substantially higher (table 6.3). I recorded a 4.6-fold increase on their annual offtake of 2219 animals, and after recalculation of their carcass weights and biomasses, the average biomass per carcass also increased slightly (table 6.3).

Table 6.3 Comparison of annual offtake between this study (Jan. – Dec. 2003) and that of Fa and Garcia Yuste 2001, adjusted for likely species misidentifications and new carcass biomasses according to section 6.2.3 (Jan. 1998 – Apr. 1999)

	Fa and Garcia Yuste 2001 p.a.	This study p.a.
Total estimated offtake (carcasses)	2,219	10,236
Total biomass (kg)	7,966	40,377
No. species recorded	58	52
Mean biomass/carcass (kg)	3.59	3.94
% animals consumed in hunt camps	6.6	11.6
% animals wasted in traps	9.4	9.4

The proportion of species with lower reproductive potential (the larger-bodied, more vulnerable species) would be expected to decrease as a result of overharvesting. First, I calculated the proportion that each mammal species comprised of the total mammal offtake for each study, and compared the most commonly hunted species (figure 6.3). In order to investigate this pattern, I conducted three analyses. I concentrated on mammals because data on reproductive rates – specifically, r_{max}, the maximum rate of reproduction – are scant for reptiles and birds, the other major taxonomic groups hunted in Sendje. Species are listed in descending order of r_{max} in figure 6.3, and there is a highly significant difference in the proportion of species between the two studies ($\chi^2 = 416$, df = 17, $p < 0.001$). The proportions of *C. monticola* and *A. africanus* have increased whilst the proportions of many other species, both high and low r_{max}, appear to have decreased.

Second, by plotting the proportional change in species representation between the two datasets, against r_{max}, it can be seen that although there is a general decrease in the proportion of many species in the offtake (due to a comparatively large increase in the two most numerous species, *C. monticola* and *A. africanus*), this is not biased towards higher r_{max} species (figure 6.4). The picture does not change greatly if trapped species are considered alone, but it is worth noting that four out of the 11 species which have increased in proportion since Fa and Garcia Yuste's study are gun-hunted monkeys, in particular black colobus (*Colobus satanus*), suggesting that arboreal primates have not yet reached levels of depletion in the study area but are being increasingly hunted. In contrast, the proportion of mandrills (*Mandrillus sphinx*), which are trapped as well as shot, has decreased.

Figure 6.3 Proportion of each mammal species/close taxonomic groups out of total mammals recorded in offtake during each study overall (n = 2420 for Fa and Garcia Yuste 2001; n = 8692 for this study), for all mammals with offtake sample size > 5 for at least one study. Species listed in descending order of r_{max}. Data for this study includes camp consumption but not wastage; data for Fa and Garcia Yuste 2001 includes both.

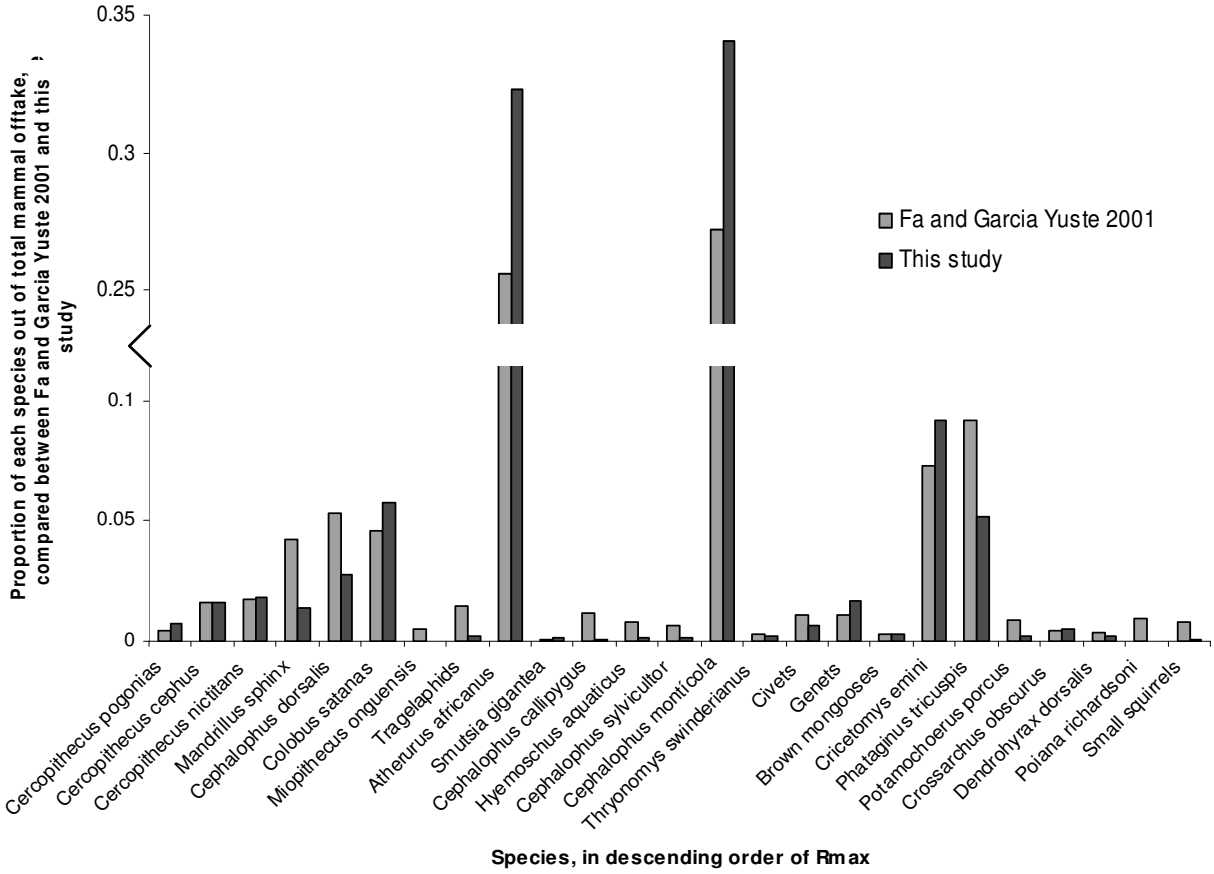
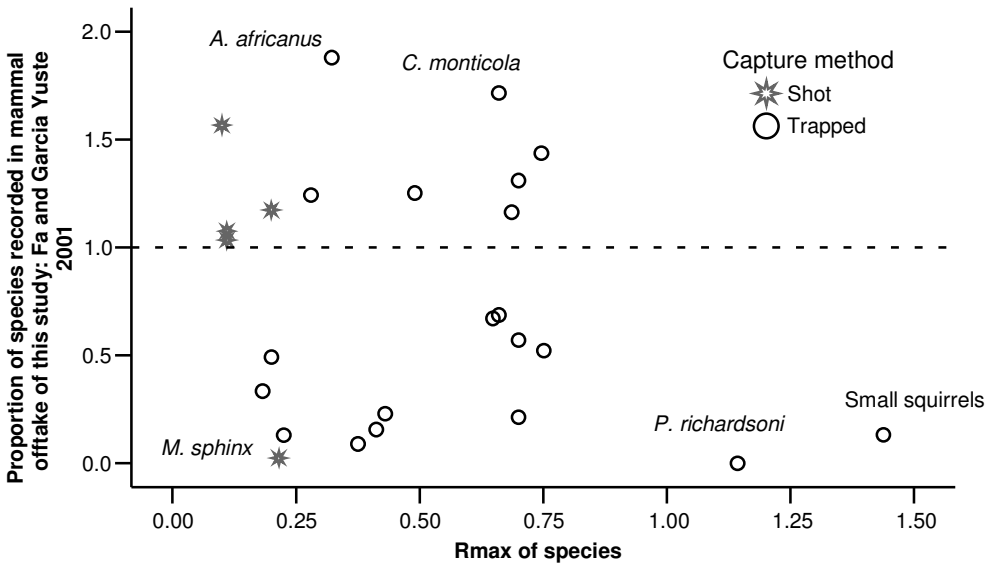


Figure 6.4 Proportion of species out of total mammals for Fa and Garcia Yuste 2001:this study, against r_{max}, separated by method of capture. The dotted line indicates no change in the proportion.



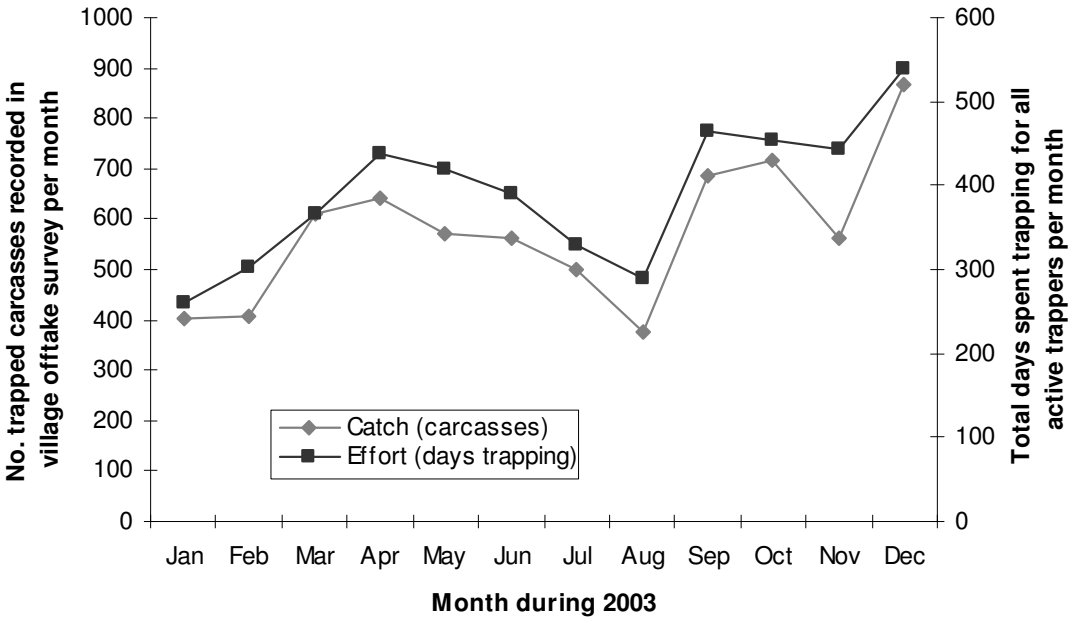
From the total offtake from each study (i.e. including those animals consumed in camps), the mean r_{max} calculated for all mammals (weighted by the number in each sample) was very similar for the two studies (0.41 for this study, n = 8692 mammals; 0.42 for Fa and Garcia Yuste, n = 2420 mammals), as well as for trapped mammals only (0.44 for this study, n = 7774 mammals; 0.45 for Fa and Garcia Yuste, n = 2157 mammals).

If overharvesting were taking place, it might be expected that catch per unit effort (CPUE) has decreased over time. Comparing the most common measure of CPUE, catch per unit of time, between the two studies suggests that catch actually increased per day spent hunting. This study recorded a total of 5062 days hunting, resulting in 1.85 animals/day (4697 days trapping during 2003 produced 8428 trapped animals, including camp consumption and wastage, resulting in 1.79 animals/day trapping), whereas Fa and Garcia Yuste's 1914 days hunting resulted in only 1.60 animals/day. Unfortunately, it is not possible to establish whether this difference is statistically significant.

6.3.2 Changes in trapping effort

A reduction in prey availability can cause hunters to increase their effort; thus changes in effort, can act as indicator of sustainability. In the hunter interviews nearly every respondent stated that there were fewer animals in the forest now than in the past, and most reasoned that this was because there were more trappers than there used to be. For example, a 54 year old trapper stated that, 'in the past there were more jobs and fewer trappers – these days there are a thousand trappers in the forest'. However, according to the measure of CPUE above, the catch per day spent hunting appears not to have changed greatly since Fa and Garcia Yuste's study, or even to have increased. Throughout this study period, the total catch, in terms of trapped carcasses registered in the village offtake per month, was closely correlated to the number of days spent trapping (Pearson's correlation: R = 0.942, n = 12, $p < 0.001$; figure 6.5). The mean CPUE was 1.47 animals/day trapping (not accounting for camp consumption and wastage) (range 1.27 – 1.66). There was no observed downward trend in CPUE over the course of 2003, although there was some variation in monthly CPUE. This variation in CPUE was not significantly correlated with rainfall or temperature, but trappers did spend more time trapping during the rainy seasons (March to May and September to November) and during December in the run up to Christmas (see appendix 1 for rainfall and minimum/maximum temperature patterns during the study period).

Figure 6.5 Monthly catch (number of carcasses) and effort (total number of days spent trapping) for all trappers combined during 2003



Can changes in other measures of trapping effort provide evidence for depletion? Using the reports of where trappers had been trapping over the past decade or so, and how many traps they had in each place, I calculated the mean distance per trap from Sendje from 1990 until the end of 2003 (figure 6.6a). The mean distance of a trap from Sendje remained constant during this period at 13.1 km (range 11.8 – 15.3 km), suggesting that trappers have been operating in the same camps for an extended period of time, and that they have not been gradually increasing the area over which they have been trapping, at least since 1990. This would initially suggest that they are not depleting the resource, according to central place foraging theory, as described in chapter 4. However, the mean number of traps per trapper has increased steadily over the same time period, from 56 in 1990 to 92 in 2003 (figure 6.6b). Thus whilst trappers have on average travelled the same distance to trap over time, they have increased the number of traps they set in each place, either to compensate for decreasing returns or to increase their harvest.

Figure 6.6 (a) Mean distance per trap from Sendje at quarterly intervals each year from 1990 – 2003. The mean remains constant at 13.1 km (range = 11.8 – 15.3 km). (b) Mean number of traps per trapper per quarter from 1990 – 2003. The mean was 56 in 1990 and 92 in 2003.

Figure 6.6a

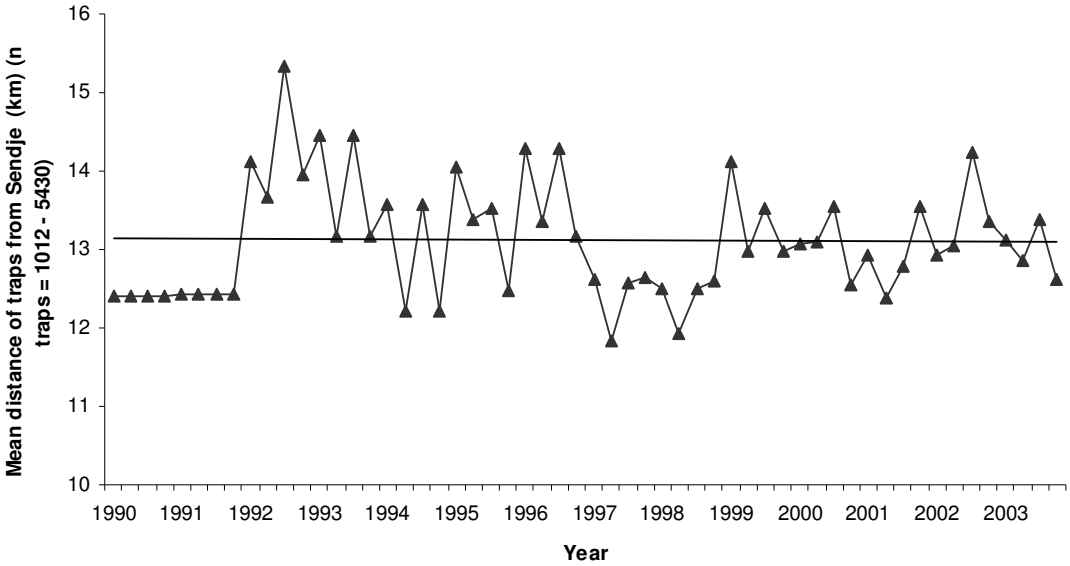
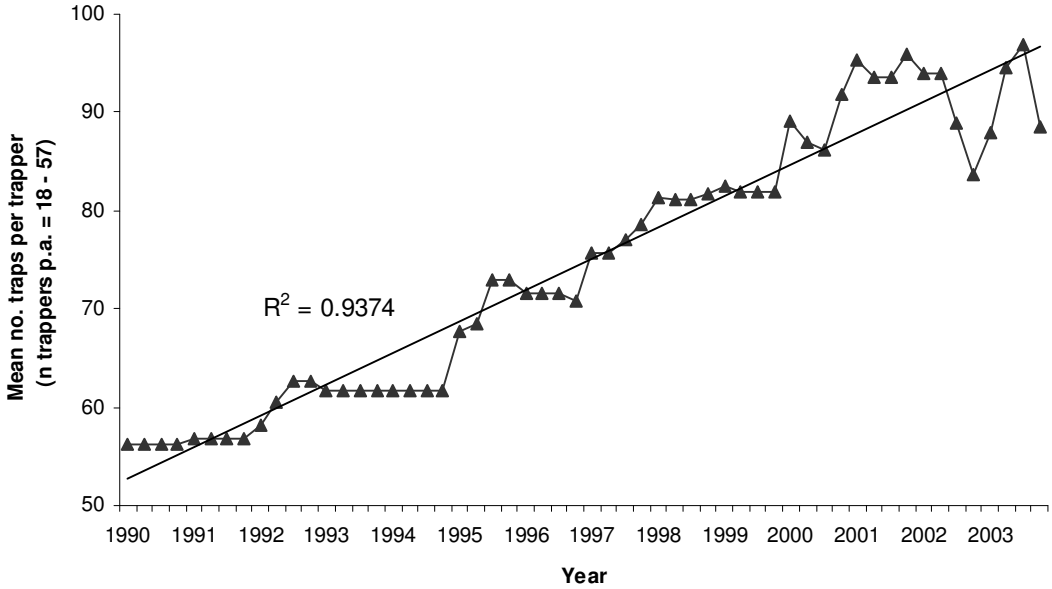


Figure 6.6b



On a smaller spatial and temporal scale, trapping appears to be in accordance with central place foraging theory. Trappers set more traps increasingly further from camp the longer they are based there (figure 6.1: the large purple dots represent a greater number of traps in the trap group, and tend to be found further away from a camp than the smaller trap groups). It seems that the area immediately around a camp becomes rapidly depleted (within a few months), and trappers both radiate further out from the camp and set more traps, in order to compensate for decreasing catch either in terms of numbers or quality (chapter 4).

6.3.3 Single-species effects of trapping

In chapter 4 I showed that overall trap rate increased with a camp's distance from Sendje. In order to look at impacts on individual species with increasing distance from Sendje - in effect, the impact of trapping on biodiversity of the area - I now look in more detail at the catch of particular species per unit trap effort at different camps. As most trappers were only followed once each, I took the number of traps recorded for a particular trapper in a particular camp from his follow as constant throughout his time there, and isolated his mean monthly offtake throughout his time at that camp from the village offtake survey. I then summed the total number of traps per month at each camp for all trappers followed there (the number of trap months) and the total offtake from those trappers at that camp per month, and broke it down into the offtake per trap month for the seven most common species: *C. monticola, C. dorsalis, A. africanus, Cricetomys emini, Phataginus tricuspis, M. sphinx* and *Kinixis erosa* (figure 6.7). The offtake was lower for nearly all species closer to the village (certainly within the 10 km radius zone within reach of day-trip trappers), with the possible exception of *C. emini* and *P. tricuspis*. Two species, *C. monticola* and *K. erosa,* showed significant linear increases in offtake per trap month with increasing distance from Sendje, whilst *C. emini* showed a slight linear decline at the 0.10 level of significance (table 6.4). This suggests that at least some of the more commonly trapped species show signs of depletion closer to the village.

Figure 6.7 Offtake per trap month for (a) *C. monticola* and *A. africanus* and (b) *C. dorsalis, C. emini, P. tricuspis, M. sphinx* and *K. erosa*, with distance from Sendje

Figure 6.7a

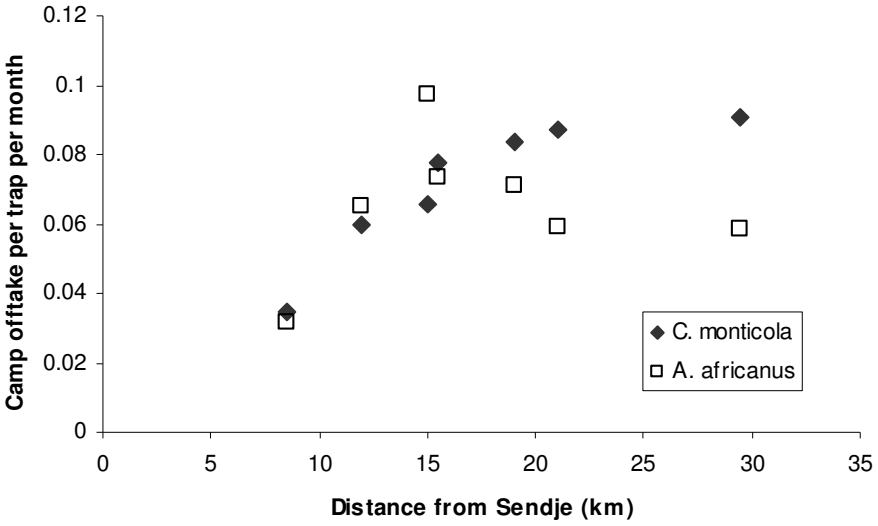


Figure 6.7b

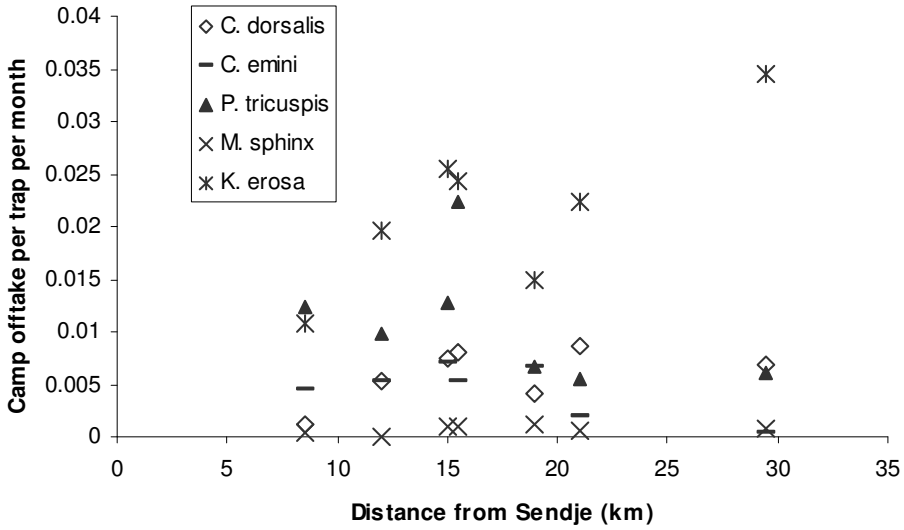


Table 6.4 Results of simple linear regressions using distance from Sendje (km) as the explanatory variable to predict changes in catch per unit trap effort of different species (df = 6)

Response variable (offtake per trap month)	t	*p*	adjusted R^2	slope
Cephalophus monticola	3.94	0.011	0.708	+ve
Cephalophus dorsalis		NS		
Atherurus africanus		NS		
Cricetomys emini	-2.06	0.094	0.352	-ve
Mandrillus sphinx		NS		
Phataginus tricuspis		NS		
Kinixis erosa	2.65	0.045	0.502	+ve

6.3.4 Total bushmeat harvests

If the area under exploitation is known, calculating changes in the overall harvest per unit area can indicate sustainability of the system as a whole. Given the estimated total captured biomass of 40,377 kg, the total annual biomass harvested across all the hunting zones added together (total area 142 km^2), as shown in figure 6.1, was 284 $kgkm^{-2}$. The biomass harvested per zone was very variable: of the seven zones for which I could accurately map the full trapping area, Ebang (Manjana) camp had the lowest offtake at 131 $kgkm^{-2}$ per year and Avindja the highest at 878 $kgkm^{-2}$ per year (table 6.5). These harvest estimates are so high because they do not include the buffer areas between camps, as incorporated in the total trapping zone (figure 6.2). Combining the estimated total captured biomass with the total trapping zone of 307 km^2 gives a more realistic overall harvest of 132 $kgkm^{-2}$ per year.

However, the total trapping zone of 307 km^2 simply includes the area actually or potentially being hunted by trappers and gun-hunters from Sendje. It does not account for the entire prey catchment zone. Whilst this is hard to delineate accurately, as I was unable to record exactly where hunters from neighbouring areas were active (for example, hunters were known to be present at Churu camp at least some of the time during the study, having come from Evinayong district on the other side of the park), a crude estimate of the catchment area available solely to Sendje hunters and their prey is 600 km^2. This is considerably smaller than the 1,010 km^2 described by Fa and Garcia Yuste (2001) but still double that of the total trapping zone, and reduces the current estimated biomass harvest to about 67 $kgkm^{-2}$ per year. Assuming that the prey catchment area was the same during Fa and Garcia Yuste's study (i.e. that they overestimated the prey catchment area), their total biomass harvest can be recalculated at around 13 $kgkm^{-2}$ per year.

Table 6.5 Offtake biomass per species and total per year for camps where trap zone was adequately mapped (see figure 6.1). Biomasses per species are shown from the full village offtake survey from November 2002 to January 2004; total annual estimated biomass per camp was calculated by including wastage and camp/household consumption and averaging the biomass per year.

Trapping zone	Village	Anvila	Avindja	Bisun	Etombong	Mabumom	Ebang
Species biomass 2002-4 (kg)							
Cephalophus monticola	726.7	1769.4	2289.5	897.7	1945.1	3329.7	750.5
Cephalophus dorsalis	136.0	501.4	815.9	85.0	790.4	934.9	255.0
Potamochoerus porcus	205.5	29.4	29.4	0.0	0.0	205.5	58.7
Tragelaphus spekei	425.5	0.0	0.0	38.7	38.7	0.0	77.4
Hyemoschus aquaticus	0.0	17.9	0.0	0.0	0.0	26.9	0.0
Cephalophus silvicultor	146.0	36.5	36.5	0.0	73.0	0.0	0.0
Cephalophus callipygus	0.0	17.8	17.8	0.0	35.6	71.2	17.8
Dendrohyrax dorsalis	2.8	0.0	0.0	2.8	2.8	0.0	0.0
Neotragus batesi	0.0	4.5	2.3	0.0	0.0	0.0	0.0
Cephalophus leucogaster	0.0	0.0	0.0	0.0	0.0	35.0	0.0
Cephalophus nigrifrons	0.0	0.0	0.0	0.0	0.0	16.0	0.0
Tragelaphus scriptus	0.0	0.0	0.0	29.0	0.0	0.0	0.0
Atherurus africanus	513.6	1080.8	1065.0	570.3	1830.7	1540.8	586.1
Cricetomys emini	180.4	32.7	21.4	110.5	72.2	5.6	30.4
Thryonomys swinderianus	84.0	0.0	0.0	0.0	0.0	0.0	0.0
Giant squirrels	0.4	0.0	0.0	0.0	0.0	0.0	0.0
Small squirrels	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Anomalurus beecrofti	0.0	0.0	0.0	0.0	0.5	0.0	0.0
Colobus satanus	27.7	156.9	655.4	258.5	673.9	2307.9	0.0
Cercopithecus nictitans	70.5	15.1	120.9	141.0	186.3	181.3	0.0
Cercopithecus cephus	90.2	3.6	46.9	126.3	83.0	97.5	0.0
Mandrillus sphinx	157.7	43.8	227.8	78.9	78.9	113.9	0.0
Cercopithecus pogonias	67.1	3.7	7.5	63.3	55.9	29.8	0.0
Lophocebus albigena	0.0	0.0	0.0	0.0	12.5	0.0	0.0
Pan troglodytes	0.0	0.0	0.0	34.0	0.0	0.0	0.0
Cercocebus torquatus	3.9	0.0	0.0	0.0	0.0	0.0	0.0
Miopithecus onguensis	0.0	0.0	0.0	0.0	1.2	0.0	0.0
Genetta servalina	5.2	15.7	1.7	10.4	13.9	0.0	7.0
Nandinia binotata	4.9	4.9	7.3	9.7	24.3	7.3	0.0
Crossarchus platycephalus	11.3	1.1	0.0	0.0	0.0	0.0	0.0
Atilax paludinosus	3.0	0.0	3.0	3.0	3.0	0.0	0.0
Mongoose sp.	0.0	0.0	0.0	0.0	3.0	3.0	0.0
Panthera pardus	0.0	0.0	0.0	0.0	0.0	23.0	0.0
Civettictis civetta	12.0	0.0	0.0	0.0	0.0	0.0	0.0
Bdeogale nigripes	0.0	0.0	0.0	0.0	2.0	2.0	0.0
Kinixis erosa	51.4	182.5	227.3	107.8	270.4	413.1	91.2
Osteolaemus tetraspis	390.5	31.1	0.0	0.0	4.4	102.1	155.3
Varanus niloticus	19.2	15.3	3.8	19.2	26.8	11.5	11.5
Trionyx triungus	7.8	0.0	0.0	0.0	0.0	0.0	0.0
Psittacus erithacus	258.0	0.0	0.0	0.0	0.0	0.0	0.0
Agelastes niger	4.6	13.8	8.3	4.6	9.2	2.8	4.6
Guttera plumifera	8.3	3.1	1.0	5.2	13.4	1.0	12.4
Himantornis haematopus	0.5	0.5	0.0	0.5	1.0	0.0	0.0
Corythaeola cristata	3.9	0.0	0.0	1.3	0.0	0.0	0.0
Pigeon/dove sp.	0.6	0.0	0.0	0.0	0.0	0.0	0.0
Achatina sp.	0.5	0.0	0.0	0.0	0.0	0.0	0.0
Phataginus tricuspis	104.9	62.1	79.6	120.4	169.0	81.6	52.4
Smutsia gigantea	40.8	0.0	40.8	0.0	20.4	81.7	40.8
Conraua goliath	0.0	0.0	0.0	0.0	0.0	0.0	22.5

Zone area (km^2)[1]	25.8	10.1	6.8	13.3	30.1	33.0	17.3
Village offtake biomass 2002-4 (kg)	3765	4044	5709	2718	6441	9625	2174
Total estimated biomass 2002-4 (kg)[2]	4597	4937	6970	3318	7864	11751	2654
Total estimated biomass 2003 (kg)	3940	4232	5974	2844	6741	10072	2275
Total estimated biomass ($kg/km^2/yr$)	153	419	878	214	224	305	131

[1] Area of minimum convex polygon as measured in figure 6.1
[2] Including wastage at 9.4% and camp/household consumption at 11.6% of carcasses

6.4 DISCUSSION

In this chapter I have evaluated patterns of sustainability at various different scales. Firstly, I evaluated patterns of catch and effort over three different temporal scales: the present (the study period, 2003), the short-term (since the study of Fa and Garcia Yuste five years earlier) and the longer-term (over the past decade). Secondly, I looked at differences in harvests on three different spatial scales: at the level of individual hunter camps (with increasing distance from Sendje), at the level of the active area being exploited by Sendje hunters, and across the wider landscape of the Monte Mitra area. Finally, I compared offtakes at two taxonomic levels: overall offtakes for all hunters in the village and offtake rates per species.

While I was able to collect detailed data on spatial and temporal hunting patterns and accurate estimates of trapping offtake during my study period, I was unable to collect data on terrestrial prey densities or prey population dynamics, biology or behaviour. For the reasons outlined in the introduction, sustainability indices that rely on knowledge of these parameters would therefore have given misleading results. However, I have shown that simple spatio-trends in catch and effort over time can help to evaluate sustainability.

Over the short term, overall offtake rates appear relatively healthy. This study found a considerably higher harvest rate than that of Fa and Garcia Yuste (2001). This is both in terms of numbers of animals and total biomass. The higher total biomass is partly due to the recalculation of their figures for individual carcass weights (using observed data rather than that from the literature), reducing the total biomass they recorded by around a third. However this does not fully explain why the offtake was so much higher in this study. Whilst offtake was high in the first month of their study, they recorded a dramatic decrease in both catch and effort soon afterwards. The fact that this study found increased offtake suggests that this was not an effect of rapid depletion. A possible alternative explanation is 'interview fatigue', as either the hunters became less cooperative or the research assistant less fastidious in collecting the data. Such problems with data collection are common without tight supervision by researchers. Therefore the true offtake rate during the time of Fa and Garcia Yuste's study is not certain, but

may well have been considerably higher than they report. If the first month catch they recorded is assumed to be typical, around 9000 animals per year would have been recorded during their study; a figure very similar to the total estimated offtake of this study of around 10,000 animals per year. The number of hunters they recorded in that first month (36) was also very similar to the mean number active per month during this study (40 registering animals in the village offtake survey). It therefore seems reasonable to assume that this first month's data during their study is more representative of offtake and effort during that period.

Catch per unit of time spent trapping remained stable during my study period, and even appeared to have increased slightly since Fa and Garcia Yuste's study five years previously. Over a longer time-scale, trappers had not been increasing their effort in terms of travelling further from the village to set traps. They had however increased their trapping effort within the same trapping area, in terms of the number of traps set per trapper. This underlines again the importance of choosing the correct measure of effort when analysing trends in CPUE, as explored in chapter 4. There I showed that the number of effective traps set was more important than distance or days spent hunting in determining the total trapping effort, and subsequent success in terms of offtake, and was the major distinction between the high- and medium-impact forest trapping strategies.

This increase in trapping effort over time does not necessarily indicate depletion; trappers may simply be responding to new market demand or an increasing lack of alternative livelihood options, and therefore investing more effort in trapping for the commercial trade. Overall, in terms of hunters' harvests, trapping at current rates appears to be sustainable at least in the short- to medium-term from a livelihoods perspective. However, this does not answer the question of whether trapping is sustainable from a biodiversity perspective - and therefore ultimately from a human perspective in the long-term. For this we need to look at offtake at the species-level over time and space.

At first glance, species richness appears slightly lower in this study, with the number of species in the offtake list having decreased from 58 to 52 species (table 6.3). However, this is likely to be partly due to sampling and identification issues. More importantly, species richness is a poor measure of biodiversity when non-random sampling is occurring (as here) or the proportion of each species is not taken into account (species diversity). Rather than indicating the loss of vulnerable species from the prey profile, the greater apparent species richness observed in Fa and Garcia Yuste's previous study is likely to be a sampling artefact, in that they simply listed more of the smaller species that went unrecorded in this study (e.g. squirrels – figure 6.4). Many species were recorded in this study both anecdotally in the village and during forest survey work (e.g. hunter follows and transects), but some did not appear in the offtake survey as

they were not preferred prey. Examples are buffalo (*Syncerus caffer*), gorilla (*Gorilla gorilla*), giant otter shrew (*Potamogale velox*) (trapped during the pilot study, June 2002), various snakes, many birds and at least one species of otter. Most of these species were not targeted, although some were incidentally trapped from time to time but considered too small, undesirable or otherwise unprofitable to collect or bring back to the village. The appearance of very rare species in the offtake, which would only naturally be expected to appear on a time-scale of years, makes species richness alone a poor indicator of biodiversity. Also, apparent species richness can actually increase in more depleted areas, as fewer, large species (e.g. large ungulates and primates) disappear from the prey profile and are replaced with a wider variety of smaller species (e.g. squirrels), which were previously considered unprofitable to hunt.

Diversity can also increase due to habitat changes, with secondary forest or agricultural land often supporting higher biomass and biodiversity of certain taxa, particularly ungulates and rodents, than primary forest (Caro, 2001; Wilkie, 1989). This is unlikely to be a factor here, where habitat conversion is minimal (typically the field zone is no further than 1-2 km from the village, and is composed of a few fields set within the forest) and the main human activity in the Monte Mitra area is hunting. This may explain why species that thrive in degraded habitat, such as cane rat (*Thryonomys swinderianus*) and bushbuck (*Tragelaphus scriptus*), which are usually common in village offtake studies, were rarely recorded here. The lack of bushbuck in the village zone in particular is unexpected. It has a Fang name which distinguishes it from the similar-looking sitatunga (*Tragelaphus spekei*) and elders report that it used to be plentiful near the village, but that it is easy to trap, so has been hunted out. However, sitatunga, which are thought to be more vulnerable to hunting (Kingdon, 1997), are still caught in reasonable numbers in the marshy areas around the village, particularly to the west (table 6.5). Unfortunately, problems with identification make accurate comparisons between this and the Fa and Garcia Yuste study difficult (see notes to appendix 5 for further details on this issue). This highlights the difficulties of working in remote locations with poor national scientific expertise and limited published studies on many of the species concerned.

What is clear is that the proportion of *C. monticola* and *A. africanus* has increased in the offtake whilst that of the majority of other species has decreased. Assuming no confounding factors such as changes in trap type or location, this suggests that while these two species are both robust to hunting, other species are less so, and are being depleted. This is in accordance with other bushmeat studies in the region, which find high levels of these two species in the offtake (e.g. Noss 1998b; Fa *et al.* 1995). This relative robustness to heavy exploitation seems surprising given both species' relatively low r_{max} (figure 6.3). However, our understanding of the species' biology is far from complete. It may be that the reproductive capacity of wild *A. africanus* is higher than research to date - mainly on captive populations - suggests (Emmons,

1983; Jori *et al.*, 1998). *C. monticola*, especially females, showed accelerated maturation in an intensively hunted area in the Ituri forest (Hart, 2000). This was more so than for red duikers, suggesting that *C. monticola* may be able to compensate for declining densities with increased reproduction. Biological knowledge is even poorer for non-mammalian taxa. r_{max} data for reptiles and birds was hard to find – and both are commonly substantial components of hunting offtake (e.g. reptiles making up 12% of this study's offtake by numbers, of which 10% was the hinge-backed tortoise, *Kinixis erosa*).

Most of the low r_{max} species that increased proportionally in the offtake were arboreal monkeys. These are mainly targeted with guns, confirming the findings of chapters 4 and 5 that gun-hunting is increasing. This may be because guns and ammunition are becoming increasingly affordable or available, but may also partly be a reaction to depletion of more valuable terrestrial prey; without knowledge of these socio-economic drivers, changes in offtake alone are uninformative.

Species vary in their vulnerability to trapping. Hart (2000) found that red duikers as a group seemed more susceptible to variations in hunting pressure and habitat fragmentation than blue duikers. For example, white-bellied duiker (*Cephalophus leucogaster*) is a species that becomes increasingly rare under trapping, and could suffer from 'piggyback extinction' (Clayton *et al.*, 1997) where traps continue to produce acceptable yields of more common game species (Hart, 2000). Certainly in Monte Mitra, the bay duiker, *C. dorsalis*, is by far the most commonly trapped red duiker, and *C. leucogaster* was rare in the offtake.

All the commonly trapped species show signs of depletion close to the village (figure 6.7). However, this is a natural result of central place foraging (see chapter 4) and does not necessarily indicate unsustainability – the population may be stable but simply being maintained at a reduced density (Hart, 2000). Strict comparisons of density variation can also be misleading where particular microhabitats in the different hunting zones naturally support different prey communities, such as the observation above of marshy areas near the village supporting higher densities of sitatunga (although on the whole, habitat variation is minimal throughout the Monte Mitra area). Factors like habitat cover, fragmentation and topography can also have a modulating effect on the vulnerability of prey to hunting (Broseth & Pedersen, 2000) and can result in behavioural responses to hunting by the prey, such as movement to refuge areas where they are inaccessible or harder to hunt (e.g. Verkauteren & Hygnstrom, 1998). Avindja camp has very high harvest rates compared to the other camps (table 6.5). This supports reports from the hunters there that the area still supports high numbers of large ungulates, the reason they set large foot snares to target such species (see chapter 4). Being in a

mountainous area limits the possible size of the trapping zone around Avindja, but presumably offers a refuge for prey.

This is where consideration of the 'sustainable landscape' is important (Robinson & Redford, 1994). A more likely explanation for seemingly low densities of prey closer to the village continuing to sustain hunting over time is that this area is acting as a 'sink', being replenished by a larger adjoining 'source' area (Hill & Padwe, 2000; Novaro *et al.*, 2000). The applicability of source-sink theory varies across species and habitats, being dependent on population densities and ranging patterns (Hill & Padwe, 2000). It assumes dispersal from the source to the sink, which has not been well studied, particularly in tropical forests. One study that examined dispersal in duikers was conducted by Hart (2000) in the Ituri forest of Democratic Republic of Congo. He found that dispersal rates were higher in a hunted than unhunted area, and concluded that dispersal was potentially important in maintaining small ungulate populations under exploitation.

Defining the sink area requires detailed mapping of trapping activity. The survey period, and therefore extent of hunting measured, will bias the size of the active sink. The total of all the trapping zones around the village and different camps during 2003 (figure 6.1) was only 142 km^2, but produced a harvest of at least 284 $kgkm^{-2}$ per year. This is well above the 152 $kgkm^{-2}$ per year hypothesised as theoretically sustainable (reviewed by Robinson and Bennett, 2000a). Taking into account trapper movement within and between patches, the actual area under exploitation at any one time is even less. Where harvests are apparently higher than would appear sustainable, source areas are probably supplementing the prey base. The 'total potential trapping zone' of 307 km^2 shown in figure 6.2 implicitly includes some area as a built-in source, as not all the area within it is covered by traps at any one time, and the harvest rate within this area is already below the overall level suggested as sustainable, at 132 $kgkm^{-2}$ per year. However, the actual prey catchment area, at 600 km^2, supports a harvest of only about 67 kg km^{-2}. It is therefore important to take spatial scale into account when considering the overall harvest rate.

However, intercontinental differences in wildlife densities and productivity should also be taken into account here. The figure of 152 $kgkm^{-2}$ per year as the maximum possible sustainable harvest was derived from Manu National Park in Peru (see Robinson and Bennett, 2000a). Given that the productivity of afrotropical forests has been calculated to be higher than that of the neotropics (Fa and Peres, 2001), the actual sustainable bushmeat harvest for this central African site may in fact be somewhat higher.

The biomass that can be supported by a particular habitat varies widely and is particularly low in moist forests (Robinson & Bennett, 2000a; Robinson & Bennett, 2004; White, 1994). One forest is not like another (as shown in chapter 5 in the comparison of primate densities and biomass across sites), so assuming that what works for one site will work for another is a risky strategy. Critically, the source must be large enough to support undisturbed populations of particularly vulnerable species, which have large home ranges and live at low densities, often in specific habitats – for example, mandrills (*Mandrillus sphinx*) and elephants (*Loxodonta africana*) in the Monte Mitra area.

Camps in the southern zone of the study area that were included in Fa and Garcia Yuste's study (Abengnam, Ongamsok and Tomasi; figure 6.2) had been unhunted since the ECOFAC ban in mid-2002, so were not included in the total trapping zone of this study. The camp where Fa and Garcia Yuste found highest levels of unsustainable hunting according to Robinson and Redford's index was Ongamsok. It is unclear whether the loss of these camps has had a beneficial or adverse effect on prey populations in the area as a whole. Whilst this southern exclusion zone may now be increasing the size of the source area available for the reduced sink, the loss of the these camps has undoubtedly increased pressure on the remaining accessible camps, probably reducing or removing the usual 'fallow' periods as hunters switch back and forth between camps (nearly all the remaining accessible camps were in use during 2003, bar Esuasas; figure 6.1). Certainly there must be a limit to the number of trappers the area can support, and evidence from the hunter interviews suggest there are more commercial trappers operating in Monte Mitra than there used to be (see chapter 3). In particular an influx of more high-impact non-Sendje native trappers (see chapter 4) to the area may be unsustainable.

By cross-referencing trends from all these different sources it has been possible to build up a picture of the likely overall sustainability of the system, which would not have been possible by focusing on any one indicator in isolation. Overall harvests in the Monte Mitra area are still at least as high as they were five years ago; this does not stem from expansion into unchartered territory, but from the exploitation of a long-term hunting zone that has been operating on a camp-rotation system for decades. The proportion of more vulnerable species in the offtake has not decreased dramatically over this short-term timescale either, but this may be due to the fact that the area has a long history of trapping, so particularly vulnerable species were already at low densities by the time of Fa and Garcia Yuste's study. In the offtake, blue duiker and brush-tailed porcupine are still prevalent. This suggests that their yields are economically viable and probably sustainable. This is likely due to a combination of the high turnover of these particular species and replenishment from the surrounding source area, most of which lies within Monte Alén National Park.

Chapter 7

Discussion

I first present a summary of the main findings of the thesis, answering the questions posed in section 1.2.6 at the start of this thesis (section 7.1). Next I discuss in more detail some of the key themes running through the thesis: issues that influence the entire supply chain and the likelihood of overall sustainability of the system (section 7.2). I then consider the implications of these findings for the practical management of bushmeat hunting and trade in Río Muni, and make some recommendations for policy intervention in the short- and long-term, bearing in mind the unpredictability and inherent uncertainties of the system (section 7.3). I end with some final brief conclusions and suggestions for future research (section 7.4).

7.1 CAUSES AND EFFECTS OF HUNTING IN RÍO MUNI

7.1.1 Why do people eat bushmeat?

Both urban and rural consumers prefer fresh meat and fish over frozen, but as fresh food types are more expensive, only higher income households can afford to meet these preferences. There is no particular demand for bushmeat (fresh or smoked) over other types of fresh produce; rather fresh fish is the most preferred food type in both Bata and Sendje. Consumption of all fresh foods increases with increasing income, but they are necessities rather than luxury goods (with income coefficients of less than one), suggesting that demand is elastic and that fresh fish in particular is likely to be a substitute for bushmeat. Preference for particular bushmeat species appears to be linked to availability rather than price, with the more common species such as blue duiker (*Cephalophus monticola*) and brush-tailed porcupine (*Atherurus africanus*) being preferred. There is thus no specific demand for particularly rare species. Primate meat is cheaper per kilogram than ungulates or rodents, and black colobus (*Colobus satanus*) and great apes (*Gorilla gorilla* and *Pan troglodytes*) are among the cheapest bushmeat types in the market. Currently price is the main constraint to people consuming fresh meat and fish. However, with rising incomes as a result of the economic boom, together with increasing

urbanisation as people flock to the cities in search of employment and the current poor provision of fresh fish and domestic meat alternatives, urban demand for bushmeat is likely to increase.

7.1.2 Why do people hunt?

The economic decay of dictatorial rule has reduced the availability of paid employment for rural people in Equatorial Guinea. In the absence of jobs, men in Sendje hunt bushmeat to earn income, supplying the demand from Bata for bushmeat. Households consume more frozen produce (in particular frozen mackerel) than bushmeat, as it is cheaper. Commercial hunting shows an inverted-U pattern with increasing household income (excluding income earned from hunting itself), in that middle-income households are more likely to hunt commercially. Gun-hunting (rather than trapping) appears to increase linearly with total household income. The median monthly income from hunting was less than half that of waged employment. Although hunting can earn a good monthly income, in general men prefer the security of a regular wage, and nearly all said they didn't like hunting. The majority of hunters were Sendje residents, although a handful of men from other villages were also hunting commercially in the area. Younger hunters, and those from other villages, put in more hunting effort (trapping overnight in the forest, setting more traps and moving them more frequently) and had a higher impact in terms of number of carcasses and biomass caught. In Sendje, trapping is currently the most common type of hunting by far (catching 90% of animals), and is the preferred gear type for most hunters because it has lower barriers to entry than gun-hunting in terms of cost and skill, and renders the greater profit per carcass. However, a large proportion of the offtake coming from some other areas of Río Muni is gun-hunted (up to 80% from the Bata district), suggesting that gun-hunting has become more prevalent in other, more populous areas of the country. Gun-hunters tend to target diurnal primates first, as, being social and visible by day, they are relatively easy and convenient to hunt.

7.1.3 Is hunting sustainable?

Large numbers of prey are being hunted in the Monte Mitra area (over 10,000 animals per year including those consumed in camps and rotting in traps), mostly within Monte Alén National Park. Prey populations are more depleted closer to the village, with success rate per trap increasing with distance from the village. However, previous research indicates that this hunting zone of around 300 km^2 within the Monte Mitra area has sustained high offtakes for at least the last five years (Fa & Garcia Yuste, 2001). The average distance of traps from the village has not increased over the past decade or so, as hunters operate by switching back and forth between a set of long-established hunter camps. However, the number of traps set per trapper has steadily increased over the same period, suggesting that overall catch per unit effort (CPUE) may be decreasing.

Species appear to vary in their vulnerability to trapping and gun-hunting. Changes in the offtake prey profile over the last five years suggest a possible decrease in some rarer species and a consequent increase in the proportion of the two most common species, blue duiker and brush-tailed porcupine (which made up 28% and 26% respectively of the total offtake in Sendje during 2003). Of seven commonly trapped species, blue duiker and tortoise (*Kinyxis erosa*) showed clear evidence of depletion around the village. Surveys of primates close to the village (where gun-hunting is heavier and more long-term) and 30 km into the forest (where gun-hunting is lighter and more recent) enabled the densities of gun-hunted primates to be compared under different hunting pressures. Black colobus were nearly extirpated by hunting around the village whilst the densities of three guenon monkeys were reduced but to a lesser extent. Although not preferred by consumers, black colobus were targeted by gun-hunters, because they were sufficiently valuable per carcass and presumably easier to hunt than other similarly-valued species. It seems that even a moderate level of gun-hunting has the potential to decimate this particularly vulnerable primate, for which Monte Alén National Park appears to be a global stronghold.

7.1.4 What policies could ensure sustainable hunting?

As described above, the results of this thesis help to us to understand the causes and effects of bushmeat hunting in Río Muni and therefore to evaluate the potential of different policies to increase sustainability. In this section I very briefly outline policy interventions that apply to the main results listed above.

The finding that there is no particular preference for either bushmeat over fresh meat or fish alternatives, or for rarer species over more common ones, means that increasing the supply of alternative fresh protein sources (therefore decreasing their price) should reduce demand for bushmeat, without adversely affecting food security (chapter 2). Alternatively, increasing the supply of better quality imported frozen meat or fish and improving marketing of its nutritional value should have the same effect.

Primate meat is one of the least preferred bushmeat types, but primates are particularly threatened by the increase in gun-hunting in Río Muni (chapter 5). Imposing a ban on gun-hunting or on the hunting or commercial trade of certain predominately gun-hunted species such as apes, mandrill and black colobus would help to reduce the impact on these more vulnerable species. This would have only a small impact on the overall scale of the trade in Monte Mitra, as the majority of offtake is made up of trapped species such as rodents and duikers (chapter 6), and minimal impact on livelihoods of the rural poor, as gun-hunting households tend to be wealthier than trapping households (chapter 3) so less vulnerable to this loss of income.

High offtakes appear to have been sustained in the Monte Mitra area for some years, but there is some evidence that hunting effort has been increasing, perhaps because of a decrease in alternative livelihood opportunities, an increase in the cost of living or an increase in the number of hunters due to the immigration of commercial hunters from other areas of Río Muni (chapter 6). By excluding foreign hunters from Sendje and increasing rural income-generating opportunities, this hunting pressure would be reduced. This would also decrease the per capita livelihoods impact on Sendje hunters of enforcing protection of Monte Alén National Park – a measure necessary to protect populations of rarer species that are adversely impacted by hunting. As hunters that have the most impact on wildlife are young men, often migrants, who hunt for cash, alternative income-generating activities need to be developed for them in particular (chapters 3 and 4). Livestock rearing or aquaculture projects could provide such an alternative income source, given adequate political and financial support.

In section 7.3, I outline more thoroughly some potential policy options and discuss which are more likely to work, under certain circumstances, given the particular characteristics of bushmeat hunting in Río Muni. First, I reiterate some of the key issues that have become clear throughout the course of this thesis, in particular those presenting obstacles to or opportunities for enhancing the sustainability of hunting, which should be borne in mind before contemplating policy options.

7.2 OBSTACLES, OPPORTUNITIES AND OTHER ISSUES

I here discuss in more detail some of the obstacles, opportunities and other key issues which will affect the policy recommendations.

7.2.1 Conservation vs development

The effects that the oil boom may have on the bushmeat trade are not immediately obvious. In Latin American oil-rich forested countries, higher oil rents (Yates, 1996) have led to an increase in cattle-ranching, which whilst often contributing to forest loss, simultaneously reduces reliance on wild meat (Wunder & Sunderlin, 2004). The opposite effect has been seen in similar case studies in central Africa (Gabon and Cameroon), where land-extensive swidden agriculture was reduced due to the uncompetitiveness of the agricultural sector (for export crops) and rising wages and urban migrations (for semi-traded food crops) (*ibid.*). Another reason for this is the inherent difficulty in rearing livestock in the Afrotropics, due to the presence of trypanosomiasis, making this less feasible than in Latin America (although see section 7.3.1). One obvious result of this would be that hunting for bushmeat becomes the only profitable rural economic activity in west/central Africa, a situation exacerbated if increased

urban wealth causes a surge in demand for fresh meat (unless fresh domestic meat and fish supply increase).

In Equatorial Guinea, the deterioration of the rural economy under successive brutal regimes has further diminished any potential for agriculture-led growth: the agriculture sector, which was already far behind other countries in the region such as Cameroon and Nigeria, is now being surpassed in favour of the urban economy, as has been observed in Gabon (Wunder & Sunderlin, 2004). Many lessons can be learnt from Gabon, a country with very similar culture, geography and history, which discovered oil two decades before Equatorial Guinea. There too, as in Río Muni, the agricultural sector was poorly developed before the petrodollars started to flood in. In Gabon, oil-financed public employment and urban construction thrived whilst demands for new road building and maintenance in rural areas were neglected, further contributing to the mass migration of the most productive age-groups from rural areas to the cities (Wunder & Sunderlin, 2004; Lahm, 1994).

It has, rather controversially, been suggested that roads in rural areas would enable market access and thus could reduce hunting by enabling the development of alternative livelihoods (Wilkie and Some, 2004). However, all available evidence in central Africa shows that road construction is generally disastrous for conservation, in that it both reduces the real and effective area of forest and reduces wildlife densities in the vicinity (e.g. Laurance *et al.*, in press). The lack of rural development in Gabon, coupled with active colonial and post-colonial resettlement programmes, concentrated swidden cultivators in sedentary roadside settlements with more land-intensive methods, thus reducing forest clearing and hunting for the commercial trade across much of the landscape by a 'blind conservation strategy' (Wunder and Sunderlin, 2004). It is only in recent years, with the oil running out and logging becoming an increasingly important export-earner, that access to these forest areas is increasing again, leading to increased commercial hunting to supply the now much larger urban population (Starkey, 2004).

Unlike Gabon, the government of Equatorial Guinea does appear to be using its 'oil rent' to make efforts to develop the rural economy, particularly in terms of road-building projects. This is partly linked to logging but also appears to be an attempt to distribute the oil wealth throughout the country. The country is also smaller and more populous than Gabon, making rural production and transport more feasible, particularly if the government or international development programmes subsidise rural development. Although such development may alarm many traditional conservationists, it would be both unethical and impossible to stifle it. Instead, policies must be aimed at promoting poverty alleviation alongside wildlife conservation in order for them to be acceptable to national governments and international policy-makers.

It will be difficult for Equatorial Guinea to avoid the huge disparity that now exists between the urban wealthy and the rural poor in Gabon. Only if the petrodollars can succeed in increasing opportunities for the population as a whole will the incentives be decreased for poor rural people to hunt to feed the rich urbanites. Whilst it is highly unlikely that bushmeat can play a major role in alleviating poverty (Brown, 2003), if poverty is alleviated by oil, this could, in theory at least, indirectly help bushmeat.

7.2.2 Political and personal instability

The see-sawing economic climate of Equatorial Guinea epitomises a more general instability felt at both a national and individual level throughout the country, and in fact the region. In addition to the boom-bust economy, political instability, a lack of personal freedom, a high death and disease rate, poverty and alcoholism all contribute to a 'have-to-eat today' attitude (Bodmer, 1994), which makes the ethic of sustainability a foreign and unrealistic concept (Rao & McGowan, 2002). Low security and reduced opportunity, together with unrestricted access to a resource (leading to a free-rider effect), translates to a high discount rate for future investment (Milner-Gulland & Mace, 1998; Wilkie & Carpenter, 1999a), for both local communities and political leaders alike. At the community level, this lack of support for long-term projects has been assumed to be linked to poverty (Freese, 1998) but the existence of the same patterns in booming Asian markets demonstrate that high discounting can occur whether poor or rich (Bennett & Robinson, 2002).

7.2.3 Shifting up a gear

A preference for trapping was observed in Sendje, and it was the most common gear type used. However, as for different food types, this stated preference may be partly due to availability and affordability. Gun-hunting has been historically rare since Macias' ban in the 1970s and guns and ammunition have been expensive and hard to come by ever since. Clearly traps are still rendering sufficient returns on effort in the Monte Mitra area, which suggests still relatively profitable harvests. But there is some evidence for increased gun-hunting by higher-income households in Sendje, which has already had severe impacts on the vulnerable black colobus, and possibly other species as well. A recent bioeconomic model of bushmeat hunting by Damania *et al.* (2005) in Ghana predicted just this: that increases in household wealth tended to encourage a shift in gear type from cheaper, less effective trapping to more efficient and expensive guns.

This hypothesis also appears to be borne out by evidence from Bata's markets. A large proportion of carcasses in the 2003 survey of Mundoasi Market were found to be hunted with guns: 63% of all *Cephalophus* spp., *Cercopithecus* spp. and *Atherurus africanus* (Puit, 2003). Breaking this down by region showed that up to 80% of all species found in the market that had

come from the Bata district were shot, and as much as 40% from other areas in the market catchment area (roughly a third of Río Muni: chapter 2). Although the proportion of primates found in this market was greater than in the Central Market, suggesting increased diurnal gun-hunting in this catchment area, a larger proportion of ungulates were also hunted by gun than were those in the Sendje offtake (chapters 4, 5 and 6). These findings suggest that, with either decreased trapping success or higher incomes, or a combination of the two, there may in turn be an equivalent large-scale shift towards gun-hunting in the Monte Mitra area in the near future, which would be likely to spell doom for many local primate species.

7.2.4 Insights into sustainability

At the broad scale, across Río Muni, it appears that expansion of the commercial trade into new, previously unhunted or only lightly hunted areas further from the market, may in fact be masking local unsustainability close to the market, an effect seen elsewhere (e.g. Clayton *et al.*, 1997; chapter 2). This expansion into new areas has been exacerbated by logging infrastructure, as well as ambitious road-building projects set in place in recent years following the oil boom (pers. obs.). However, the prevalence of ungulates and primates in the market suggests that healthy prey populations do still persist in many areas of Río Muni. From an economic standpoint, the forests of Río Muni are still producing substantial harvests at a national level.

Milner-Gulland (in press) categorises bushmeat hunting in Africa under three scenarios: mature markets, frontier bonanzas and declining source-sinks. The Monte Mitra area, and in fact most of Río Muni, would appear to fall mainly, but not exclusively, into the last category. People used to live in settlements throughout the otherwise 'wilderness' area of Monte Mitra, as across Río Muni, and therefore it has been hunted for at least decades, but presumably at much lower, subsistence levels by a sparser population than would be necessary to make this a mature market.

It has been proposed that the proportion of ungulates to rodents can be used as an indicator of sustainability or a sign of diminishing access to dense forests (Wilkie & Carpenter, 1999a). Where higher ratios indicate low sustainability ('frontier bonanzas'), Bata's markets have a relatively low duiker:rodent proportion (about 2:1 in 2003 combining both markets) in comparison with other markets in the Congo Basin (the proportion in some rural markets was as high as 14:1 in the early 1990s; *ibid*). However, this is actually higher than the proportion observed over a decade previously (Fa *et al.*, 1995), which casts doubt on the reliability of market trends without a knowledge of spatial dynamics and changes in hunter behaviour (Ling & Milner-Gulland, in press). One explanation for the decrease in rodents may be that the main hunted rodent, brush-tailed porcupine, is forest-dependent and preferred, so hunting has reduced its population. However, this is not borne out by my findings in the Monte Mitra area (see

chapter 6). More likely is that a combination of a switch to guns, which target primates by day and ungulates by night, together with the expansion into new areas, has led to a reduction in the proportion of rodents being hunted. On the whole, however, the number of large ungulates appearing in Bata's markets has been relatively low for some time, suggesting that the market is relatively mature and the 'frontier bonanzas' of Río Muni are long gone.

7.2.5 Preferences

Two facts have become clear throughout this study. People in Equatorial Guinea express no particular preference for either bushmeat as a food or hunting as a livelihood. Demand for bushmeat appears to be elastic, and both urban and rural people would largely eat substitutes in the form of fresh fish and perhaps domestic livestock were they available (chapter 2). Within the bushmeat category, there is also no preference expressed for rarer species; in fact the more common species such as porcupine, pangolin and duiker are preferred by most consumers. Similarly there is no cultural prestige in hunting, but without alternatives, men have to make a living and desire to be part of the country's booming cash economy (chapter 3). Although the current lack of food and income alternatives is clearly problematic, a switch away from bushmeat would at least be culturally and ethically acceptable by the majority of the population, which is a crucial requirement of any policy attempting to get at the core of the issue.

However, as has been discussed, preferences are rarely static, but are related to elasticities, which are in turn affected by the availability and affordability of the particular good and its alternatives (chapter 2). Two things may happen as a product becomes rarer and therefore more expensive: it may become less popular, if demand is elastic (as currently in Bata), or it may gain luxury status, if demand is inelastic. Tradition, education and habit all affect this process. For example, in Gabon, many older people who have migrated from rural areas to Libreville still buy bushmeat if and when they can afford it, because it reminds them of life in the village, but younger, second generation urbanites, who were not brought up on bushmeat, are more likely to spurn it in favour of 'modern' domestic alternatives (Starkey, 2004). Parallels can be draw here with preference and consumption of game in the UK due to changes in game and domestic meat availability and demographic structure over the past few centuries. Thus preferences of the population as a whole may evolve over time, but often only over a timescale of generations.

7.3 POLICY RECOMMENDATIONS

I outline here some policy options that may be feasible in Río Muni, and discuss their limitations, costs and likelihood of success. As discussed in section 1.2.6, policy interventions

can be divided into those that aim to reduce demand for bushmeat and those that aim to control (or increase) supply of bushmeat. It is worth noting that it will probably be easier to put in control measures at the demand end (focal urban centres) than the supply end (open access forests). Policies will vary as to the time-scale on which they can be instigated and will be effective; in fact some of the long-term options necessitate various short-term interventions having already been put in place.

I hope that during the course of this thesis it has become clear that due to the complexity of the bushmeat issue, no one intervention will work in isolation; both supply and demand need to be tackled simultaneously if bushmeat hunting is going to be managed sustainably. A lesson can be learnt here from Asia; whilst supply of wild meat has been reduced (by depletion rather than control), demand on the whole has not, at least for certain luxury species, thereby simply increasing prices and continuing incentives to hunt (e.g. Bennett & Rao, 2002).

7.3.1 Reducing demand for bushmeat

A variety of different incentives and disincentives can be imposed on the consumer to reduce demand for bushmeat, and I outline the more feasible options below. I do not suggest policies to do with formal price-fixing of bushmeat to encourage a switch to alternatives here, as this is both difficult to implement and monitor and only serves to support the illegal trade (Wilkie & Carpenter, 1999a). Furthermore, constraining supply (for example by imposing market or trade taxes) effectively increases prices, and I will discuss this in the next section. As there is no particular demand for bushmeat over other types of fresh meat and fish, and thus the reason for bushmeat demand lies more in the lack of acceptable substitutes rather than preferences *per se* (see chapter 2), it is policies that increase these upon which I concentrate.

Marketing of frozen and non-animal protein bushmeat substitutes

Ultimately, if the sustainability of bushmeat and fresh fish offtake rates is to be ensured, the potential for substitute goods will need to be explored. Rose (2001) suggests that the marketing of bushmeat alternatives has the potential to change consumption behaviour. Equatoguineans spend a relatively large proportion of their expendable income on heavily marketed and expensive Western products such as Coca-Cola or condensed milk as baby food (pers. obs.). In theory, given sufficient economic incentive, awareness could be improved of the nutritional value of frozen meat and fish, or even of vegetarian alternatives. However, given the current poor quality of imported frozen produce and often dubious storage and market facilities in Bata, there may be some justification to the commonly held view that frozen food is unhealthy (similar observations have been made in Libreville, Gabon: Starkey, 2004). Clearly standards of food storage and handling would have to be improved in order for this to become an acceptable alternative for many consumers.

There appears to be no particular demand for rare or threatened species, such as apes and black colobus. Primates are a special case in that they are particularly vulnerable to overharvesting due to their life history traits (Robinson & Redford, 1991), and being closely related to humans, pose increased health risks in terms of transmission of diseases such as Ebola and retroviruses (e.g. Wolfe *et al.*, 2005; Wolfe *et al.*, 2004). An education programme – on national radio, for example, which has a very wide audience – warning of the potential dangers of eating primate meat could therefore both be prudent in terms of human health and serve to decrease demand for these species. A ban on eating primates instigated in northern Río Muni in 2005 because of the Ebola risk met with limited success, but could have worked better with improved public education (S. Allebone-Webb, pers. comm.). Such social marketing has been more effective in Cameroon and Gabon (see e.g. Starkey, 2004). In Gabon a change in tastes away from bushmeat has been observed by the younger more urbanised populace of Libreville (Starkey, 2004); it is possible that a similar change in tastes is occurring in Bata, as many respondents claimed they did not eat bushmeat because it was 'dirty meat' (see chapter 2). In theory, marketing of alternatives could be effective in changing consumer behaviour relatively quickly, but the reliable supply of sufficient acceptable bushmeat alternatives in the long-term may be more challenging.

Production of fresh fish as a bushmeat substitute

In the long-term, initiatives to increase the production and availability of fresh domestic meat and fish within Equatorial Guinea itself may help to meet the increasing demand for fresh produce.

There was a strong preference for fresh fish (both marine and freshwater) expressed by consumers in both Bata and Sendje. It therefore seems that fresh fish is an acceptable (and for many people preferable) substitute for bushmeat. However, 90% of fish consumed in Equatorial Guinea is imported; an amazing fact considering the marine and freshwater resources of the country. The FAO has set up a project in Equatorial Guinea aimed at expanding the capacity of sustainable artisanal fisheries (FAO, 2003), calculating that Bata has the capacity to sustain fish catches of 240,000 tonnes per year, compared to the 4000-5000 tonnes officially reported in 2001 (Pigeonnière, 2001). (Although it should be noted that this latter figure may well be an underestimate, given the reliability of official data and the fact that much fishing is small-scale and therefore likely to go unreported.)

However, recent linkages between the reduction in supply of marine fish stocks and bushmeat exploitation in Ghana (Brashares *et al.*, 2004) are a warning that unless coordinated management of bushmeat and fish is undertaken, the protection of one may result in depletion of

the other (Rowcliffe *et al.*, 2005). Fisheries in the Gulf of Guinea are heavily depleted, largely due to fishing by European Union vessels effectively subsidised under fishing licence agreements (Watson and Brashares, 2004). As the exploitation and trade of natural resources becomes increasing global, we need to understand large-scale economic interactions between resources (Rowcliffe *et al.*, 2005). 'Managing multiple commons' requires the development of new management approaches that are cross-sectoral and international in scope (*ibid*).

Freshwater fish supplies are not much better off: in sub-Saharan Africa, per capita fish supply dropped from 9 kilograms a year in 1973 to 6.6 kilograms in 2001, compared to an increase from 12 to 16 kilograms worldwide (von Bubnoff, 2005). Unlike bushmeat, very little fish is traded to Bata from rural villages, although whether this is a result of dwindling supplies or low market demand relative to bushmeat is not entirely clear (see chapter 3). There have been recent calls for urgent investment in aquaculture projects across Africa in order to match population growth and the subsequent demand for animal protein (von Bubnoff, 2005). Apart from anecdotal reports of a single micro-scale aquaculture project in the Mongomo district of Río Muni (S. Allebone-Webb, pers. comm.), the potential for aquaculture in Río Muni seems underdeveloped and remains untested. Such aquaculture projects are very labour-intensive, require considerable financing and capacity building, and run the risk of releasing invasive species into the environment (S. Allebone-Webb, pers. comm.), but are certainly a policy worth further exploration.

Production of fresh domestic meat as a bushmeat substitute

Fresh domestic livestock currently scores low in terms of preferences in Bata. However, preferences can only develop once a product is reasonably familiar (Turrell, 1998). Livestock rearing in Equatorial Guinea is vastly underdeveloped, and the results of my analyses of availability, consumption and preference all reflect this (see chapters 2 and 3). However, this does not necessarily mean that domestic meats could not become a more important component of the Equatoguinean diet. Fresh domestic livestock meat is scarce in Bata. Goats, sheep, pigs and poultry are reared *ad hoc* in villages with no formal livestock husbandry or veterinary provision, and few of these animals reach the cities. All fresh beef in Bata comes from cows imported from northern Cameroon, but these supply only a total of three butcher's stalls in the entire city, all run by the same supplier. The lack of cattle-rearing in the country is attributed to the presence of tsetse fly (Ministry of Agriculture, Republic of Equatorial Guinea, pers. comm.), which transmits trypanosomiasis (although Equatorial Guinea only has low endemicity for this disease: WHO, 2004).

However, the fact that there was once an established cattle-ranching industry (rearing dwarf cattle, a breed resistant to trypanosomiasis) on Bioko Island, providing around 100,000 kg of

meat per year during the colonial period (Fa, 2000), dispels the idea that livestock husbandry is an impossibility in Equatorial Guinea. There has clearly been both supply and demand for this bushmeat substitute in the past. It is true that the volcanic soils of Bioko are much more productive than the mainland, so whilst revitalising the beef industry there seems quite feasible, introducing it to Río Muni may be more challenging. This said, neighbouring parts of southern Cameroon have an established livestock industry (Teale, 2003), including poultry and other trypanosomiasis-resistant species, so husbandry of the type of smaller livestock that currently roam the villages of Río Muni may still be quite feasible. Pigs are particularly productive (Feer, 1996) and can be easily reared either free-range or penned, fed on kitchen waste. However, in Equatorial Guinea apparently some villages ban pigs because they cause damage to crops, so this option would require education as well as promotion, perhaps in addition to mitigation of such adverse effects (S. Allebone-Webb, pers. comm.).

Thus it appears that with political will, livestock rearing could be promoted more vigorously as a response to current and anticipated future demand for fresh produce. In an oil-rent based economy, there tends to be a move away from the agricultural sector as it becomes increasingly unprofitable and unable to compete with foreign imports. However, as imports are mainly in the form of frozen produce, then whilst they are providing for the nutritional needs of the population, they are not ultimately what people currently want.

Subsidised livestock husbandry, on a more intensive, peri-urban scale, limited to the already degraded habitat immediately surrounding present settlements, would both help to provide an alternative livelihood for hunters and increase domestic fresh protein supply, whilst minimising forest loss (Wilkie & Some, 2001). However, such initiatives will require considerable, expensive, long-term political support both in-country and from international development organisations. Total spending on arable and livestock research and development has declined in most developing countries in the past 30 years (Anderson *et al.*, 1994) and certainly this is the case for Equatorial Guinea; ultimately this trend must be reversed if food security and wildlife conservation in Africa are not going to be severely compromised (Milner-Gulland *et al.*, 2003).

Finally, three *caveats* should be made here. Firstly, even small-scale agriculture will reduce forest cover, and this necessarily decreases and usually fragments the habitat available for wildlife. Ranching of the sort that was once found on Bioko would again result in large-scale habitat conversion (Butynski, 1994). In addition to reducing wild habitat, the secondary action of hunting crop pests to protect plantations may also reduce wildlife, particularly primates, in these agricultural areas. Secondly, we must be realistic about the productivity of tropical forests; the ability of the forest zone of a tropical country such as Equatorial Guinea to produce meat from either wild or domestic animals is limited, whether the forest remains in place or not

(Barnes and Lahm, 1997). Finally, rearing of domesticated species is only likely to be cost-effective in areas near markets where wildlife is already depleted (so the costs of hunting are greater) and transport costs are minimised, such as peri-urban areas (see also next section).

7.3.2 Reducing and controlling the supply of bushmeat

I do not include suggestions for increasing supply of bushmeat, as they have invariably been found to be unsuccessful. For example, captive-breeding of wildlife has been widely mooted in the past (e.g. Ajayi, 1974; Ajayi & Tewe, 1980; Ajayi *et al.*, 1978; Jori *et al.*, 1998) but attempts have met with little success in central Africa, where people traditionally hunt for protein and have little experience with or interest in rearing livestock let alone more challenging wild species (P. Houben, pers. comm.; Feer, 1996). The use of rearing bushmeat is particularly doubtful in Equatorial Guinea, where there appears to be no particular demand for bushmeat over other fresh protein alternatives, emphasising the need for research to assess demand before investing in expensive long-term projects with apparently limited potential in the first place.

Regulation of the trade

In the short-term, both livelihoods and biodiversity could be preserved by effective regulation of the trade. There is little specific demand for vulnerable and endangered species most at risk of overexploitation, such as the great apes and black colobus. By allowing hunting outside protected areas and trade of only the more robust, fast-reproducing species that are not reliant on primary forest, such as brush-tailed porcupine and blue duiker (see chapter 6), a sustainable trade could continue to contribute to livelihoods and national protein needs. Military roadblocks are set up on all roads leading out of Bata, 10 km from the town, where bushmeat could be confiscated or taxed. This is already carried out intermittently by rent-seeking wildlife officials and members of the military who charge 'taxes' at these roadblocks. Although preventing corruption at this level would be an enormous challenge, this at least proves that such interventions are theoretically possible, given sufficient incentive (i.e. guards who are well paid and both understand and sympathise with the need for conservation). Hence whilst in theory this policy could be effective very quickly, in reality achieving these incentives requires long-term education and capacity building. In fact, even if rent-seeking officials simply demand even greater bribes and force the trade underground, this will still have the end result of forcing the price of bushmeat up, and as long as demand for bushmeat is elastic, this should reduce demand.

There is already a ban in place on the hunting and trade of elephant, which appears on the whole to be universally obeyed (pers. obs.; S.Allebone-Webb and J. Rist, pers. obs.; see section 1.3.9). Elephants are only hunted by specialised Government-licensed hunters, with the meat mainly sold cheaply to local villagers and the ivory going to the Government (pers. obs.). Of course, given the value of ivory, the Government has a vested interest in strictly controlling this trade.

But the fact that there appears to be little or no elephant poaching outside of this regulated trade is encouraging, and suggests that a similar ban on great apes may also be feasible. This would also tap into many tribes' taboos against hunting or eating apes, as well as fears about the associated disease risks. It would also be relatively practical to implement, given that most apes are hunted with guns, allowing selection of prey.

Short-term enforcement of protected areas

There is an urgent need for the effective protection of Monte Alén National Park from hunting. Eight internationally threatened species were recorded as hunted for bushmeat during this study (appendix 2), according to the 2004 IUCN Red List (IUCN, 2004), all of which were hunted inside the park. This is perhaps the most pressing action required to ensure the survival of the black colobus in particular. This primate, listed as Vulnerable on IUCN's Red List (IUCN, 2004), and with a restricted range, may be found at higher densities in Monte Alén National Park than anywhere else on earth (chapter 5). However it is being decimated by hunting (populations in our survey area at Mabumom were reducing by the month from around the camp) so this last stronghold urgently needs to be secured. Mandrills and apes are also likely to be severely threatened by hunting in Monte Alén, but being at naturally low populations and therefore difficult to survey, such impacts are harder to detect. Gun-hunting is responsible for the majority of primate offtake so prevention of gun-hunting inside the park should be a top priority. As gun-hunting is difficult for poachers to conceal, being diurnal, noisy and necessitating the carriage of a large and obvious shotgun, patrols to control this practice should be relatively effective, as long as park guards are given sufficient incentive for enforcing the law.

In Equatorial Guinea, adequate legal structures would appear to already be in place for protection of wildlife from overexploitation. There is an ample system of protected areas (around 16% of the country's area) and legislation banning hunting and trade of certain vulnerable species (see appendix 2, although selection methods for designation of nationally protected species are rather dubious). However enforcement is nearly entirely non-existent, except as a form of personal rent-seeking by wildlife officials (pers. obs.) and one isolated case of an initiative by CUREF to confiscate illegally traded marine turtles, which simply pushed the trade underground (pers. obs. and A. Formia, pers. comm.).

It was clear from our initial focus group discussions during the pilot trip that people in Sendje were unclear as to the exact boundary of Monte Alén National Park. This is hardly surprising given that one of the directors of ECOFAC was similarly unclear at the time (pers. obs.), and the ECOFAC website (http://www.ecofac.org) to this day still shows the old 1997 extent of the park (which is around two-thirds of its present-day size). An obvious first step is to make local

people fully aware of the presence of a protected area on their doorstep. In 2005 INDEFOR started to mark the park boundaries, although this task is still not complete (S. Allebone-Webb, pers. comm.). In mid-2002 ECOFAC guard camps were set up in the southern half of the hunting zone of this study, and that (presumably combined with my presence in the village, to some extent) meant that the area was left untouched for at least 18 months, even though the camp was in reality very poorly attended by park guards (pers. obs.; chapter 6). Political restrictions are such that whilst on the one hand there often appears to be no law, and therefore no law enforcement, conversely if there is an idea that the authorities may clamp down, the populace show considerable restraint in their actions.

Long-term management of protected areas

In the long-term, it is not reasonable to expect these enforcement measures to be sufficient in isolation, due to the predicted increase in demand for bushmeat as a fresh meat with an increase in oil-related incomes, and the fact that the majority of people in villages surrounding the park are likely to be making a living from bushmeat. In the long-term, protected area managers need to look at realistic alternative foods and livelihoods, and this involves both political and community engagement at the highest and lowest levels.

Whilst up-to-date baseline data on wildlife distributions and densities are scant for Monte Alén National Park, they are practically non-existent for the other designated protected areas on Río Muni. This urgent work needs technical support and money, and long-term capacity building of INDEFOR and park staff in monitoring and assessment. Unless such monitoring is carried out, Equatorial Guinea will justifiably continue to be sidelined during international conservation initiatives such as those dealing with great apes and elephants (e.g. Tutin, 2005).

The protected area authorities also need to become more strategic, using research to underpin management, rather than simply 'ticking boxes' to satisfy donors. Two good examples are ECOFAC's cane rat rearing and *economato* projects, which both failed due to lack of local support, disillusionment, indifference and corruption at all levels. Park vehicles are as likely to be used to transport bushmeat out of the park as guards into it (pers. obs.). This long-term, strategic view requires long-term commitment by dedicated individuals. Unfortunately this has resulted in a 'chicken and egg' situation; the best, most experienced individuals choose to work in locations where there is already a network of expatriate conservationists and development organisations to lend support and reduce the feeling of isolation, and where the likelihood and ease of success is greater. Unfortunately Equatorial Guinea offers no such network or support.

Short-term community management of hunting zone

Sendje has a well-defined community structure and accepted regulatory framework. There is an elected village president (the local Partído Democrático de Guinea Ecuatorial (PDGE) representative), a vice-president and a traditional chief of each sub-tribe. Weekly village meetings are held at which anyone in the village can speak. Gaining the support of the village president and communicating a proposal through the village meeting means that new initiatives can be readily enforced. The majority of the village, being reliant on hunting for income, has a vested interest in increasing the hunting catch rate. All bemoan the presence of commercial hunters from other villagers as one of the reasons why trapping success has decreased over the years (in addition to the fact that there are more people from Sendje itself trapping than there used to be, for lack of jobs). The only person who benefits from their presence is the village president, from a gatekeeper 'tax' charged to enter the forest (5000 CFA or about US $9 per quarter). Supporting the community in banning foreign commercial hunters altogether, or increasing the tax charged to foreign hunters and investing it in community projects, would in theory be a win-win for both conservation and development (for all but the foreign hunters and the village president, who would have to be compensated in some fashion), reducing the impact on wildlife and increasing catches for local hunters, and could be very rapid to implement.

Long-term community management of hunting zone

For effective conservation of the most vulnerable wildlife populations, in the long run the community would have to be excluded from hunting inside the park, most likely resulting in a 'community hunting zone' (extending around 10 km to the east from Sendje), significantly smaller in area than the current hunting zone. This is about the maximum distance that hunters can travel to and from the village and check snare lines in a day (chapter 4), and ties in with recommendations made by other studies to limit the hunting radius so as to increase the regularity of snare-checking and reduce wastage (Fimbel *et al.*, 2000; Muchaal & Ngandjui, 1999). Reducing wastage would increase productivity and rates of returns to hunters without increasing the level of exploitation (Homewood, 1999).

Unfortunately, there is a limit to which harvests within this community hunting zone would be able to contribute to livelihoods (chapter 6). Wildlife populations are clearly already depleted in this area (even the resilient blue duiker and brush-tailed porcupine are found at lower densities within the village hunting zone, up to 10 km from the village). Even if productivity was improved due to increased dispersal out of the now larger source (the protected Monte Alén National Park) and wastage was decreased, harvests would still be unlikely to provide sufficient income for even the current number of local Sendje-native hunters, without either compensation or alternative livelihoods being provided.

We have to be honest about the ability of community-based conservation measures to protect wildlife from hunting where local people quite reasonably see it as an open-access, economic resource that has always been theirs to exploit. An evaluation of the effectiveness of protected areas in Africa found that success was most highly correlated with positive public attitude and enforcement measures, rather than education and community outreach programmes (Struhsaker *et al.*, 2004). Of course positive public attitude can stem from some conservation measure, but economic realities mean that in Río Muni people need employment, and in order for them not to continue hunting at the same time, this employment has to extend further than picking up a weekly pay packet (pers. obs).

Eves and Ruggiero (2000) found that the amount of hunting conducted by rural communities in the People's Republic of Congo varied according to the combination of alternative employment opportunities and hunting controls. In 'conservation villages' (with jobs and hunting bans), hunting appeared to contribute relatively little to the overall cash economy, in 'logging villages' (with jobs but no bans) hunting was a major contributor, and in 'no-industry villages' (few jobs and no bans), hunting was the primary contributor. Increases in income can simply cause an increase in more efficient gun-hunting, as opposed to trapping, as an additive rather than alternative source of income (Damania *et al.*, 2005). Hunting for bushmeat is not capable of contributing to long-term economic growth (Brown & Williams, 2003), on either a national or local scale. Community support needs to be engendered, in order to allow continued subsistence use of forest resources rather than uncontrolled commercial hunting, as part of wider initiatives to revive the rural economy.

Promotion of alternative livelihoods

Men hunt mainly to earn income, and either reduce or, more usually, stop hunting when preferred alternative livelihoods are open to them (chapter 3). Jobs need to be targeted particularly at young, possibly migrant, men, as hunters fitting this profile have the greatest impact on wildlife (chapter 4). Growing of cash crops already provides some income for women in Sendje (bringing in valuable income to the household: chapter 3), and this is a much more prevalent livelihood activity in other areas of Río Muni, particularly the north-east (chapter 1). Whilst agriculture is not currently perceived as a male activity in Sendje, many of the older men used to work on plantations in the area in the colonial era and their memories are generally positive. Plantations could therefore be resuscitated, and would provide regular income from a preferred livelihood, which is time-consuming enough to prevent farmers hunting in their spare time (at least to any great extent).

An alternative, and in theory providing a 'double-whammy' by tackling growing demand for animal protein at the same time as creating rural livelihoods, is livestock rearing, fishing and

aquaculture projects. All would require considerable financial subsidies (aquaculture particularly so due to substantial initial outlays to pay the costs of labour to dig the ponds), training, and veterinary and technical support, and would certainly not be rapid to implement. Such projects would ideally work best as co-operatives, as long as the hurdles of organisation, sustained commitment and co-operation (not cultural norms for hunters who operate predominately at a short-term, individual level: chapter 3) could be overcome, so would require long-term education and capacity-building. The major *caveat* to this from a conservation perspective is that this will only be an attractive option once the costs of rearing domesticated species are lower than the costs of hunting – which is usually only the case when wildlife densities are very low. This means that such projects are likely to meet with greater success in the less marginalised peri-urban areas, where wildlife is depleted and market access reduces transport costs, rather than the poorest and most marginalised sectors of the rural economy, unless sufficient incentives (i.e. significant government or development agency subsidies) are offered.

7.3.3 Next steps for policy

It must be reiterated that none of the policies described above will work in isolation; both demand and supply must be tackled together in order to change the incentives of both consumers and hunters. Ideally, more detailed, long-term data and analysis are required in order to make concrete recommendations. However, the feasibility of some of these policies will not be clear without field-testing, and therefore at some point research must translate into action. Finally, changing economics, politics and human behaviour mean that any management of bushmeat hunting must be adaptive, and the success of any policy monitored and evaluated on a regular basis (Shea, K. and NCEAS Working Group on Population Management, 1998).

7.4 FUTURE DIRECTIONS

Godoy (2001) found in his long-term study of lowland Amerindians that project researchers learned as they went along. Later surveys contained 'better questions and more accurate answers' than earlier ones. I went in 'blind' to work in Equatorial Guinea, and with minimal support and limited grasp of Spanish, ambitiously attempted to cover an entire bushmeat supply chain. Clearly, with the benefit of hindsight, some data would have been better collected differently. However, I hope that the results of this study show what can be achieved virtually single-handedly, starting from scratch and on a tight budget, in a country that by many has been written off. Broad, baseline studies such as this are needed so that future researchers are better able to hone their research questions and 'fill in the gaps'.

I hope this study will work to inform conservation and development managers on the bushmeat issue in general, but particularly the urgent issue of unsustainable hunting and trade in Equatorial Guinea. The findings I have presented here could - and should - have far-reaching repercussions. Equatorial Guinea has in the past been largely sidelined by international conservation organisations, but it contains a wealth of globally important wildlife that needs urgent protection. Surprisingly, some aspects of Equatorial Guinea may make policy change more feasible than might at first be imagined. It is a unique country in many respects, politically and socially somewhat isolated and Spanish-speaking (a factor that should not be underestimated; most expatriate technical advisors who speak Spanish have experience of Latin America rather than central Africa). Nearly all the policy recommendations outlined above require considerable financial and political support, most in the long-term, and Equatorial Guinea is now one of the few countries in Africa with the resources at hand to support such initiatives. Conservation International have reported recent success in talks with President Obiang regarding funding for protected area management; with continued hard work, let us hope that the conservation of wildlife, together with improving rural people's livelihoods, will remain on his agenda.

References

Abernethy, K., Ntsame Effa, E., Starkey, M., Wilkie, D., & Telfer, P. (2002). Gestion de la filière viande de brousse. Ministère de l'Economie forestière, des Eaux, de la Pêche, du Reboisement, chargé de l'Environnement et de la Protection de la Nature, République Gabonaise, Libreville.

Adams, W.M., Aveling, R., Brockington, D., Dickson, B., Elliott, J., Hutton, J., Roe, D., Vira, B., & Wolmer, W. (2004) Biodiversity conservation and the eradication of poverty. *Science*, **306**, 1146-1149.

Aedo, C., Morales, R., Telleria, M.T., & Velayos, M. (2001) *Botánica y botánicos en Guinea Ecuatorial* Real Jardín Botánico-CSIC/Agencia Española de Cooperación Internacional, Madrid.

Ajayi, S.S. (1974) Giant rats for meat - and some taboos. *Oryx*, **12**, 379-380.

Ajayi, S.S. & Tewe, O.O. (1980) Food preference and carcass composition of the grass cutter (*Thryonomys swinderianus*) in captivity. *African Journal of Ecology*, **18**, 133-140.

Ajayi, S.S., Tewe, O.O., Moriarty, C., & Awesu, M.O. (1978) Observations on the biology and nutritive value of the African giant snail *Archachatina marginata*. *East African Wildlife Journal*, **16**, 85-95.

Albrechtsen, L., Fa, J.E., Barry, B., & Macdonald, D.W. (in press) Contrasts in availability and consumption of animal protein in West Africa: Bioko Island as a case study. *Environmental Conservation*.

Alvard, M. (1995) Intraspecific prey choice by Amazonian hunters. *Current Anthropology*, **36**, 789-818.

Alvard, M.S. (1993) Testing the ecologically noble savage hypothesis - interspecific prey choice by Piro hunters of Amazonian Peru. *Human Ecology*, **21**, 355-387.

Alvard, M.S. (1994) Conservation by native peoples - prey choice in a depleted habitat. *Human Nature-an Interdisciplinary Biosocial Perspective*, **5**, 127-154.

Ammann (1994) The bushmeat babies. In BBC Wildlife, pp. 16-21.

Anadu, P.A., Elamah, P.O., & Oates, J.F. (1988) The bushmeat trade in southwestern Nigeria - a case-study. *Human Ecology*, **16**, 199-208.

Anderson, J.R., Pardey, P.G., & Roseboom, J. (1994) Sustaining growth in agriculture - a quantitative review of agricultural research investments. *Agricultural Economics*, **10**, 107-123.

Anstey, S. (1991). Wildlife utilisation in Liberia. WWF/FDA Wildlife Survey Report.

Apaza, L., Wilkie, D., Byron, E., Huanca, T., Leonard, W., Perez, E., Reyes-Garcia, V., Vadez, V., & Godoy, R. (2002) Meat prices influence the consumption of wildlife by the Tsimane Amerindians of Bolivia. *Oryx*, **36**, 382-388.

Ape Alliance (1998). The African bushmeat trade: a recipe for extinction. Ape Alliance, Cambridge.

Asibey, E.A.O. (1974) Wildlife as a source of protein in Africa south of the Sahara. *Biological Conservation*, **6**, 32-39.

Asibey, E.A.O. & Child, G. (1991) Wildlife management for rural development in sub-Saharan Africa. *Unasylva*, **41**, 10.

Auzel, P. & Hardin, R. (2001). Colonial history, concessionary politics and collaborative management of equatorial African rain forests. In *Hunting and bushmeat utilisation in the African rainforest: perspectives towards a blueprint for conservation action* (eds M.I. Bakarr, G.A.B.D. Fonseca, R.A. Mittermeier, A.B. Rylands & K.W. Painemilla), pp. 21-38. Conservation International, Washington D.C.

Auzel, P. & Wilkie, D.S. (2000). Wildlife use in northern Congo: hunting in a commercial logging concession. In *Hunting for sustainability in tropical forests* (eds J.G. Robinson & E.L. Bennett), pp. 413-426. Columbia University Press, New York.

Bakarr, M.I., Fonseca, G.A.B.D., Mittermeier, R.A., Rylands, A.B., & Painemilla, K.W., eds. (2001) *Hunting and bushmeat utilisation in the African rainforest: perspectives towards a blueprint for conservation action*. Conservation International, Washington D.C.

Barnes, R.F.W. (2002) The bushmeat boom and bust in West and Central Africa. *Oryx*, **36**, 236-242.

Barnes, R.F.W., Beardsley, K., Michelmore, F., Barnes, K.L., Alers, M.P.T., & Blom, A. (1997) Estimating forest elephant numbers with dung counts and a geographic information system. *Journal of Wildlife Management*, **61**, 1384-1393.

Barnes, R.F.W. & Lahm, S.A. (1997) An ecological perspective on human densities in the central African forests. *Journal of Applied Ecology*, **34**, 245-260.

Barnett, A. (1995) *Expedition field techniques: primates* Expedition Advisory Committee, Royal Geographic Society, London, UK.

Bassett, T.J. (2005) Card-carrying hunters, rural poverty, and wildlife decline in northern Côte d'Ivoire. *The Geographical Journal*, **171**, 24-35.

BBC (2005) Country profile: Equatorial Guinea, Vol. 2005. http://news.bbc.co.uk/1/hi/world/africa/country_profiles/1023151.stm.

Begon, M., Harper, J.L., & Townsend, C.R. (1996) *Ecology: individuals, populations and communities*, 3rd edn. Blackwell Science, Oxford.

Bennett, E.L. (2002) Is there a link between wild meat and food security? *Conservation Biology*, **16**, 590-592.

Bennett, E.L., Milner-Gulland, E.J., Bakarr, M., Eves, H.E., Robinson, J.G., & Wilkie, D.S. (2002) Hunting the world's wildlife to extinction. *Oryx*, **36**, 328-329.

Bennett, E.L. & Rao, M. (2002). Wild meat consumption in Asian tropical forests: is this a glimpse of the future for Africa? In *Links between biodiversity conservation, livelihoods and food security: the sustainable use of wild species for meat* (eds S. Mainka & M. Trivedi). IUCN, Gland, Switzerland and Cambridge, UK.

Bennett, E.L. & Robinson, J.G. (2000) Hunting of wildlife in tropical forests: implications for biodiversity and forest peoples. World Bank, Washington D.C.

Bennett, E.L. & Robinson, J.G. (2002). Into the frying pan and onto the shelves of the apothecary: the fate of tropical wildlife in Africa. In *Terrestrial ecoregions of Asia: a conservation assessment*. Island Press, Washington, D.C.

Bernard, H.R. (2002) *Research methods in anthropology: qualitative and quantitative approaches*, 3rd edn. AltaMira Press, Walnut Creek, USA and Oxford, UK.

Birdlife International (2005) BirdLife's online World Bird Database, Version 2.0. Birdlife International, Cambridge.

Blom, A., Alers, M.P.T., Feistner, A.T.C., Barnes, R.F.W., & Barnes, K.L. (1992) Primates in Gabon - current status and distribution. *Oryx*, **26**, 223-234.

Blum, J. (2004) U.S. oil firms entwined in Equatorial Guinea deals: Riggs probe led to SEC inquiry on corruption, profiteering (ed W. Post), Vol. 2005. http://www.washingtonpost.com/wp-dyn/articles/A1101-2004Sep6.html.

Bodmer, R.E. (1994). Managing wildlife with local communities in the Peruvian Amazon: the case of the Reserva Communal Tamshiyacu-Tahuayo. In *Natural connections: perspectives in community-based conservation* (eds D. Western, R.M. Wright & S.C. Strum), pp. 113-134. Island Press, Washington D.C.

Bodmer, R.E. (2000) Integrating hunting and protected areas in the Amazon. In Entwistle, A. & Dunstone, N. (eds) *Priorities for the conservation of mammalian diversity.* Cambridge University Press, Cambridge.

Bourliere, F. (1985) Primate communities: their structure and role in tropical ecosystems. *International Journal of Primatology*, **6**, 1-26.

Bousquet, F., Le Page, C., Bakam, I., & Takforyan, A. (2001) Multiagent simulations of hunting wild meat in a village in eastern Cameroon. *Ecological Modelling*, **138**, 331-346.

Bowen-Jones, E. (1998) A review of the commercial bushmeat trade with emphasis on Central/West Africa and the great apes. *African Primates*, **3**, Supplement S1-S43.

Bowen-Jones, E., Brown, D., & Robinson, E. (2001). Bushmeat - a pilot study. Output 3 - draft report to DEFRA, including feasibility and prioritisation of the current and further-required research activities and potential solutions. DEFRA (DETR) Wildlife and Countryside Directorate, London.

Bowen-Jones, E., Brown, D., & Robinson, E. (2002). Assessment of the solution orientated research needed to promote a more sustainable bushmeat trade in Central and West Africa. DEFRA, London.

Bowen-Jones, E. & Pendry, S. (1999) The threat to primates and other mammals from the bushmeat trade in Africa, and how this threat could be diminished. *Oryx*, **33**, 233-246.

Brashares, J.S., Arcese, P., & Sam, M.K. (2001) Human demography and reserve size predict wildlife extinction in West Africa. *Proceedings of the Royal Society of London Series B-Biological Sciences*, **268**, 2473-2478.

Brashares, J.S., Arcese, P., Sam, M.K., Coppolillo, P.B., Sinclair, A.R.E., & Balmford, A. (2004) Bushmeat hunting, wildlife declines, and fish supply in West Africa. *Science*, **306**, 1180-1183.

Brockelman, W.Y. & Ali, R. (1987). Methods of surveying and sampling forest primate populations. In *Primate conservation in the tropical rainforest* (eds C.W. Marsh & R.A. Mittermeier), pp. 23-62. Alan R.Liss, New York.

Broseth, H. & Pedersen, H.C. (2000) Hunting effort and game vulnerability studies on a small scale: a new technique combining radio-telemetry, GPS and GIS. *Journal of Applied Ecology*, **37**, 182-190.

Brown, D. (2003) Bushmeat and poverty alleviation: implications for development policy. *ODI Wildlife Policy Briefing*, **2**.

Brown, D. & Williams, A. (2003) The case for bushmeat as a component of development policy: issues and challenges. *International Forestry Review*, **5**, 148-155.

Brugiere, D. (1998) Population size of the black colobus monkey *Colobus satanus* and the impact of logging in the Lope Reserve, Central Gabon. *Biological Conservation*, **86**, 15-20.

Brugiere, D. & Fleury, M.C. (2000) Estimating primate densities using home range and line transect methods: a comparitive test with the Black Colobus monkey *Colobus satanus*. *Primates*, **41**, 371-380.

Buckland, S.T., Anderson, D.R., Burnham, K.P., Laake, J.L., Borchers, D.L., & Thomas, L. (2001) *Introduction to distance sampling* Oxford University Press, Oxford.

Burnham, K.P., Anderson, D.R., & Laake, J.L. (1980) Estimation of density from line transect sampling of biological populations. *Wildlife Monograph*, **72**, 1-202.

Butynski, T.M. & Koster, S.H. (1994) Distribution and conservation status of primates in Bioko Island, Equatorial Guinea. *Biodiversity and Conservation*, **3**, 893-909.

Cannon, J. (2001). Potential applications of bioeconomic modelling in West Africa. In *Hunting and bushmeat utilisation in the African rainforest: perspectives towards a blueprint for conservation action* (eds M.I. Bakarr, G.A.B.D. Fonseca, R.A. Mittermeier, A.B. Rylands & K.W. Painemilla). Conservation International, Washington D.C.

Carillo, E., Wong, G., & Cuaron, A.D. (2000) Monitoring mammal populations in Costa Rican protected areas under different hunting restrictions. *Conservation Biology*, **14**, 1580-1591.

Caro, T.M. (2001) Species richness and abundance of small mammals inside and outside an African national park. *Biological Conservation*, **98**, 251-257.

Caspary, H. (2001). Regional dynamics of hunting and bushmeat utilisation in West Africa. In *Hunting and bushmeat utilisation in the African rainforest: perspectives towards a blueprint for conservation action* (eds M.I. Bakarr, G.A.B.D. Fonseca, R.A. Mittermeier, A.B. Rylands & K.W. Painemilla). Conservation International, Washington D.C.

Castroviejo Bolivar, J., Blom, A., & Alers, M.P.T. (1990). Chapter 21: Equatorial Guinea. In *Antelopes: global survey and regional action plans. Part 3: West and Central Africa* (ed R. East). IUCN/SSC Antelope Specialist Group.

Cavendish, W. (1999) Poverty, inequality and environmental resources: quantitative analysis of rural households. *WPS/99-9*.

Chapman, C.A., Gautier-Hion, A., Oates, J.F., & Onderdonk, D.A. (1999). African primate communities: determinants of structure and threats to survival. In *Primate communities* (eds J.G. Fleagle, C. Janson & K.E. Reed), pp. 1-37. Cambridge University Press, Cambridge.

Chardonnet, P., ed. (1995) *Faune sauvage Africaine: la ressource oubliée*. International Game Foundation, CIRAD-EMVT, Luxembourg.

Charnov, E.L. (1976a) Optimal foraging: attack strategy of a mantid. *American Naturalist*, **110**, 141-151.

Charnov, E.L. (1976b) Optimal foraging: the marginal value theorem. *Theoretical Population Biology*, **9**, 129-136.

Chenevix-Trench, P. (1997) *People and cattle: agents of ecological change in a dry montane forest, Samburu District, Kenya*. PhD, University of London, London.
CIA (2002) The World Factbook: Equatorial Guinea, Vol. 2003. http://www.cia.gov/cia/publications/factbook/print/ek.html.
CITES (2005) Convention on Internation Trade in Endangered Species of Wild Fauna and Flora: http://www.cites.org/. **16/12/2005**.
Clark, C. (1990) *Mathematical bioeconomics: the optimal management of renewable resources* Wiley and Sons, New York.
Clayton, L., Keeling, M., & Milner-Gulland, E.J. (1997) Bringing home the bacon: a spatial model of wild pig hunting in Sulawesi, Indonesia. *Ecological Applications*, **7**, 642-652.
Colell, M., Mate, C., & Fa, J.E. (1994) Hunting among Moka-Bubis in Bioko - dynamics of faunal exploitation at the village level. *Biodiversity and Conservation*, **3**, 939-950.
Conservation International (2003). Conservation priority setting for the Upper Guinea Forest Ecosystem, West Africa: project summary. Conservation International with GEF/UNDP funding.
Cowlishaw, G. (1999) Predicting the pattern of decline of African primate diversity: an extinction debt from historical deforestation. *Conservation Biology*, **13**, 1183-1193.
Cowlishaw, G. & Dunbar, R. (2000) *Primate conservation biology* University of Chicago Press, Chicago.
Cowlishaw, G., Mendelson, S., & Rowcliffe, J.M. (2005a) Structure and operation of a bushmeat commodity chain in southwestern Ghana. *Conservation Biology*, **19**, 139-149.
Cowlishaw, G., Mendelson, S., & Rowcliffe, J.M. (2005b) Evidence for post-depletion sustainability in a mature bushmeat market. *Journal of Applied Ecology* **42**, 460-468
Crawley, M.J. (2002) *Statistical computing: an introduction to data analysis using S-Plus* John Wiley and Sons Ltd, Chichester.
Crookes, D.J., Ankudey, N., & Milner-Gulland, E.J. (in press) The usefulness of a long-term bushmeat market dataset as an indicator of system dynamics. *Environmental Conservation*.
CUREF (1998). Sintesis de la zona Mitra-Sistema Nacional de Areas Protegidas, Guinea Ecuatorial. CUREF, Bata.
CUREF (2002) Carte Guinea Ecuatorial (ArcView). Proyecto de Conservación y Utilización Racional de los Ecosistemas Forestales, Ministerio de Bosques, Pesca y Medio Ambiente, Bata.
Damania, R., Milner-Gulland, E.J., & Crookes, D.J. (2005) A bioeconomic analysis of bushmeat hunting. *Proceedings of the Royal Society of London Series B-Biological Sciences*, **272**, 259-266.
Davies, A.G. (1987) *The Gola Forest Reserves, Sierra Leone* IUCN, Gland, Switzerland and Cambridge, UK.
Davies, A.G. (1994). Colobine populations. In *Colobine monkeys: their ecology, behaviour and evolution* (eds A.G. Davies & J.F. Oates), pp. 285-310. Cambridge University Press, Cambridge.
Davies, A.G., ed. (2002a) *African forest biodiversity: a field survey manual for vertebrates*. Earthwatch, UK.
Davies, A.G. & Richards, P. (1991). Rain forest in Mende life: resources and subsistence strategies in rural communities around the Gola North Forest Reserve (Sierra Leone). ESCOR, UK Overseas Development Administration.
Davies, A.G., Schulte-Herbrüggen, B., Kümpel, N.F., & Mendelson, S. (in press). Hunting and trapping in the Gola forests, south-eastern Sierra Leone: bushmeat from farm, fallow and forest. In *The consumptive use of wildlife in the tropics: challenges for the 21st century* (eds D. Brown & A.G. Davies). ZSL Conservation Biology series, Blackwell Science, Oxford.
Davies, G. (2002b) Bushmeat and international development. *Conservation Biology*, **16**, 587-589.
de Garine, I. (1996). Chapitre 54: Préférences alimentaires et ressources de la forêt Camérounaise. In *L'alimentation en forêt tropicale: intéractions bioculturelles et perspectives de développement* (eds A. Hladik, H. Pagezy, O.F. Linares, J.A. Koppert & A. Froment), Vol. 2. UNESCO, Paris.

de Merode, E. (1998) *Protected areas and local livelihoods: contrasting systems of wildlife management in the Democratic Republic of Congo*. PhD, University College London, London.
de Merode, E., Homewood, K., & Cowlishaw, G. (2004) The value of bushmeat and other wild foods to rural households living in extreme poverty in the Eastern Democratic Republic of Congo. *Biological Conservation*, **118**, 583-592.
de Thoisy, B., Renoux, F., & Julliot, C. (2005) Hunting in northern French Guiana and its impact on primate communities. *Oryx*, **39**, 149-157.
Dei, G.J.S. (1989) Hunting and gathering in a Ghanaian rain-forest community. *Ecology of Food and Nutrition*, **22**, 225-243.
DfID (2001). Sustainable livelihoods guidance sheets. Department for International Development, London.
DfID (2002). Wildlife and poverty study. Livestock and Wildlife Advisory Group, Department for International Development, London.
Dreyfus-Leon, M.J. (1999) Individual-based modelling of fishermen search behaviour with neural networks and reinforcement learning. *Ecological Modelling*, **120**, 287-297.
Duncan, R.P., Blackburn, T.M., & Worthy, T.H. (2002) Prehistoric bird extinctions and human hunting. *Proceedings of the Royal Society of London Series B-Biological Sciences*, **269**, 517-521.
East, T. (2003) *Urban consumer demand for bushmeat and its implications on the sustainability of the bushmeat trade in Equatorial Guinea*, Imperial College of Science and Technology, London.
East, T., Kümpel, N.F., Milner-Gulland, E.J., & Rowcliffe, J.M. (2005) Determinants of urban bushmeat consumption in Río Muni, Equatorial Guinea. *Biological Conservation*, **126**, 206-215.
ECOFAC (2002). Composante Guinée Ecuatoriale: rapport d'activités, janvier-juin 2002. ECOFAC-GE, Bata.
EIA (2003) Equatorial Guinea, Vol. 2003. Energy Information Administration, Department of Environment.
Elkan, P. (2000) Managing hunting in a forest concession in northern Congo. pp28-29 in Bennett, E.L. & Robinson, J.G. *Hunting of wildlife in tropical forests: implications for biodiversity and forest peoples.* World Bank, Washington D.C.
Emmons, L.H. (1983) A field study of the African brush-tailed porcupine, *Atherurus africanus,* by radiotelemetry. *Mammalia*, **47**, 183-194.
Estes, R.D. (1991) *The behavior guide to African mammals* Russel Friedman Books, South Africa.
Eves, H.E. & Ruggiero, R.G. (2000). Socioeconomics and the sustainability of hunting in the forests of Northern Congo. In *Hunting for sustainability in tropical forests* (eds J.G. Robinson & E.L. Bennett), pp. 427-454. Columbia University Press, New York.
Fa, J.E. (2000). Hunted animals in Bioko Island, West Africa: sustainability and future. In *Hunting for sustainability in tropical forests* (eds J.G. Robinson & E.L. Bennett), pp. 168-198. Columbia University Press, New York.
Fa, J.E., Currie, D., & Meeuwig, J. (2003) Bushmeat and food security in the Congo Basin: linkages between wildlife and people's future. *Environmental Conservation*, **30**, 71-78.
Fa, J.E. & Garcia Yuste, J.E. (2001) Commercial bushmeat hunting in the Monte Mitra Forests, Equatorial Guinea: extent and impact. *Animal Biodiversity and Conservation*, **24**, 31-52.
Fa, J.E., Johnson, P.J., Dupain, J., Lapuente, J., Koster, P., & Macdonald, D.W. (2004) Sampling effort and dynamics of bushmeat markets. *Animal Conservation*, **7**, 409-416.
Fa, J.E. & Juste, J. (1994) Biodiversity conservation in the Gulf of Guinea Islands. *Biodiversity and Conservation*, **3**, 757-758.
Fa, J.E., Juste, J., Burn, R.W., & Broad, G. (2002a) Bushmeat consumption and preferences of two ethnic groups in Bioko Island, West Africa. *Human Ecology*, **30**, 397-416.
Fa, J.E., Juste, J., Delval, J.P., & Castroviejo, J. (1995) Impact of market hunting on mammal species in Equatorial Guinea. *Conservation Biology*, **9**, 1107-1115.
Fa, J.E. & Peres, C.A. (2001). Game vertebrate extraction in African and Neotropical forests: an intercontinental comparison. In *Conservation of exploited species* (eds J.D. Reynolds,

G.M. Mace, J.G. Robinson & K.H. Redford), pp. 203-241. Cambridge University Press, Cambridge.
Fa, J.E., Peres, C.A., & Meeuwig, J. (2002b) Bushmeat exploitation in tropical forests: an intercontinental comparison. *Conservation Biology*, **16**, 232-237.
Fa, J.E., Yuste, J.E.G., & Castelo, R. (2000) Bushmeat markets on Bioko Island as a measure of hunting pressure. *Conservation Biology*, **14**, 1602-1613.
FAO (2001). The state of food insecurity in the world 2000. Food and Agriculture Organisation of the United Nations, Rome, Italy.
FAO (2003) Resumen informatívo sobre la pesca por paises: la Republica de Guinea Ecuatorial, Vol. 2004. Food and Agriculture Organisation of the United Nations.
Fashing, P.J. & Cords, M. (2000) Diurnal primate densities and biomass in the Kakamega Forest: an evaluation of census methods and a comparison with other forests. *American Journal of Primatology*, **50**, 139-152.
Feer, F. (1996). Chapitre 66: Les potentialités de l'exploitation durable et de l'élevage du gibier en zône forestière tropicale. In *L'alimentation en forêt tropicale: intéractions bioculturelles et perspectives de développement* (eds A. Hladik, H. Pagezy, O.F. Linares, J.A. Koppert & A. Froment), Vol. 2. UNESCO, Paris.
Fernandez Sobrado, D., Ela Mba, M.A., Posa Bohome, C., Reid, J., Morra, W.A., & Hearn, G.W. (2004) Commerical monkey hunting on Bioko Island, Equatorial Guinea: results of a hunter survey. *Folia Primatologica*, **75**, 374-5.
Fimbel, C., Curran, B., & Usongo, L. (2000). Enhancing the sustainability of duiker hunting through community participation and controlled access in the Lobeke region of southeastern Cameroon. In *Hunting for sustainability in tropical forests* (eds J.G. Robinson & E.L. Bennett), pp. 356-374. Columbia University Press, New York.
Fimbel, R.A., Grajal, A., & Robinson, J.G., eds. (2001) *The cutting edge: conserving wildlife in logged tropical forest*. Columbia University Press, New York.
Fitzgibbon, C. (1998). The management of subsistence harvesting: behavioural ecology of hunters and their mammalian prey. In *Behavioural ecology and conservation biology* (ed T. Caro), pp. 449-473. Oxford University Press, Oxford.
Fitzgibbon, C.D., Mogaka, H., & Fanshawe, J.H. (1995) Subsistence hunting in Arabuko-Sokoke Forest, Kenya, and its effects on mammal populations. *Conservation Biology*, **9**, 1116-1126.
Fitzgibbon, C.D., Mogaka, H., & Fanshawe, J.H. (1996). Subsistence hunting and mammal conservation in a Kenyan coastal forest: resolving a conflict. In *The exploitation of mammal populations* (eds V.S. Taylor & N. Dunstone). Chapman and Hall, London.
Fleury, M.C. & Gautier-Hion, A. (1999) Seminomadic ranging in a population of black colobus (Colobus satanas) in Gabon and its ecological correlates. *International Journal of Primatology*, **20**, 491-509.
Freese, C.H. (1998) *Wild species as commodities: managing markets and ecosystems for for sustainability* Island Press, Washington, D.C.
Fretwell, S.D. & Lucas, H.L. (1970) On territorial behaviour and other factors influencing habitat distribution in birds. *Acta Biotheoretica*, **19**, 16-36.
Gadsby, E.L. (1990). The status and distribution of the drill, *Mandrillus leucophaeus*, in Nigeria. Wildlife Conservation International, WWF(US), WWF(UK) and the Nigerian Government.
Gally, M. & Jeanmart, P. (1996). Etude de la chasse villageoise en forêt dense humide d'Afrique Centrale. Faculté Universitaire des Sciences Agronomiques de Gembloux.
Garcia, J.E. & Mba, J. (1997) Distribution, status and conservation of primates in Monte Alén National Park, Equatorial Guinea. *Oryx*, **31**, 67-76.
Garcia Yuste, J.E. (1995). Inventário y censo de las poblaciones de primates de Parque Nacional Monte Alén. ECOFAC/AGRECO-CTFT, Republic of Equatorial Guinea.
Gaston, K.J. & Blackburn, T.M. (1995) Birds, body size and the threat of extinction. *Philosophical Transactions of the Royal Society B*, **347**.
Gautier-Hion, A.M., Colyn, M., & Gautier, J.-P. (1999) *Histoire naturelle des primates d'Afrique Centrale* ECOFAC, Libreville, Gabon.

Ginsberg, J.R. & Milner-Gulland, E.J. (1994) Sex-biased harvesting and population dynamics in ungulates: implications for conservation and sustainable use. *Conservation Biology*, **8**, 157-166.
Glantz, M.H. (1981). Considerations of the societal value of an El Niño forecast and the 1972-3 El Niño. In *Resource management and environmental stochasticity* (eds M.H. Glantz & J.D. Thompson). John Wiley and Sons, New York.
Global Forest Watch (2003) Central Africa: Interactive Map. Global Forest Watch, World Resources Institute, Washington, D.C.
Godoy, R., Brokaw, N., & Wilkie, D. (1995) The effect of income on the extraction of non-timber tropical forest products - model, hypotheses, and preliminary findings from the Sumu Indians of Nicaragua. *Human Ecology*, **23**, 29-52.
Godoy, R.A. (2001) *Indians, markets and rainforests: theory, methods, analysis* Columbia University Press, New York.
Gonzalez Kirchner, J.P. (1994) *Ecología y conservación de los primates de Guinea Ecuatorial* CEIBA Ediciones, Malabo, Equatorial Guinea.
Gonzalez-Kirchner, J.P. (1996a) Habitat preference of two lowland sympatric guenons on Bioko Island, Equatorial Guinea. *Folia zoologica*, **45**, 201-208.
Gonzalez-Kirchner, J.P. (1996b) Notes on habitat use by the russet-eared guenon (*Cercopithecus erythrotis* Waterhouse 1838) on Bioko Island, Equatorial Guinea. *Tropical Zoology*, **9**.
Gonzalez-Kirchner, J.P. (1997) Behavioural ecology of two sympatric colobines on Bioko Island, Equatorial Guinea. *Folia zoologica*, **46**, 97-104.
Grandin, B. (1988) *Wealth ranking in smallholder communities: a field manual* Intermediate Technology Publications.
Guijt, I. & Pretty, J.N., eds. (1992) *Participatory rural appraisal for farmer participatory research in Punjab, Pakistan*. Sustainable Agriculture Programme, IIED, London.
Harcourt, A.H., Stewart, K.J., & Inahoro, I.M. (1989) Gorilla quest in Nigeria. *Oryx*, **23**, 7-13.
Hart, J.A. (2000). Impact of sustainability of indigenous hunting in the Ituri Forest, Congo-Zaire: a comparison of unhunted and hunted duiker populations. In *Hunting for sustainability in tropical forests* (eds J.G. Robinson & E.L. Bennett), pp. 106-153. Columbia University Press, New York.
Hearn, G.W. & Morra, W.A. (2001). The approaching extinction of monkeys and duikers on Bioko Island, Equatorial Guinea, Africa. Arcadia University Bioko Biodiversity Protection Program, Glenside, PA, USA.
Hearn, G.W., Ross, C., Garcia Francisco, J., Fernandez Sobrado, D., Ela Mba, M.A., Posa Bohome, C., & Morra, W.A. (2004) Monkey group encounter rates (1996-2003) in the Gran Caldera de Luba, Bioko Island, Equatorial Guinea (oral presentation to XX Congress of the IPS). *Folia Primatologica*, **75**, 231-353.
Hearn, J. (2001) Unfair game - The bushmeat trade is wiping out large African mammals. *Scientific American*, **284**, 24D-26.
Heymans, J.C. (1994). Utilisation rationale de la faune sauvage: élevage de petit gibier. Groupement AGRECO-CTFT/Ministère de l'Agriculture, Pêche et Alimentation, Republic of Equatorial Guinea.
Hill, K. & Padwe, J. (2000). Sustainability of Ache hunting in the Mbaracayu Reserve, Paraguay. In *Hunting for sustainability in tropical forests* (eds J.G. Robinson & E.L. Bennett), pp. 79-105. Columbia University Press, New York.
Hill, K., Padwe, J., Bejyvagi, C., Bepurangi, A., Jakugi, F., Tykuarangi, R., & Tykuarangi, T. (1997) Impact of hunting on large vertebrates in the Mbaracayu Reserve, Paraguay. *Conservation Biology*, **11**, 1339-1353.
Homewood, K. (1999). Local livelihoods and community wildlife management. Report presented at TFF Bushmeat Working Group (unpublished), London.
Homewood, K., ed. (2005a) *Rural resources and local livelihoods in Africa*. James Currey, Oxford.
Homewood, K. (2005b). Rural resources, local livelihoods and poverty concepts. In *Rural resources and local livelihoods in Africa* (ed K. Homewood). James Currey, Oxford.
ILCA (1981). Introduction to the East African Range Livestock Study, Nairobi.

IMF (2005) World Economic Outlook: globalization and external imbalances, Vol. 2005. World Economic and Financial Surveys, International Monetary Fund.
Infield, M. (1988). Hunting, trapping and fishing within and on the periphery of the Korup National Park, Rep. No. Paper number 6 of the Korup National Park Socio-economic Survey. World Wide Fund for Nature.
IUCN (1996). African primates: status survey and conservation action plan (revised edition). IUCN, Gland, Switzerland.
IUCN (2004) 2004 IUCN Red List of Threatened Species: www.redlist.org, Vol. 2005. IUCN, Gland.
Jerozolimski, A. & Peres, C.A. (2003) Bringing home the biggest bacon: a cross-site analysis of the structure of hunter-kill profiles in Neotropical forests. *Biological Conservation*, **111**, 415-425.
Jones, T.S. (1998). The Sierra Leone monkey drives. In *Mammals of Ghana, Sierra Leone and Gambia* (eds P. Grubb, T.S. Jones, A.G. Davies, E.D. Starin & J.E. Hill), pp. 214-219. Trendrine Press, UK.
Jorgenson, J.P. (1995) Maya subsistence hunters in Quintana Roo, Mexico. *Oryx*, **29**, 49-57.
Jori, F., Lopez-Bejar, M., & Houben, P. (1998) The biology and use of the African brush-tailed porcupine (Atherurus africanus, Gray, 1842) as a food animal. A review. *Biodiversity and Conservation*, **7**, 1417-1426.
Juste, J. & Fa, J.E. (1994) Biodiversity conservation in the Gulf of Guinea Islands - taking stock and preparing action. *Biodiversity and Conservation*, **3**, 759-771.
Juste, J., Fa, J.E., Delval, J.P., & Castroviejo, J. (1995) Market dynamics of bushmeat species in Equatorial-Guinea. *Journal of Applied Ecology*, **32**, 454-467.
Katz, E.G. (1995) Gender and trade within the household: observations from rural Guatemala. *World Development*, **23**, 327-342.
Keylock, N. (2002) *The importance of hunting for bushmeat to a rural community in Equatorial Guinea*. MSc, Imperial College London, London.
King, S. (1994) Utilisation of wildlife in Bakossiland, West Cameroon, with particular reference to primates. *TRAFFIC Bulletin*, **14**.
Kingdon, J. (1997) *The Kingdon guide to African mammals* Academic Press, London.
Klitgaard, R.E. (1990) *Tropical gangsters* Basic Books, New York.
Kokko, H., Lindstrom, J., & Ranta, E. (2001). Life histories and sustainable harvesting. In *Conservation of exploited species* (eds J.D. Reynolds, G.M. Mace, K.H. Redford & J.G. Robinson). Cambridge University Press and Zoological Society of London, Cambridge.
Koster, S.H. & Hart, J.A. (1988) Methods of estimating ungulate populations in tropical forests. *African Journal of Ecology*, **26**, 117-126.
Krebs, J.R. & McCleery, R.H. (1984). Optimization in behavioural ecology. In *Behavioural ecology: an evolutionary approach* (eds J.R. Krebs & N.B. Davies), pp. 91-121. Blackwell, Oxford.
Kuchikura, Y. (1988) Efficiency and focus of blowpipe hunting among Semaq Beri hunter-gatherers of Peninsular Malaysia. *Human Ecology*, **16**.
Kümpel, N.F., East, T., Keylock, N., Rowcliffe, J.M., Cowlishaw, G., & Milner-Gulland, E.J. (in press). Determinants of bushmeat consumption in Río Muni, Equatorial Guinea: an urban-rural comparison. In *The consumptive use of wildlife in the tropics: challenges for the 21st century* (eds A.G. Davies & D. Brown). Blackwell Science, Oxford.
Ladele, A.A., Joseph, O.A., Omotesho, O.A., & Ijaiya, T.O. (1996) Sensory quality ratings, consumption pattern and preference for some selected meat types in Nigeria. *International Journal of Food Sciences and Nutrition*, **47**, 141-145.
Lahm, S. (1994). Hunting and wildlife in northeastern Gabon: why conservation should extend beyond protected areas. Institut de Recherche en Ecologie Tropicale, Makokou, Gabon.
Lasso Alcala, C.A. (1995). Biodiversidad animal del Parque Nacional de Monte Alén: report to Proyecto ECOFAC-Guinea Ecuatorial. AGRECO-CTFT y Asociación Amigos de Coto Doñana, Bata, Equatorial Guinea.
Laurance, W.F., Croes, B.M., Tchignoumba, L., Lahm, S.A., Alonso, A., Lee, M.E., Campbell, P., & Ondzeano, C. (in press) Impacts of roads and hunting on central African rainforest mammals. *Conservation Biology*.

Ling, S. & Milner-Gulland, E.J. (in press) Dynamic bioeconomic models are required to assess the sustainability of bushmeat hunting. *Conservation Biology*.

Liniger-Goumaz, M. (1989) *Small is not always beautiful: the story of Equatorial Guinea* Barnes and Noble Books, Totowa, New Jersey.

Lundberg, P., Ranta, E., Ripa, J., & Kaitala, V. (2000) Population variability in space and time. *Trends in Ecology and Evolution*, **15**, 460-464.

Magnuson, L. (2005) Conservation of African monkeys. *International Journal of Primatology*, **26**, 511-513.

Mainka, S. & Trivedi, M., eds. (2002) *Links between biodiversity conservation, livelihoods and food security: the sustainable use of wild species for meat*. IUCN, Gland, Switzerland.

Matthews, A. & Matthews, A. (2002) Distribution, population density, and status of sympatric Cercopithecids in the Campo-Ma'an area, Southwestern Cameroon. *Primates*, **43**, 155-168.

Mba Mba, J. (1998). Estudio antropológico del poblado del Misergue concentrado: fase 1. ECOFAC, Republic of Equatorial Guinea.

McGraw, W.S. & Oates, J.F. (2002) Evidence for a surviving population of Miss Waldron's red colobus. *Oryx*, **36**, 223.

McKey, D. (1978). Soils, vegetation and seed-eating by black colobus monkeys. In *The ecology of arboreal folivores* (ed G.G. Montgomery), pp. 423-438. Smithsonian Institution Press, Washington.

Mendelson, S., Cowlishaw, G., & Rowcliffe, J.M. (2003) Anatomy of a bushmeat commodity chain in Takoradi, Ghana. *Journal of Peasant Studies*, **31**, 73-100.

Milner-Gulland, E.J. (2001a). Assessing sustainability of hunting: insights from bioeconomic modelling. In *Hunting and bushmeat utilisation in the African rainforest: perspectives towards a blueprint for conservation action* (eds M.I. Bakarr, G.A.B.D. Fonseca, R.A. Mittermeier, A.B. Rylands & K.W. Painemilla), pp. 113-151. Conservation International, Washington D.C.

Milner-Gulland, E.J. (2001b). Insights from the bio-economic modelling of bushmeat hunting: a report to the Conservation International Foundation as part of their Bushmeat Initiative. Department of Environmental Science and Technology, Imperial College London, London.

Milner-Gulland, E.J. (2002) Is bushmeat just another conservation bandwagon? *Oryx*, **36**, 1-2.

Milner-Gulland, E.J. (in press). Developing a framework for assessing the sustainability of bushmeat hunting. In *Wildlife conservation: in pursuit of ecological sustainability* (ed D. Lavigne), Limerick, Ireland.

Milner-Gulland, E.J. & Akcakaya, H.R. (2001) Sustainability indices for exploited populations. *Trends in Ecology & Evolution*, **16**, 686-692.

Milner-Gulland, E.J., Bennett, E.L., & SCB 2002 Annual Meeting Wild Meat Group (2003) Wild meat: the bigger picture. *Trends in Ecology & Evolution*, **18**, 351-357.

Milner-Gulland, E.J. & Clayton, L. (2002) The trade in wild pigs in North Sulawesi, Indonesia. *Ecological Economics*, **42**, 165-183.

Milner-Gulland, E.J. & Leader-Williams, N. (1992) A model for incentives for the illegal exploitation of black rhinos and elephants: poaching pays in Luangwa Valley, Zambia. *Journal of Applied Ecology*, **29**, 388-401.

Milner-Gulland, E.J. & Mace, R. (1998) *Conservation of biological resources* Blackwell Science, Oxford.

Milner-Gulland, E.J., Shea, K., Possingham, H., Coulson, T., & Wilcox, C. (2001) Competing harvesting strategies in a simulated population under uncertainty. *Animal Conservation*, **4**, 157-167.

Ministério de Planificación y Desarrollo Económico (1997). II Censo General de población y viviendas en Guinea Ecuatorial. Dirección General de Estadística, Ministério de Planificación y Desarrollo Económico, República de Guinea Ecuatorial, Malabo.

Ministério de Planificación y Desarrollo Económico (2002). Resumen de los principales resultados del III Censo General de poblacion y viviendas en Guinea Ecuatorial. Direccion General de Estadistica y Cuentas Nacionales, Ministério de Planificación y Desarrollo Económico, Republica de Guinea Ecuatorial, Malabo.

Mitani, M. (1991) Niche overlap and polyspecific associations among sympatric cercopithecids in the Campo Animal Reserve, southwestern Cameroon. *Primates*, **32**, 137-151.
Mitchell, A.H. & Tilson, R.L. (1986). Restoring the balance: traditional hunting and primate conservation in the Mentawai islands. In *Primate ecology and conservation* (eds J.G. Else & P.C. Lee), pp. 249-260. Cambridge University Press, Cambridge.
Mittermeier, R.A. (1987). Effects of hunting on rainforest primates. In *Primate conservation in the tropical rainforest* (eds C.W. Marsh & R.A. Mittermeier), pp. 109-146. Alan R. Liss, Inc., New York.
Monkkonen, M. & Aspi, J. (1997) Sampling error in measuring temporal density variability in animal populations and communities. *Ann. Zool. Fennici*, **34**, 47-57.
Morra, W.A., Posa Bohome, C., Ela Mba, M.A., & Hearn, G.W. (2004) Bioko Island's bushmeat market: implications for primate conservation. *Folia Primatologica*, **75**, 397.
Muchaal, P.K. & Ngandjui, G. (1999) Impact of village hunting on wildlife populations in the western Dia Reserve, Cameroon. *Conservation Biology*, **13**, 385-396.
Naughton-Treves, L. & Weber, W. (2001). Human dimensions of the African rain forest. In *African Rain Forest Ecology and Conservation* (eds W. Weber & *e. al*), pp. 30-43. Yale University Press.
Newing, H. (2001) Bushmeat hunting and management: implications of duiker ecology and interspecific competition. *Biodiversity and Conservation*, **10**, 99-118.
Newing, H. (2006). Social impacts of industrial logging concessions: effects on forest user rights. Rainforest Foundation UK.
Newing, H.S. (1994) *Behavioural ecology of duikers (Cephalophus spp.) in forest and secondary growth, Tai, Cote d'Ivoire*. PhD, University of Stirling, Scotland.
Njiforti, H.L. (1996) Preferences and present demand for bushmeat in north Cameroon: Some implications for wildlife conservation. *Environmental Conservation*, **23**, 149-155.
Noss, A.J. (1997) The economic importance of communal net hunting among the BaAka of the Central African Republic. *Human Ecology*, **25**, 71-89.
Noss, A.J. (1998a) Cable snares and bushmeat markets in a central African forest. *Environmental Conservation*, **25**, 228-233.
Noss, A.J. (1998b) The impacts of BaAka net hunting on rainforest wildlife. *Biological Conservation*, **86**, 161-167.
Noss, A.J. (1998c) The impacts of cable snare hunting on wildlife populations in the forests of the Central African Republic. *Conservation Biology*, **12**, 390-398.
Noss, A.J. (2000). Cable snares and nets in the Central African Republic. In *Hunting for sustainability in tropical forests* (eds J.G. Robinson & E.L. Bennett), pp. 282-304. Columbia University Press, New York.
Novaro, A.J., Redford, K.H., & Bodmer, R.E. (2000) Effect of hunting in source-sink systems in the neotropics. *Conservation Biology*, **14**, 713-721.
Ntiamoa-Baidu, Y. (1998a). Wildlife development plan 1998-2003. Volume 6: sustainable use of bushmeat. Wildlife Department, Ministry of Lands and Forestry, Republic of Ghana, Accra.
Ntiamoa-Baidu, Y. (1998b) *Wildlife utilization and food security in Africa* Forestry Department, Food and Agriculture Organisation of the United Nations.
Oates, J.F. (1994). The natural history of African colobines. In *Colobine monkeys: their ecology, behaviour and evolution* (eds A.G. Davies & J.F. Oates), pp. 75-128. Cambridge University Press, Cambridge.
Oates, J.F. (1996) Habitat alteration, hunting and the conservation of folivorous primates in African forests. *Australian Journal of Ecology*, **21**, 1-9.
Oates, J.F., Abedi-Lartey, M., McGraw, W.S., Struhsaker, T.T., & Whitesides, G.H. (2000) Extinction of a West African red colobus monkey. *Conservation Biology*, **14**, 1526-1532.
Oates, J.F., Whitesides, G.H., Davies, A.G., Waterman, P.G., Green, S.M., Dasilva, G.L., & Mole, S. (1990) Determinants of variation in tropical forest primate biomass: new evidence from West Africa. *Ecology*, **7**, 328-343.
Olsson, O., Brown, J.S., & Smith, H.G. (2001) Gain curves in depletable food patches: a test of five models with European starlings. *Evolutionary Ecology Research*, **3**, 285-310.

Orians, G.H. & Pearson, N.E. (1979). On the theory of central place foraging. In *Analysis of ecological systems* (eds D.J. Horn, R.D. Mitchell & G.R. Stairs), pp. 154-177. Ohio State University Press, Columbus.

Outreman, Y., Le Ralec, A., Wajnberg, E., & Pierre, J.S. (2005) Effects of within- and among-patch experiences on the patch-leaving decision rules in an insect parasitoid. *Behavioural Ecology and Sociobiology*, **58**, 208-217.

Peres, C.A. (1990) Effects of hunting on western Amazonian primate communities. *Biological Conservation*, **54**, 47-59.

Peres, C.A. (1999) General guidelines for standardising line-transect surveys of tropical forest primates. *Neotropical Primates*, **7**, 11-16.

Peres, C.A. (2000) Effects of subsistence hunting on vertebrate community structure in Amazonian forests. *Conservation Biology*, **14**, 240-253.

Petersen, D. (2003) *Eating apes* University of California Press.

Pigeonnière, A. (2001) *Atlas de Guinea Ecuatorial* Les Editions J.A., Madrid.

Plumptre, A. & Reynolds, V. (1994) The effect of selective logging on the primate populations in the Budongo Forest Reserve, Uganda. *Journal of Applied Ecology*, **31**, 631-641.

Plumptre, A.J. (2000) Monitoring mammal populations with line transect techniques in African forests. *Journal of Applied Ecology*, **37**, 356-368.

Plumptre, A.J. & Harris, S. (1995) Estimating the biomass of large mammalian herbivores in a tropical montane forest: a method of faecal counting that avoids assuming a 'steady state' system. *Journal of Applied Ecology*, **32**, 111-120.

POST (2005). The bushmeat trade. Parliamentary Office of Science and Technology, London.

Pretty, J.N. & Scoones, I., eds. (1989) *Rapid rural appraisal for economics: exploring incentives for tree management in Sudan*. IIED and Institute of Environmental Studies, University of Khartoum, Sudan.

Price, M.V. & Correll, R.A. (2001) Depletion of seed patches by Merriam's kangaroo rats: are GUD assumptions met? *Ecology Letters*, **4**, 334-343.

Price, S.A. (2006) *Evolution of the Cetartiodactyla: phylogeny, life histories and conservation*. PhD thesis, University of Virginia.

Puit, M. (2003) *Etude de la commercialisation de la viande de brousse dans la région continentale Río Muni, Guinée Equatoriale*. MSc, Université de Liège, Liège.

Puit, M. & Ghiurghi, A. (2004). Inventaire des grands et moyens mammifères dans l'extension sud du Parc National de Monte Alén. ECOFAC/AGRECO/FFI.

Rao, M. & McGowan, P.J.K. (2002) Wild-meat use, food security, livelihoods and conservation. *Conservation Biology*, **16**, 580-583.

Redford, K. (1991) The ecologically noble savage. *Orion*, **9**, 24-29.

Redford, K.H. (1992) The empty forest. *Bioscience*, **42**, 412-422.

Redford, K.H. & Robinson, J.G. (1987) The game of choice - patterns of Indian and colonist hunting in the Neotropics. *American Anthropologist*, **89**, 650-667.

Redford, K.H. & Stearman, A.M. (1993) Forest-dwelling native Amazonians and the conservation of biodiversity - interests in common or in collision? *Conservation Biology*, **7**, 248-255.

Redmond, I. (1995) The ethics of eating ape. *BBC Wildlife*, 72-74.

Refisch, J. & Kone, I. (2005) Market hunting in the Tai Region, Côte d'Ivoire and implications for monkey populations. *International Journal of Primatology*, **26**, 621-629.

República de Guinea Ecuatorial (1988). Decréto Ley Num. 8/1988 (31 de diciembre) sobre la reguladora de Fauna, Silvestre, Caza y Areas Protegídas. Ministério de Bosques, Pesca y Medio Ambiente, República de Guinea Ecuatorial.

República de Guinea Ecuatorial (1997). Decréto Ley Num. 3/1997 (14 de mayo), por el que se amplia el Area Protegida del Monte Alén y se le declara 'Parque Nacional'. Ministério de Pesca y Forestal, República de Guinea Ecuatorial.

República de Guinea Ecuatorial (2000). Decréto Ley Num. 4/2000 (22 de mayo) sobre las Areas Protegidas en Guinea Ecuatorial, Instituto Nacional de Areas Protegidas (INAP). Ministério de Bosques, Pesca y Medio Ambiente, República de Guinea Ecuatorial.

Ribot, J.C. (1998) Theorizing access: forest profits along Senegal's charcoal commodity chain. *Development and Change*, **29**, 307-341.

Robinson, J.G. & Bennett, E.L. (2000a). Carrying capacity limits to sustainable hunting in tropical forests. In *Hunting for sustainability in tropical forests* (eds J.G. Robinson & E.L. Bennett). Columbia University Press, New York.
Robinson, J.G. & Bennett, E.L., eds. (2000b) *Hunting for sustainability in tropical forests*. Columbia University Press, New York.
Robinson, J.G. & Bennett, E.L. (2002) Will alleviating poverty solve the bushmeat crisis? *Oryx*, **36**, 332-332.
Robinson, J.G. & Bennett, E.L. (2004) Having your wildlife and eating it too: an analysis of hunting sustainability across tropical ecosystems. *Animal Conservation*, **7**, 397-408.
Robinson, J.G. & Bodmer, R.E. (1999) Towards wildlife management in tropical forests. *Journal of Wildlife Management*, **63**, 1-13.
Robinson, J.G. & Redford, K.H. (1991). Sustainable harvest of neotropical forest mammals. In *Neotropical wildlife use and conservation* (eds J.G. Robinson & K.H. Redford), pp. 415-429. University of Chicago Press, Chicago.
Robinson, J.G. & Redford, K.H. (1994) Measuring the sustainability of hunting in tropical forests. *Oryx*, **28**, 249-256.
Rose, A.L. (2001). Social changes and social values in mitigating bushmeat commerce. In *Hunting and bushmeat utilisation in the African rainforest: perspectives towards a blueprint for conservation action* (eds M.I. Bakarr, G.A.B.D. Fonseca, R.A. Mittermeier, A.B. Rylands & K.W. Painemilla), pp. 59-74. Conservation International, Washington D.C.
Ross, M.L. (1999) The political economy of the resource curse. *World Politics*, **51**, 297-322.
Rowcliffe, J.M., Cowlishaw, G., & Long, J. (2003) A model of human hunting impacts in multi-prey communities. *Journal of Applied Ecology*, **40**, 872-889.
Rowcliffe, J.M., Milner-Gulland, E.J., & Cowlishaw, G. (2005) Do bushmeat consumers have other fish to fry? *Trends in Ecology and Evolution*, **20**, 274-276.
Rowe, N. (1996) *The pictorial guide to the living primates* Pogonias Press, New York.
Ruel, M.T., Minot, N., & Smith, L. (2005) Patterns and determinants of fruit and vegetable consumption in sub-Saharan Africa: a multicountry comparison. World Health Organisation.
Sabater-Pi, J. (1981) Exploitation of gorillas, *Gorilla gorilla gorilla* Savage and Wymann 1847, in Río Muni, Republic of Equatorial Guinea, West Africa. *Biological Conservation*, **19**, 131-140.
Sabater-Pi, J. & Groves, C. (1972) The importance of higher primates in the diet of the Fang of Río Muni. *Man*, **7**, 239-243.
Schenck, M., Nsame Effa, E., Starkey, M., Wilkie, D., Abernethy, K., Telfer, P., Godoy, R., & Treves, A. (2006) Why people eat bushmeat: results from two-choice, taste tests in Gabon, Central Africa. *Human Ecology,* **34**, 433-445.
Scoones, I. & McCracken, J. (1989). Participatory rapid rural appraisal in Wollo, Ethiopia: peasant association planning for natural resource management. Ethiopian Red Cross Society, UMCC-DPP and IIED.
Sellen, D.W. (2003) Nutritional consequences of wealth differentials in East African pastoralists: the case of the Datoga of northern Tanzania. *Human Ecology*, **31**, 529-570.
Senterre, B. & Lejoly, J. (2001). Los grandes tipos de habitat forestales de Río Muni. In *Botánica y botánicos en Guinea Ecuatorial* (eds C. Aedo, R. Morales, M.T. Telleria & M. Velayos), pp. 171-199. Real Jardín Botánico-CSIC/Agencia Española de Cooperación Internacional.
Shea, K. & NCEAS Working Group on Population Management (1998) Management of populations in conservation, harvesting and control. *Trends in Ecology and Evolution*, **13**, 371-375.
Siegel, S. & Castellan, N.J.J. (1988) *Nonparametric statistics for the behavioral sciences*, 2nd edn. McGraw-Hill, Singapore.
Simmen, B., Julliot, C., Bayart, F., & Pages, E. (1998) Densités de primates en forêt guyanaise: test d'une méthode d'estimation par transect. *C.R. Acad. Sci. Paris, Sciences de la vie*, **321**, 699-704.

Slade, N.A., Gomulkiewicz, R., & Alexander, H.M. (1998) Alternatives to Robinson and Redford's method for assessing overharvest from incomplete demographic data. *Conservation Biology*, **12**, 148-155.
Solly, H. (2001) Village hunters and city sellers: the bushmeat economy in the Dja Reserve. Unpubl. manuscript.
Solly, H. (2004) Bushmeat hunters and secondary traders: making the distinction for livelihood improvement. *ODI Wildlife Policy Briefing*, **8**.
Sosis, R. (2001) Sharing, consumption and patch choice on Ifaluk Atol - evaluating an explanatory hypothesis. *Human Nature - an interdisciplinary biosocial perspective*, **12**, 221-245.
Sosis, R. (2002) Patch choice decisions among Ifaluk fishers. *American Anthropologist*, **104**, 583-598.
Starkey, M. (2004) *Commerce and subsistence: the hunting, consumption and sale of bushmeat in Gabon*. PhD, University of Cambridge, Cambridge.
Steel, E.A. (1994). Study of the value and volume of bushmeat commerce in Gabon. WWF, Gabon.
Stephens, D.W. & Krebs, J.R. (1986) *Foraging theory* Princeton University Press, Princeton, New Jersey.
Stevart, T. (1999). Diversité des orchidées d'Afrique centrale océanique; rapport du mission. ECOFAC-GE and Agreco-GEIE.
Struhsaker, T.T., Struhsaker, P.J., & Siex, K.S. (2004) Conserving Africa's rain forests: problems in protected areas and possible solutions. *Biological Conservation*, **123**, 45-54.
Surendra Varman, K. & Sukumar, R. (1995) The line transect method for estimating densities of large mammals in tropical deciduous forest: an evaluation of models and field experiments. *Journal of Bioscience*, **20**, 273-287.
Sutherland, W.J. & Gill, J.A. (2001). The role of behaviour in studying sustainable exploitation. In *Conservation of exploited species* (eds J.D. Reynolds, G.M. Mace, K.H. Redford & E. Robinson). Cambridge University Press, Cambridge.
Takeda, J. & Sato, H. (1996). Chapitre 48: Stratégies de subsistance et apports en protéines du régime alimentaire des cultivateurs Ngandu et Boyela de la Cuvette Centrale du Zaïre. In *L'alimentation en forêt tropicale: intéractions bioculturelles et perspectives de développement* (eds A. Hladik, H. Pagezy, O.F. Linares, J.A. Koppert & A. Froment), Vol. 2. UNESCO, Paris.
Tambi, N.E. & Maina, O.W. (2003) Patterns of change in beef production and consumption in Africa. *Rev. Sci. Tech. Off. Int. Epiz.*, **22**, 965-976.
Teale, A.J. (2003). Novel immunisation strategies against protozoan parasites. International Livestock Research Institute.
Tenhumberg, B., Keller, M.A., Possingham, H.P., & Tyre, A.J. (2001) Optimal patch-leaving behaviour: a case study using the parasitoid Cotesia rubecular. *Journal of Animal Ecology*, **70**, 683-691.
Thomas, L., Laake, J.L., Strindberg, S., Marques, F.F.C., Buckland, S.T., Borchers, D.L., Anderson, D.R., Burnham, K.P., Hedley, S.L., Pollard, J.H., & Bishop, J.R.B. (2003) Distance 4.1, Release 2. Research Unit for Wildlife Population Assessment, University of St Andrews, St Andrews, U.K.
Turrell, G. (1998) Socioeconomic differences in food preference and their influence on healthy food purchasing choices. *Journal of Human Nutrition and Dietetics*, **11**.
Tutin, C.e.a. (2005). Regional Action Plan for the Conservation of Chimpanzees and Gorillas in Western Equatorial Africa. Conservation International, Washington, D.C.
ULG Consultants Ltd (1998). Bushmeat survey: literature review, field work and recommendations for a sustainable community based wildlife resource management system. Protected Areas Development Programme, Western Region, Ghana.
UNDG (2003). Indicators for monitoring the Millenium Development Goals: definitions, rationale, concepts and sources. United Nations, New York.
UNDP (2000). The UNDP Poverty Report 2000, New York.
UNDP (2005). Human Development Report. United Nations Development Programme.
van Perlo, B. (2002) *Birds of Western and Central Africa* HarperCollins, London.

Verkauteren, K.C. & Hygnstrom, S.E. (1998) Effects of agricultural activities and hunting on home ranges of female white-tailed deer. *Journal of Wildlife Management*, **62**, 280-285.
von Bubnoff, A. (2005) Africa urged to create more fish farms. *Nature*, **436**, 1077.
Walker, R., Hill, K., Kaplan, H., & McMillan, G. (2002) Age-dependency in hunting ability among the Ache of Eastern Paraguay. *Journal of Human Evolution*, **42**, 639-657.
Wallechinsky, D. (2003) The 10 Worst Living Dictators. *PARADE*, **16/02/2003**.
Wallis, J. (2004) Country profile: Equatorial Guinea. *Bushmeat Quarterly*, **11**, 9-11.
Walsh, D. (2004) A murderous dictator, his rapper son and a $700m-a-year oil boom. *The Independent*, **16/03/2004**.
Walsh, P.D., White, L.J.T., Mbina, C., Idiata, D., Mihindou, Y., Maisels, F., & Thibault, M. (2001) Estimates of forest elephant abundance: projecting the relationship between precision and effort. *Journal of Applied Ecology*, **38**, 217-228.
Walsh, P.D.e.a. (2003) Catastrophic ape decline in western equatorial Africa. *Nature*, **422**, 611-614.
Waltert, M., Lien, Faber, K., & Muhlenberg, M. (2002) Further declines of threatened primates in the Korup Project Area, south-west Cameroon. *Oryx*, **36**, 257-265.
Watson, I. & Brashares, J.S. (2004) The bushmeat trade and fishing licence agreements in West Africa. *ODI Wildlife Policy Briefing*, **4**.
White, L. & Edwards, A. (2000) *Conservation research in the African rainforests: a technical handbook* Wildlife Conservation Society, New York.
White, L.J.T. (1994) Biomass of rain forest mammals in the Lopé Reserve, Gabon. *Animal Ecology*, **63**, 499-512.
White, L.J.T. (1995) Factors affecting the duration of elephant dung piles in rain forest in the Lopé Reserve, Gabon. *African Journal of Ecology*, **33**, 142-150.
Whitesides, G.H., Oates, J.F., Green, S.M., & Kluberdanz, R.P. (1988) Estimating primate densities from transects in a West African rain forest: a comparison of techniques. *Journal of Animal Ecology*, **57**, 345-367.
WHO (2004) Geographical distribution of African Trypanosomiasis, Vol. 2004. Communicable Disease Surveillance and Response (CSR), World Health Organisation.
Wickramasinghe, A., Ruiz Perez, M., & Blockhus, J. (1996) Nontimber forest product gathering Ritigala Forest (Sri Lanka): household strategies and community differentiation. *Human Ecology*, **24**.
Wikipedia (2005) Equatorial Guinea, Vol. 2005. www.en.wikipedia.org/wiki/Equatorial_Guinea.
Wilkie, D., Ntsame Effa, E., Abernethy, K., & Starkey, M. (2002). Etude socio-économique sur la consommation de la viande de brousse (work in progress). Wildlife Conservation Society, Gabon.
Wilkie, D. & Some, L. (2001) Alternative Protein and Income. In BCTF Collaborative Action Planning Meeting Proceedings (eds N.D. Bailey, H.E. Eves, A. Stefan & J.T. Stein). Bushmeat Crisis Task Force, Silver Spring, MD 319.
Wilkie, D.S. (1989) Impact of roadside agriculture on subsistence hunting in the Ituri Forest of northeastern Zaire. *American Journal of Physical Anthropology*, **78**, 485-494.
Wilkie, D.S. (2001). Bushmeat hunting in the Congo Basin - a brief overview. In *Hunting and bushmeat utilisation in the African rainforest: perspectives towards a blueprint for conservation action* (eds M.I. Bakarr, G.A.B.D. Fonseca, R.A. Mittermeier, A.B. Rylands & K.W. Painemilla), pp. 17-20. Conservation International, Washington D.C.
Wilkie, D.S. & Carpenter, J.F. (1999a) Bushmeat hunting in the Congo Basin: an assessment of impacts and options for mitigation. *Biodiversity and Conservation*, **8**, 927-955.
Wilkie, D.S. & Carpenter, J.F. (1999b) Can nature tourism help finance protected areas in the Congo Basin? *Oryx*, **33**, 332-338.
Wilkie, D.S. & Godoy, R.A. (2000) Economics of bushmeat. *Science*, **287**, 975-976.
Wilkie, D.S. & Godoy, R.A. (2001) Income and price elasticities of bushmeat demand in lowland Amerindian societies. *Conservation Biology*, **15**, 761-769.
Wilkie, D.S., Shaw, E., Rotberg, F., Morelli, G., & Auzel, P. (2000) Roads, development and conservation in the Congo Basin. *Conservation Biology*, **14**, 1614-1622.
Wilkie, D.S., Sidle, J.G., & Boundzanga, G.C. (1992) Mechanized logging, market hunting, and a bank loan in Congo. *Conservation Biology*, **6**, 570-580.

Wilkie, D.S., Starkey, M., Abernethy, K., Nstame Effa, E., Telfer, P., & Godoy, R. (2005) Role of prices and wealth in consumer demand for bushmeat in Gabon, Central Africa. *Conservation Biology*, **19**, 268-274.

Wilks, C. & Issembe, Y. (2000) *Guide pratique d'identification: les arbres de la Guinée Equatoriale, Région Continentale* Projet CUREF, Bata.

Winterhalder, B., Baillargeon, W., Cappelletto, F., Daniel Jnr, I.R., & Prescott, C. (1988) The population ecology of hunter-gatherers and their prey. *Journal of Anthropological Archaeology*, **7**, 289-328.

Winterhalder, B. & Lu, F. (1997) A forager resource population ecology model and implications for indigenous conservation. *Conservation Biology*, **11**, 1354-1364.

Wolfe, N.D., Heneine, W., Carr, J.K., Garcia, A.D., Shanmugam, V., Tamoufe, U., Torimiro, J.N., Prosser, A.T., LeBreton, M., Mpoudi-Ngole, E., McCutchan, F.E., Birx, D.L., Folks, T.M., Burke, D.S., & Switzer, W.M. (2005) Emergence of unique primate T-lymphotropic viruses among central African bushmeat hunters. *PNAS*, 0501734102.

Wolfe, N.D., Switzer, W.M., Carr, J.K., Bhullar, V.B., Shanmugam, V., Tamoufe, U., Prosser, A.T., Torimiro, J.N., Wright, A., Mpoudi-Ngole, E., McCutchan, F.E., Birx, D.L., Folks, T.M., Burke, D.S., & Heneine, W. (2004) Naturally acquired simian retrovirus infections in central African hunters. *The Lancet*, **363**, 932-937.

Wolfheim, J.H. (1983) *Primates of the world: distribution, abundance, and conservation* University of Washington Press, Seattle.

World Bank (2004) *African Development Indicators* World Bank, Washington DC.

World Bank (2005a) Equatorial Guinea Country Profile: Millennium Development Goals (ed W. Bank), Vol. 2005. World Bank: http://devdata.worldbank.org/idg/IDGProfile.asp?CCODE=GNQ&CNAME=Equatorial+Guinea&SelectedCountry=GNQ.

World Bank (2005b) Equatorial Guinea data profile, World Development Indicators database, April 2005, Vol. 2005. World Bank.

WRI (2003) Earthtrends: the environmental information portal, Vol. 2005. World Resources Institute: http://earthtrends.wri.org/text/biodiversity-protected/country-profile-57.html.

Wright, P.C. & Jernvall, L. (1999). The future of primate communities; a reflection of the present? In *Primate communities* (eds J.G. Fleagle, C. Janson & K.E. Reed). Cambridge University Press, Cambridge.

Wright, S.J., Zeballos, H., Dominguez, I., Gallardo, M.M., Moreno, M.O., & Ibanez, R. (2000) Poachers alter mammal abundance, seed dispersal and seed predation in a neotropical forest. *Conservation Biology*, **14**, 227-239.

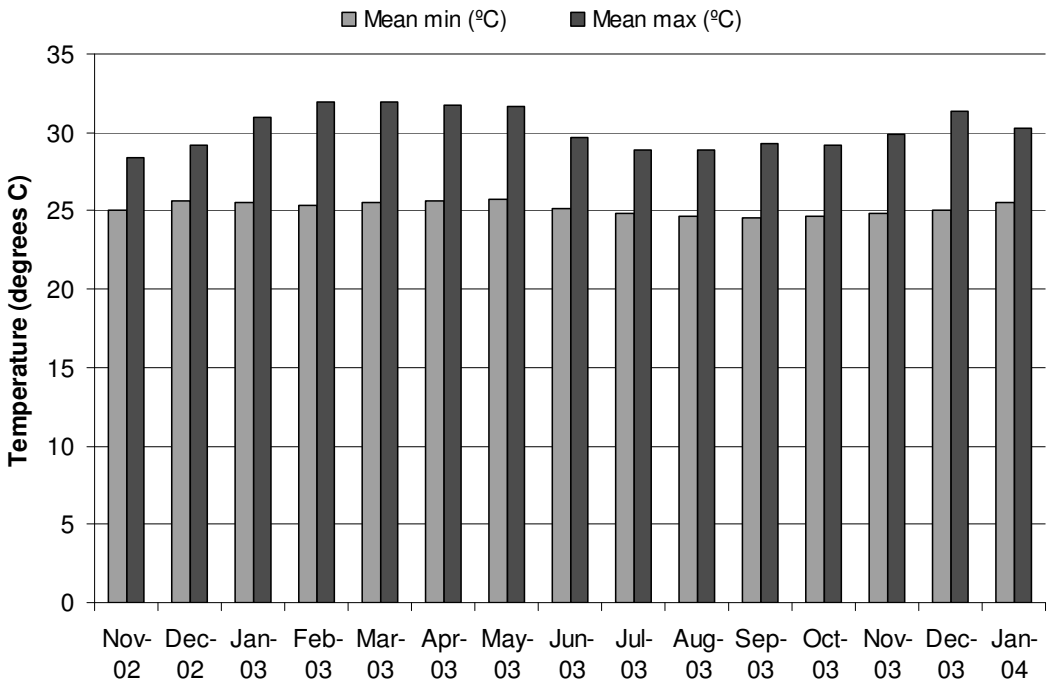
Wunder, S. & Sunderlin, W.D. (2004) Oil, macroeconomics and forests: assessing the linkages. *The World Bank Research Observer*, **19**, 231-257.

Yates, D.A. (1996) *The rentier state in Africa: oil rent dependency and neocolonialism in the Republic of Gabon* Africa World Press, Trenton, NJ.

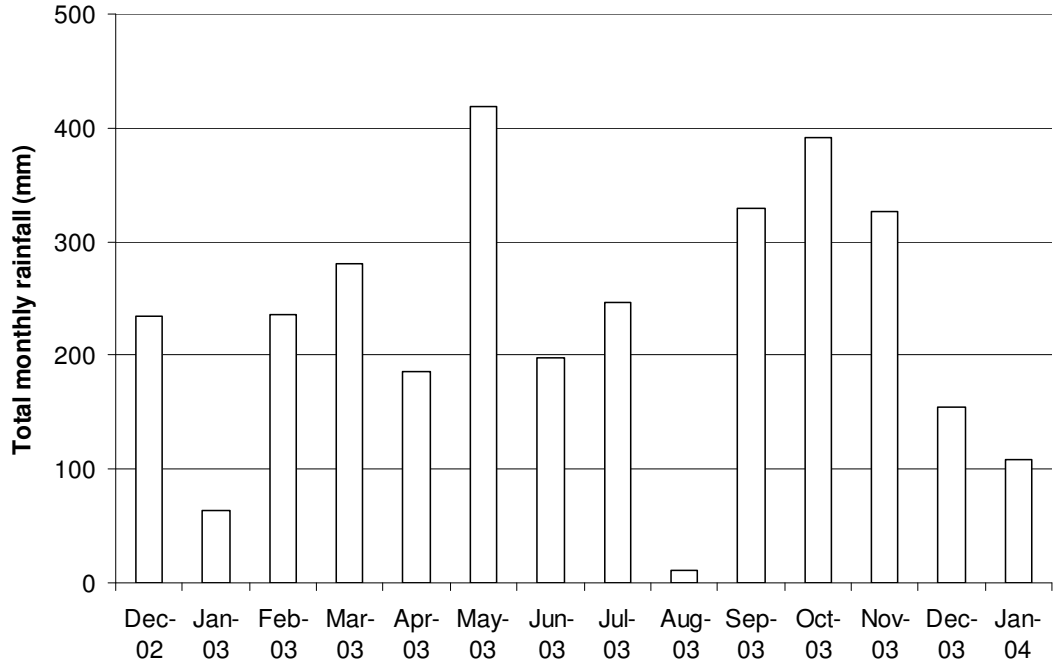
Yost, J.A. & Kelly, P.M. (1983). Shotguns, blowguns, and spears: the analysis of technological efficiency. In *Adaptive responses of native Amazonians* (eds R.B. Hames & W.T. Vickers), pp. 189-224. Academic Press, New York.

Appendix 1 Weather patterns as measured by local research assistant daily at 8am in Sendje throughout study period

Appendix 1a Mean monthly minimum-maximum temperatures (˚C)



Appendix 1b Total monthly rainfall (mm)



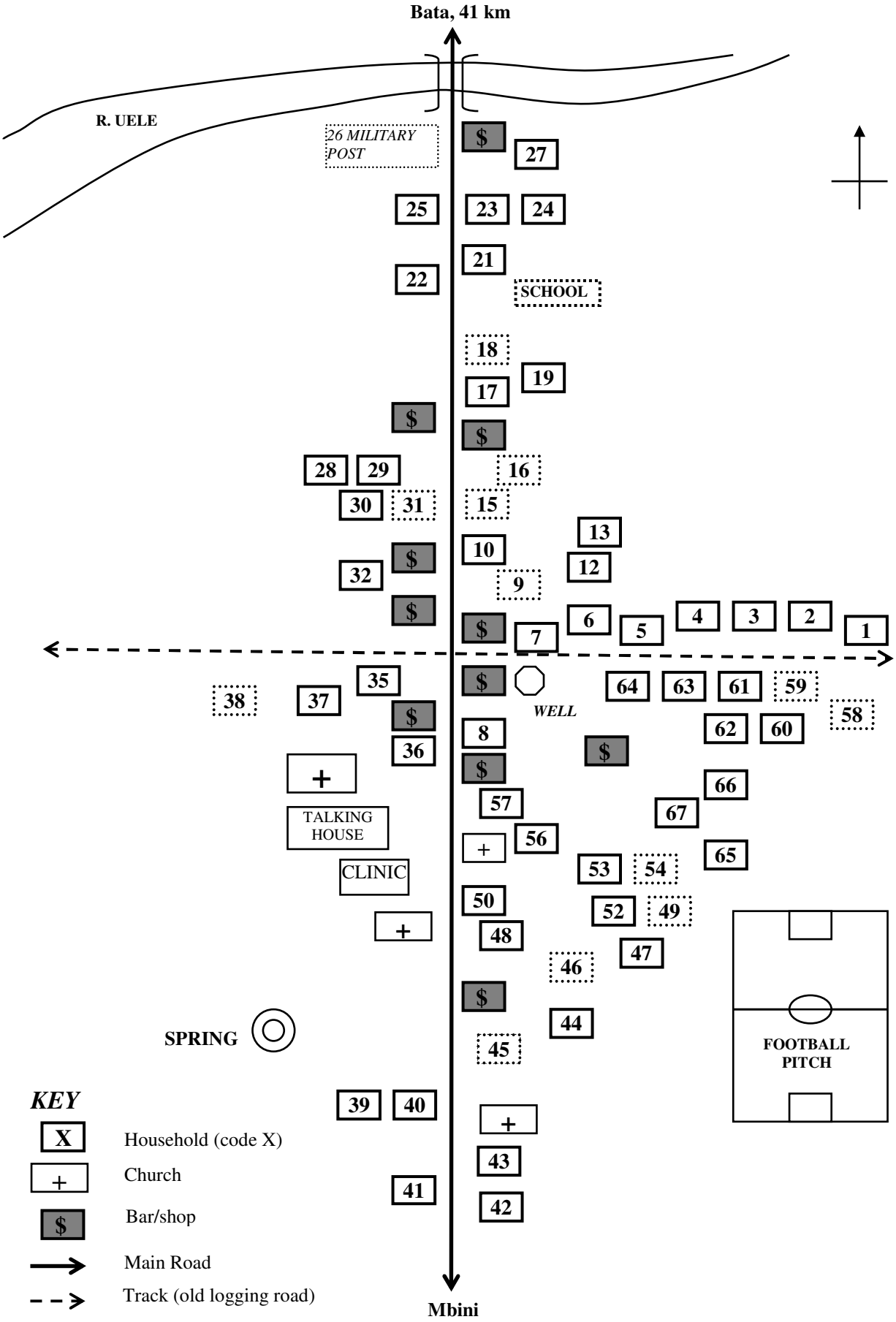
Appendix 2 Bushmeat species recorded in Sendje offtake (this study), Bata's Central Market (this study), Bata's Mundoasi Market (Puit, 2003) or through personal observation, 2002 – 2003, with IUCN Red List category (IUCN, 2004), CITES listing (CITES, 2005) and Equatorial Guinea official protection status (República de Guinea Ecuatorial, 1988). Taxonomy follows Kingdon (1997).

Taxon	English name	Latin name	IUCN category[1]	CITES listing[2]	EG status[3]
Primates	Chimpanzee	*Pan troglodytes*	EN	I	P
	Gorilla	*Gorilla gorilla*	EN	I	P
	Mandrill	*Mandrillus sphinx*	VU	I	
	Grey-cheeked mangabey	*Lophocebus albigena*		II	P
	Red-capped mangabey	*Cercocebus torquatus*	LR/nt	II	P
	Black colobus	*Colobus satanus*	VU	II	P
	Putty-nosed monkey	*Cercopithecus nictitans*		II	
	Moustached monkey	*Cercopithecus cephus*		II	
	De Brazza's monkey	*Cercopithecus neglectus*		II	P
	Crowned monkey	*Cercopithecus pogonias*		II	
	Northern talapoin	*Miopithecus onguensis*		II	
Insectivores	Giant otter shrew	*Potomogale velox*	EN		
Rodents	Brush-tailed porcupine	*Atherurus africanus*			
	Giant pouched rat	*Cricetomys emini*			
	Cane rat	*Thryonomys swinderianus*			
	Small squirrel spp.	*Funisciurus luecogenys?*	DD		
	Giant squirrel spp.	*Epixerus wilsoni?*	DD		
	Beecroft's anomalure	*Anomalurus beecrofti*			
Carnivores	Servaline genet	*Genetta servalina*			
	African palm civet	*Nandinia binotata*			
	Flat-headed cusimanse	*Crossarchus platycephalus*			P
	Marsh mongoose	*Atilax paludinosus*			
	Mongoose spp.	*?*			
	Leopard	*Panthera pardus*		I	
	African civet	*Civettictis civetta*			
	Black-legged mongoose	*Bdeogale nigripes*			P
	Spot-necked otter	*Lutra maculicollis*		II	
Pangolins	Tree pangolin	*Phataginus tricuspis*		II	P
	Giant pangolin	*Smutsia gigantea*		II	P
Hyraxes	Western tree hyrax	*Dendrohyrax dorsalis*			
Proboscids	African elephant	*Loxodonta africana*	VU	II	P
Ungulates	Blue duiker	*Cephalophus monticola*		II	
	Bay duiker	*Cephalophus dorsalis*	LR/nt	II	
	Peter's duiker	*Cephalophus callipygus*	LR/nt		
	White-bellied duiker	*Cephalophus leucogaster*	LR/nt		
	Black-fronted duiker	*Cephalophus nigrifrons*	LR/nt		
	Yellow-backed duiker	*Cephalophus silvicultor*	LR/nt	II	
	Dwarf antelope	*Neotragus batesi*	LR/nt		
	Sitatunga	*Tragelaphus spekei*	LR/nt		
	Bushbuck [4]	*Tragelaphus scriptus*			
	Water chevrotain	*Hyemoschus aquaticus*	DD		
	Red river hog	*Potamochoerus porcus*			P

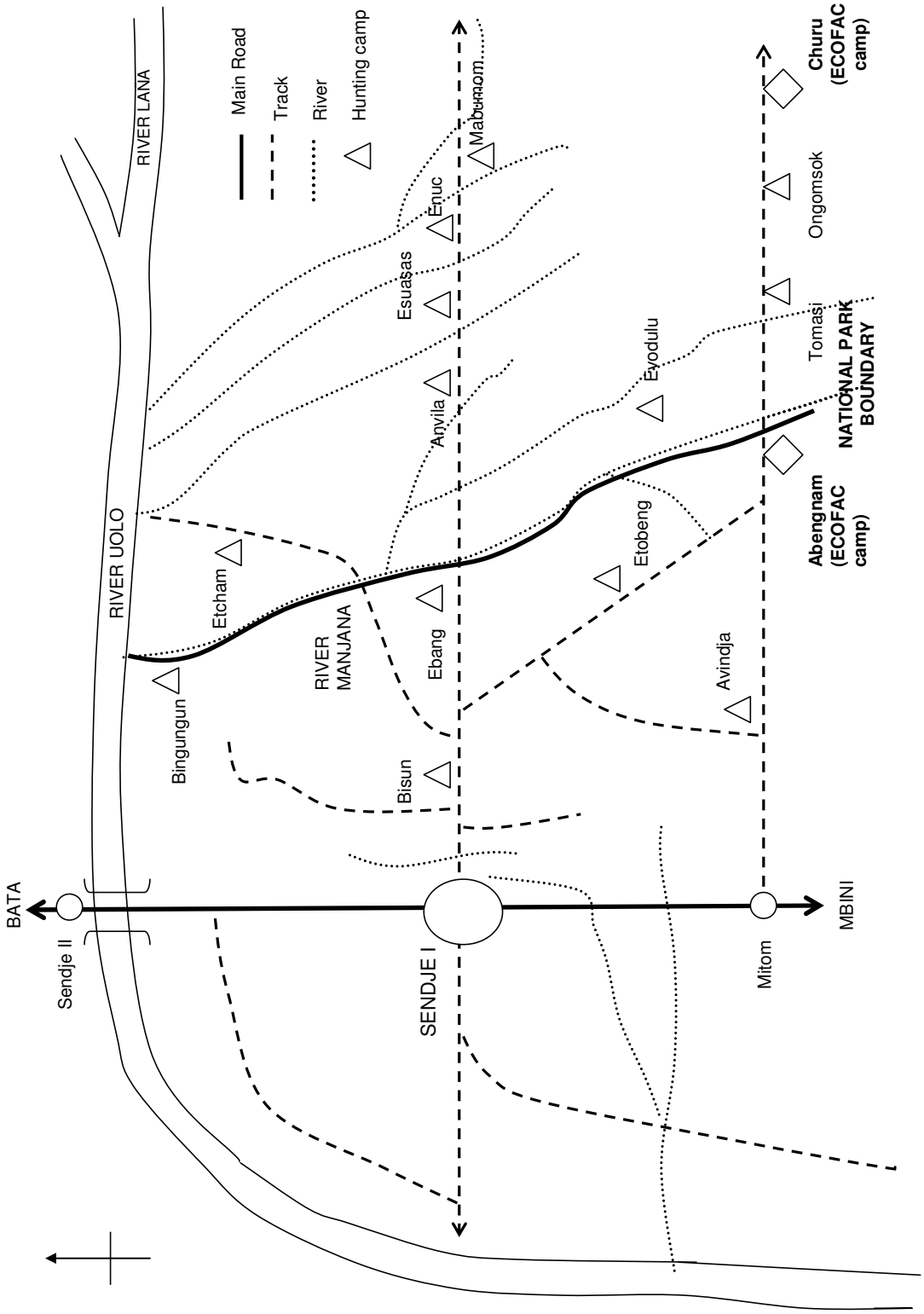
	African buffalo	*Syncerus caffer*	LR/cd		
Birds	Crowned (hawk) eagle	*Stephanoaetus coronatus*		II	P
	African fish eagle	*Haliaetus vocifer*		II	P
	Latham's francolin	*Francolinus lathami*			
	Black guineafowl	*Agelastes niger*			
	Plumed guineafowl	*Guttera plumifera*			
	Nkulengu rail	*Himantornis haematopus*			
	Great blue turaco	*Corythaeola cristata*			
	Black-casqued wattled hornbill	*Ceratogymna atrata*			
	Black-and-white-casqued hornbill	*Ceratogymna subcylindricus*			
	Pigeon/dove sp.	*?*			
	African grey parrot	*Psittacus erithacus*		II	
Reptiles	Dwarf crocodile	*Osteolaemus tetraspis*	VU	I	
	Long-snouted crocodile	*Cocodrylus cataphractus*	DD	I	
	Nile monitor	*Varanus niloticus*		II	
	Hinge-backed tortoise (?)	*Kinixis erosa/homeana*	DD	II	
	Nile softshell	*Trionyx triungus*			
	African rock python	*Python sebae*		II	
	Gaboon viper	*Bitis gabonica*			
	Rhinoceros viper	*Bitis nasicornis*			
Amphibians	Goliath frog	*Conraua goliath*	EN		
Molluscs	African giant snail	*Achatina sp.*			

[1] EN = endangered, VU = vulnerable, LRcd = lower risk conservation dependent, LRnt = near-threatened, DD = data deficient
[2] I = Appendix 1 (trade permitted only in exceptional circumstances), II = Appendix II (trade must be controlled)
[3] P = protected from hunting under Republic of Equatorial Guinea's Ley 8/1988
[4] Presence not confirmed

Appendix 3 Schematic village map of Sendje, based on map drawn by focus group during pilot study (June 2002), with all households resident during main study (January 2003 – January 2004) marked. Hashed boxes indicate those not in repeat household interview sample. The distance from the central crossroads to the bridge is about 1 km.



Appendix 4 Schematic map of area around Sendje I, based on map drawn by focus group during pilot study (June 2002)



Appendix 5 Carcasses recorded in Sendje offtake survey, November 2002 - January 2004

Taxon	Fang/Spanish name	English name	Latin name	No. indivs
Ungulates	Okong - antilope gris	Blue duiker	*Cephalophus monticola*	2849
	So - dorsalis	Bay duiker	*Cephalophus dorsalis*	238
	Nguiñ-mise - jabali	Red river hog	*Potamochoerus porcus*	20
	Mvu - sitatunga	Sitatunga	*Tragelaphus spekei*	16
	Viong - chevrotain	Water chevrotain	*Hyemoschus aquaticus*	10
	Nzip - silvicultor	Yellow-backed duiker	*Cephalophus silvicultor*	9
	Mvin - callipygus	Peter's duiker	*Cephalophus callipygus*	9
	Nnok - daman arborea	Western tree hyrax	*Dendrohyrax dorsalis*	4
	Ochen - antilope maron	Dwarf antelope	*Neotragus batesi*	3
	Mie - leucogaster	White-bellied duiker	*Cephalophus leucogaster*	2
	Nzom - nigrifrons	Black-fronted duiker	*Cephalophus nigrifrons*	1
	Nkwa - girafa	Bushbuck [1]	*Tragelaphus scriptus*	1
	Nzok - elefante	African elephant [2]	*Loxodonta africana*	1
	Sub-total			**3163**
Rodents	Ngom - puercoespin	Brush-tailed porcupine	*Atherurus africanus*	2686
	Kuin - rata	Giant pouched rat	*Cricetomys emini*	471
	Akuekuin - marmota	Cane rat	*Thryonomys swinderianus*	19
	Edun/Osen - ardilla pequena	Small squirrel spp.	*?*	1
	Mvok - ardilla gigante	Giant squirrel spp.	*?*	1
	Owonguin	Beecroft's anomalure	*Anomalurus beecrofti*	1
	Sub-total			**3179**
Primates	Mvam - colobo negro	Black colobus	*Colobus satanus*	501
	Avem - nariz blanca	Putty-nosed monkey	*Cercopithecus nictitans*	152
	Ngem-tchogo - cola roja	Moustached monkey	*Cercopithecus cephus*	138
	Esaga - mandril	Mandrill	*Mandrillus sphinx*	89
	Esuma - mona	Crowned monkey	*Cercopithecus pogonias*	63
	Ka - mangabey mejillas blancas	Grey-cheeked mangabey	*Lophocebus albigena*	3
	Engang - chimpance	Chimpanzee	*Pan troglodytes*	1
	Nsa - mangabey cabeza roja	Red-capped mangabey	*Cercocebus torquatus*	1
	Onsem - titi	Northern talapoin	*Miopithecus onguensis*	1
	Sub-total			**949**
Pangolins	Nzaia-ke - pangolin arborea	Tree pangolin	*Phataginus tricuspis*	431
	Fima - pangolin gigante	Giant pangolin	*Smutsia gigantea*	14
	Sub-total			**445**
Carnivores	Nsing - geneta	Servaline genet	*Genetta servalina*	37
	Mvein - civeta de palmeras	African palm civet	*Nandinia binotata*	28
	Nze-ngum - cusimanse	Flat-headed cusimanse	*Crossarchus platycephalus*	11
	Mva-mitam	Marsh mongoose	*Atilax paludinosus*	6
	Mva - desconocido	Mongoose spp.	*?*	3
	Nze/Ondong - tigre/pantera	Leopard	*Panthera pardus*	2
	Nsuen - lobo	African civet	*Civettictis civetta*	2
	Mva - blanco	Black-legged mongoose	*Bdeogale nigripes*	2
	Sub-total			**91**
Reptiles	Etug - tortuga	Hinge-backed tortoise (?)	*Kinixis erosa/homeana*	960
	Ncomgan - cocodrilo	Dwarf crocodile	*Osteolaemus tetraspis*	167
	Nka - iguana	Nile monitor	*Varanus niloticus*	31
	Tortuga del rio	Nile softshell	*Trionyx triungus*	1
	Sub-total			**1159**

Birds	Kokos- loro	African grey parrot	*Psittacus erithacus*	258
	Evolo - gallina de bosque	Black guineafowl	*Agelastes niger*	62
	Nkang - gallina de Guinea	Plumed guineafowl	*Guttera plumifera*	46
	Nkulengu	Nkulengu rail	*Himantornis haematopus*	5
	Kuna - tucan	Great blue turaco	*Corythaeola cristata*	4
	Paloma	Pigeon/dove sp.	*?*	1
	Sub-total			**376**
Amphibians	Rana	Goliath frog	*Conraua goliath*	12
	Sub-total			**12**
Molluscs	Caracole	African giant snail	*Achatina sp.*	1
	Sub-total			**1**
TOTAL	species	**50**	individuals	**9375** [3]

[1] May be sitatunga (*Tragelaphus spekei*)
[2] Actually caught near the next-door village of Binguru, by a specialised Government elephant hunter
[3] Total count is 9374 (49 species) if elephant is excluded

Notes

Note that these are not true figures of offtake, as some species/individuals hunted but not sold have been missed off the offtake list, and many of the smaller and less saleable species/individuals are eaten or discarded in the forest (see chapter 5). Therefore the total number of both species and individuals hunted was higher than presented here.

Also, identification of some of the rarer species was difficult, as access to field guides was limited, training of local research assistants was basic and the specificity of the Fang name to Latin classification varies. For those species I was not there to personally identify or photograph and take notes on for subsequent expert consultation, I used the animal's weight, head-body length, tail length and research assistant's notes where available to identify to species (e.g. some red duikers and mongooses). Where this was not conclusive, this has been stated e.g. 'Mongoose sp.'.