APPENDIX 1:
tHE fARMERS pERSPECTIVE

Crop raiding can lead to hunting. A. Plumptre, WCS

Introduction

The following four case studies (Hill, Nchanji, Rose, and Plumptre) focus on the degree of crop damage farmers experience, factors that might be useful in predicting which farms or farmers are likely to be most vulnerable to crop damage by wildlife, and farmers' coping strategies.

The first paper (Hill) presents data from a study carried out in Uganda amongst farmers living around the edge of a Forest Reserve. The author outlines the species responsible for the majority of crop raiding incidents at this site, gives an indication of the range of crop losses farmers experience locally, and indicates factors likely to render individual farms/farmers vulnerable to crop damage by wildlife. However, the main focus of the paper is that it is not only important to have knowledge of how much farmers lose, when they might lose it, and the animals responsible; it is also important to understand how farmers view such conflict issues in order to help explain why people consider it to be such an important issue, even when they may not lose much in the way of standing crops.

In the second and third papers Nchanji and Rose present data collected during part of a study of farming within the Banyang-Mbo Wildlife Sanctuary, Cameroon. The physical situation here is very different to that described in the previous paper where there is a hard boundary between the forest edge and people's farmlands. In Banyang-Mbo people develop farms within the forest which means there is not necessarily a recognisable boundary between forest and farm. Although these two sites in Uganda and Cameroon are both forested sites different

wildlife species are reported to cause crop damage[3]. This, in addition to the fact that there is a rather different spatial arrangement of farms in relation to tree habitats, is likely to present farmers with different problems across the two sites when trying to defend crops against wildlife. This helps illustrate the point that possible intervention initiatives may need to be site-specific, though a comparative approach should yield interesting and potentially useful information.

The work presented by Rose was carried out in the same region as that by Nchanji and these studies complement one another well. Nchanji's paper focuses on the methods for quantifying crop damage sustained on forest farms. Rose presents a different data collection protocol designed specifically to investigate particular factors associated with farm location with respect to human habitation and vegetation types as predictors of risk of crop damage by wildlife. An interesting and very pertinent point high-lighted by this paper is that under certain circumstances it can be difficult to predict from one season to another the level of damage crops might receive – this is an important point from the researcher's perspective as well as that of the farmer.

The final paper included here (Plumptre) reports on data collected from people living around the Parc National des Volcans, Rwanda. This paper documents the farmers' views rather than an independent assessment of crop damage, degree of vulnerability of different fields, etc. However, the results are consistent with those from other studies, including reports presented here, that farm location with respect to Protected Area boundary/'natural' habitat boundary, is a good predictor of degree of vulnerability to different wildlife species. In addition there is some evidence to suggest a possible link between crop raiding activities and poaching, whereby those individuals farming closest to the park boundary are most vulnerable to crop loses from wildlife but they are also the people most likely to poach animals from the park. Whether this is because they are generally poorer households with fewer resources or, because of their location, poaching is an easier option for them as compared with others living further away, is unclear. Not withstanding this it is important to try to understand how the experience of losing crops to wildlife, be they heavy losses occurring regularly or small losses that occur only infrequently, can and does influence people's perceptions, attitudes and behaviour towards wildlife.

[3] Around the Budongo Forest Reserve baboons and bush pigs are reported to cause most crop damage; within the Banyang-Mbo Wildlife Sanctuary the species responsible for most of the recorded damage are cane rats, bush pig, buffalo, bushbuck and monkey.

People, Crops and Wildlife: A Conflict of Interests

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Introduction

Crop raiding by wildlife is neither a new phenomenon or a rare one, and in many parts of rural Africa and Asia is perceived to be an increasingly important issue by farmers, people working in resource management, conservation and development. Until relatively recently there has been little attention given to vertebrate species that damage crops, with the exception of elephants and rodents (Damiba and Ables 1993; Thouless 1994; Sukumar 1990; Mill 1993). Most notably, there has been little emphasis on the impact of wildlife on small-scale farmers. Instead, research and intervention programmes have concentrated on trying to reduce the threat to wildlife from local communities, encouraging the view that wildlife are a valuable resource that can attract revenue through wildlife tourism, and thus should be protected. Something that is missing from many of these programmes is an understanding of the relevant issues from the farmers' perspective.

Perhaps not surprisingly, results from a number of relatively recent studies looking at local people's attitudes towards National Parks and conservation programmes suggest that crop raiding conflict issues in particular, reinforce the attitude amongst farmers that conservation programmes and conservation areas actually contribute to their subsistence problems rather than benefit them (Infield 1988). These findings are not just pertinent for studies from tropical regions; they have also been shown to hold in studies of farmers' attitudes to wildlife and conservation within the US (Conover and Decker 1991). Such a perspective is likely to alienate local people with detrimental effects on their support for, and co-operation with, conservation policy and practice. In addition, in recent years the emphasis within conservation policy is for a more participatory approach, taking account of local people's needs and perspectives. Thus in any study of human-wildlife conflict issues it is important that local people's perspectives and understanding of the situation be explored to obtain a more comprehensive picture of the situation under investigation.

Methods

The data I present here were collected during a 12 month study (September 1993 - August 1994 inclusive) of the impact of crop raiding by wildlife on subsistence farmers living around the edge of the Budongo Forest Reserve in Masindi District, Uganda. There is a high degree

of dependence on agriculture for subsistence within this community, with approximately 70% of people reporting it as their sole, or main, source of livelihood (Hill 1997).

A variety of crops are grown locally including carbohydrate staples such as maize (*Zea mays*), cassava (*Manihot esculenta*), sweet potatoes (*Ipomoea batatas*), taro (*Colocasia esculenta*) and finger millet (*Eleusine coracana*), legumes such as beans (*Phaseolus vulgaris*) and groundnuts (*Arachis hypogaea*), and some vegetables and fruits. There are two growing seasons during the agricultural year. The first season extends from March to July, and the second, shorter, season from July through October, with the main maize crop being planted in March/April and harvested during June and July. Cassava is grown throughout the year and has no particular harvest period. I visited a sample of 37 farms at monthly intervals to carry out farm surveys with two field assistants. During the initial visit a farm was mapped and its size calculated. Farm size ranges from 0.15 - 14.58 ha; the median value is 0.7 ha. The distance from the edge of the farm to the forest boundary, and plantation boundaries was estimated. We compiled a list of crops already present, and noted the number of stands planted of each of the main staple crops.

During each monthly visit we asked people to report any instances of crop damage and whether they had observed the animal(s) responsible at the time. I and/or the field assistants viewed all instances of crop damage to make an independent assessment of the likely species responsible for the damage. This was done using visual assessment of bite size, and spoor. A note was made of the type of crop, the plant part/stage of development attacked, and where possible, a quantitative estimate of the degree of damage was conducted. It was not always possible to estimate the degree of damage sustained because (i) the damage was too old for the recorder to be confident that the species responsible could be identified, (ii) the damage had occurred too long ago for the recorder to be able to make an accurate estimate of the degree of damage, and (iii) on two occasions the damage was so severe that the farmer concerned had already re-ploughed and re-planted the field with a different crop. On such occasions a note to that effect was made, but no estimates of the degree of damage were calculated, and the data were not included in the analyses[4]. It is recognised that because of the relatively infrequent visits made to individual farms the estimates of degree of damage, and frequency of crop damage by wildlife, are likely to be conservative estimates of what actually did occur during the study period.

[4] No estimates of amount of damage were made for 20 of the 70 recorded instances of crop damage, either because of not being able to identify the animal responsible, or because the damage had occurred too long ago to be able to make an adequate assessment of the degree of crop loss.

To assess the degree of damage we sampled five quadrats, 2m by 10m, from each affected crop stand. Quadrats were placed randomly within the crop stand. The proportion of crop damaged was calculated having counted the number of damaged or missing plants or plant parts. The mean of the five quadrat values for each damaged stand was taken as a measure of the proportion of crop damage sustained in any one sample. I estimated mean percentage crop losses for each farm, taking into account the number of stands planted of each crop and the proportion of stands that sustained crop damage. Where the same crop stand sustained losses in more than one month this was accounted for within the calculation of mean percentage losses.

Results

Wildlife as crop raiders

There were a total of 70 recorded instances of crop damage by wildlife over the 12 months of the study. A summary of the animals identified as causing crop damage, and the amount of damage ascribed to each species, is presented in Table 1. There were a number of different species recorded raiding crops from the study farms, but between them baboons and wild pigs were responsible for approximately 83% of all damage events recorded. While other animal species could cause significant amounts of damage on particular farms, it is apparent that baboons caused a much greater degree of damage locally than any other species.

Table 1: Crop raiding by wildlife

Animal	No. raiding events	% raiding events	Mean % crop losses
Baboon	49	70.0	24.9
Wild pig	9	12.9	13.9
Porcupine	3	4.3	14.3
Bushbuck	2	2.9	8.4
Chimp	1	1.4	3.4
Blue monkey	1	1.4	1.9
Cane rat & squirrel	2	4.3	13.2

The degree of damage sustained by five staple crops is summarised in Table 2. It is apparent that maize and cassava stands were damaged most frequently, and a greater degree of losses were recorded for these species, as compared with other crops. Across the whole sample the level of crop losses (at approximately just over 10 - 13%) are comparable with losses deemed acceptable within highly mechanised farming systems. However, when we look at the sub-

sample of farmers who actually experience losses we can see that these losses can be very substantial indeed, and obviously potentially devastating to individual households.

Table 2: Summary of crop losses across the year

Crop	No. raiding events	Mean % loss on farms experiencing damage	Mean % loss (whole sample)
Maize	25	26.8	10.1 [0 – 59.3]
Cassava	27	36.0	12.7 [0 – 60.7]
Sweet potatoes	4	14.2	0.8 [0 – 23.6]
Beans	6	22.0	2.4 [0 – 43.3]
Groundnuts	4	43.0	3.5 [0 – 58.8]

Are all farmers equally vulnerable to wildlife crop raiding activities? During the pilot study over 90% of people interviewed claimed that their fields suffered crop damage as a consequence of crop raiding by wildlife (Hill 1997). However, not all farms were equally at risk from crop damage by wildlife. Approximately 40% of the sample did not experience any crop raiding by wildlife during the period the farms were monitored. It is also important to note that wild animals did not visit all affected farms equally frequently.

Previous work at this site has shown that factors likely to affect vulnerability to crop raiding include (i) the distance from farm to forest edge and (ii) the number of other farms lying between any field and the forest (Hill 1997; Hill 2000). There was no damage by baboons recorded from farms lying further than 450m from the forest edge, and no damage by wild pigs recorded beyond 300m from the forest edge. The majority of farms experiencing any damage by either of these species lay at the forest edge and/or had no neighbours farming the area between them and the forest boundary. Thus proximity of farm to forest boundary and the presence/absence of neighbours farming the intervening land, are good predictors of vulnerability to raiding behaviour by wildlife. Other studies also confirm that it is those people closest to forest or Park boundaries that are at greatest risk from larger bodied animals, but the actual distance from the boundary beyond which farms are not likely to be raided varies according to the species responsible for crop damage (Naughton-Treves 1996; Plumptre and Bizumuremyi 1996).

Locally people acknowledge that proximity to the forest edge is potentially risky, but a more frequent observation refers to the fact that having neighbouring farms between your land and the forest edge is beneficial in reducing the likelihood of crop damage. People frequently commented that if you had a 'good' neighbour you were unlikely to suffer crop raiding by forest animals. In this context 'good neighbour' referred to a Zairois family – considered good or helpful neighbours because they are regarded as skilled hunters, thus few, if any, animals are thought to escape the family cooking pot.

Crop protection strategies and coping strategies

The main method used locally to protect crops from wildlife is by patrolling the fields and chasing out intruding animals - particularly groups of baboons. This is done mostly by the women and children, even though people comment that baboons are far less fearful of women and children than they are of men (this is substantiated by personal observation). People sometimes use dogs, spears, bows and arrows, and bells to help scare away raiding primates and pigs, and people work co-operatively, helping to chase away intruders from their neighbours' fields as well as their own. People are aware that killing wildlife (other than 'vermin' or pest animals) is illegal. However, "not killing any animals under any circumstances" seems to be the message that local people have acquired from various talks and meetings they have had with local forestry and conservation personnel – so, although baboons are killed occasionally, this is generally a rare event.

Can farmers predict when crops are most at risk from baboons or pigs?

An important consideration is how crop damage is distributed across the agricultural year. Does damage occur seasonally or year round – because this may have an impact on how people cope. The results of this study confirm that baboons are likely to visit fields all year round, and while they eat maize preferentially, they will also feed on cassava. Thus farmers, whose farms are located close to the forest boundary, are potentially at risk of losing staple crops year round (Hill, 2000).

Although pigs eat cassava preferentially, and it is available all year, they do not cause damage year round. Crop damage coincides with the maize harvest time (June - August) and in December. An important point with respect to wild pig raiding activity is that these animals forage at night, so fields have to be protected at night. Guarding against pigs is men's work because it requires people to spend the night near the bush, away from the village. Bush spirits are a particular threat to women and children who are therefore encouraged to stay

within the confines of the village once night falls. Families that can afford to will hire a guard to protect their fields at night; otherwise adult male members of the household do the job. This leaves women-headed households particularly vulnerable to crop damage by wild pigs – not only are they unable to supply their own male labour from the household but they are generally poorer so are unable to hire extra labour. It is unclear as yet whether the apparent seasonal pattern seen in pig damage to crops is a reflection of wild pig raiding activity being seasonal in nature. Alternately it may be more to do with the fact that during December and June through August it is difficult to guard at night, either because people are away (this includes hired labour) for the Christmas holiday period or, during the harvest time everyone, including men, are required to work hard during the day either harvesting maize or preparing it for storage, so people are unable to also stay awake at night to guard fields. This is an area that will be investigated further in a future study.

Certainly guarding can help reduce crop losses but given the nature of raiding activity, people would need to guard throughout much of the year to protect their crops adequately from the raiding activities of baboons. Increasing the amount of time that people invest in guarding their crops is not necessarily a practical solution – particularly as certain households may already be facing labour bottlenecks, without investing extra time and labour in guarding fields.

Discussion

While wildlife crop raiding can pose a significant threat to field crops, and thus farmer's livelihoods, not all farms are equally vulnerable, and for some people the potential risks are not as great as they claim. Certainly where there is a potential risk the effects can be extremely costly to the farmer both in actual crop losses and the economic (and energetic) costs of protecting crops. However, I would argue that people's actual perception of risk is perhaps as important an issue as the actual losses incurred by some individuals. People's decisions about how to behave are, at least in part, influenced by the way they perceive the problem, and if this is an issue that is going to influence people's views about the value of conservation programmes locally, then their concern over crop raiding is going to be an important factor for such programmes, irrespective of whether they have actually suffered severe crop losses or not.

Given that farmers have been coping with the problem of competition with wildlife for many years why do people feel so strongly that it is becoming increasingly hard to cope with?

From numerous discussions it is clear that people consider that nowadays they have little control over the situation, yet they say that this was not always so. In the past there were organised village hunting parties that occurred just prior to, or around the beginning of the planting season(s). People thought that by having extensive, organised hunting parties at this time, it maintained animal populations at levels that kept crop losses low, and warned animals away. This was thought to be an effective method of reducing crop losses, and provided a source of bushmeat, i.e. a form of compensation for any losses that occurred. Up until the time of Independence there were also game guards posted locally whose job was to chase troublesome wildlife back in to the forest. Although the game guards were primarily concerned with elephant control, to protect tree stands and local plantations, local small-scale farmers also benefited because villages would get the carcass of any animal killed on their land (sold or eaten). Additionally, local district records suggest that the guards regularly shot baboons which was viewed favourably by the local farmers.

To illustrate what I mean by people's perception of their degree of control of the situation I want to use an example comparing people's responses to birds and baboons. Weaver birds are common pests of grain crops throughout Africa. I frequently observed flocks of weaver birds feeding on rice, millet and young maize crops, yet when I asked about them people claimed that they were not a particular problem, unlike baboons. This was explained as follows: "birds come to the fields early in the morning and again late in the afternoon/early evening – these are times when the children are free from school so can be sent to the fields to scare the birds". But when people talk of baboons they present a very different picture. Baboons are considered to be unpredictable - they can come at any time and they will eat whatever is in the field, and what they do not eat they destroy. My data certainly confirms that crop damage attributed to baboons did not occur seasonally - maize and cassava crops are potentially vulnerable to damage at all times when they are present in the fields – providing the fields are close to the forest. People think they can predict when birds are likely to damage fields and consider their coping strategy to be an effective one. However, they cannot predict when baboons are likely to appear, and they do not consider guarding to be an effective strategy against them. The key point here is that in addition to baboons causing more damage than other species, they are also considered very difficult to deal with because 1. people cannot necessarily predict when or whether they will visit an individual farm, and 2. the protection methods available are not considered adequate.

To conclude, I suggest that while wildlife locally certainly does cause considerable damage to some farms, it is not just actual losses that impact on these farmers – while individuals carry the direct costs of crop losses the wider group of farmers also perceive themselves to be at risk from wildlife – this is at least in part influenced by the fact that they feel they have lost what few effective means of control they ever had, combined with a compensatory source of meat. When viewed in this way perhaps it is not so surprising that wildlife and crop raiding is an issue that concerns more than just those who are directly affected by it. If the issue of reducing farmer-wildlife conflict is to be addressed, and from a conservation perspective as well as an agricultural development perspective, it would seem imperative that it is taken notice of, then it is important to understand how and why this problem affects more than just those who suffer serious crop losses.

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Crop damage around Northern Banyang-Mbo Wildlife Sanctuary

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Introduction

Around Banyang-Mbo Wildlife Sanctuary, especially in the northern part, complaints of crop damage by wildlife have continued to come to the project and government offices from the bordering villages. Some of these complaints are so lauded that without quantitative data to raise reasonable arguments and sensitise the people, they may not only strain the relationship between the local communities and the project, but also will influence and mislead policy makers at all levels. Often these complaints are against the larger mammals (elephants and buffaloes) that inflict more noticeable damage to crops in the gardens during a single foray. There may be other raiders that are usually more frequent visitors throughout the growing period of the crops and may cause more damage on aggregate in the final analysis.

Crop damage in the Banyang-Mbo Sanctuary area at the moment, like elsewhere, does not seem to have any immediate solution. Solutions offered so far are either temporary or experimental, and sometimes unrealistic. A better understanding of the facilitating factors, as well as ecology of the various raiders, will certainly contribute to the development of measures that may assist in the management of the problem and reduce the conflicts.

This project was initiated with the aim to:

- identify the different raider species around the northern part of the Sanctuary,
- quantify the losses to principal crops caused by the different raiders,
- investigate major possible facilitating factors to crop raiding,
- and investigate existing crop protection methods used in the area and their effectiveness.

Methods

Study area and site

This study was carried out in the northern part of the Sanctuary because of the frequent wildlife crop damage complaints that come from that area. In addition, communities in this area, to date, have a good social relationship with the project and are more co-operative than other communities around the Sanctuary. This section of the Sanctuary is also easily

accessible by vehicle throughout the year, an important consideration given the amount of detail needed and the limited time we had to concentrate effort to a limited area.

A reconnaissance survey was conducted in all 16 villages in this area and only those with farmlands towards the Sanctuary (9) were pre-selected for secret ballot to randomly select three villages for the study sites. Because the conditions were very similar we presumed that this number was the optimum for a realistic detailed monitoring exercise. Defang, Fotabe and Tali 1 were eventually chosen.

Sampling sites

Within each of these villages, the area towards the Sanctuary with the highest concentration of food crop gardens and/or cocoa plantations was pre-selected. The land tenure system in the area permits farming along corridors with no clear demarcation for food crops and cash crop limits. An approximate line transect was made from the village through these gardens/plantations to the one nearest the Sanctuary. Starting with the first garden encountered along this transect, moving from the village towards the Sanctuary, we selected newly made gardens at approximately 200m intervals. Each garden contained maize, cocoyams, cassava and melons, or at least two of these crops. New gardens were selected to enable us to monitor crops at stages of growth from sowing to maturity. Similarly, active cocoa plantations were selected along the same, or similar, transect at approximately 400m intervals because these were usually larger than the gardens. This method of selection gave us a sample size of 13 of 29 food crop gardens in Defang, 13 of 32 gardens in Tali 1, 14 of 27 gardens in Fotabe and 8 of 19 cocoa plantations in Defang, 7 of 17 plantations in Fotabe, and 5 of 11 plantations in Tali 1.

We also undertook opportunistic observations and assessments of reported cases of crop damage by wildlife, especially those cases attributed to the larger mammals (elephants, buffaloes and bush pigs), in all the villages in the north of the Sanctuary to supplement the data systematically collected at the study sites.

Crops to monitor, land tenure and farming practice

We used Participatory Rapid Appraisal (PRA) and interpersonal discussions to ascertain the most important crops grown, the land tenure system and farming practices in the area. This was supplemented with field observations. The most important crops were cocoa and coffee for cash crops; maize, cassava, cocoyams, melons, oil palms, plantains and banana for food

crops. With the exception of melons, other vegetables were not considered in this study because they are cultivated in very small quantities locally, as was the case for oil palms, plantains, bananas and coffee.

Estimating initial stock on garden/plantation

Food crops

The approximate size of each garden selected was estimated by determining the area of its best-fit polygon using a hip-chain and compass. In April, when crops were fully sprouted, we determined mean number of mounds (cultivation units in the area), and each crop per mound, by counting the number of mounds in randomly selected 10m x 10m plots placed throughout the garden at 15m intervals, starting from the south-east corner of the garden. The slots were located along gridlines superimposed at 10m intervals along the southern edge of the garden, using the hip-chain and compass. The number of these plots varied from 10-25, depending on the size of the garden, and covered about 15% of the estimated area of each garden. Garden size ranges from 282.4 – 4,815.2m^2 with a mean size of 1,472.7m^2. As crops reached maturity we randomly harvested a certain number (10 cobs of maize, 30 coco-yam tubers and 15 cassava tubers) from each garden and converted to tonnage by weighing using a 10kg spring balance.

Cash crops (cocoa)

When cocoa pods were fully established (in July), we determined the mean number of mature cocoa trees by making total enumeration on 50m x 50m plots placed at 30m from the south eastern corner of the plantation, along gridlines superimposed at 50m, using the hip chain and compass. Plantation size ranged between 3,108.6 – 62,425.3 m^2, the average plantation being 20,760.02m^2. The number of plots varied from 3 – 15 depending on the size of the plantation, and covered about 10% of the estimated area. This was used to calculate the total number of cocoa trees in the plantation. Starting from the south eastern corner of the plantation, the mean number of cocoa pods per tree was determined by recording the number of pods on cocoa trees at approximately 10m intervals, on gridlines superimposed on the plantation at 20m intervals from a base line in the southern edge. The number of trees enumerated varied from 100 to 1200 trees, and included about 10% of the total number of estimated trees in the plantation. This was used to extrapolate the total number of cocoa pods in the plantation.

When cocoa pods were ripe (in September), we used a 10kg spring balance to measure the mean dry weight of beans extracted from 30 randomly selected pods in each plantation. This

value was later used to convert pods into tonnage (kilograms), i.e. the estimated number of pods in a plantation, divided by 30, multiplied by the estimated weight of beans from the 30 pods.

Monitoring and quantifying damage

We revisited the garden/plantation every two weeks to monitor damage by wild animals and collected data as follows:

Food crops

During each visit 4–6 people spread out along the southern edge of the garden starting from the south-eastern corner. They slowly walked a straight path through the garden, using a compass to align themselves each time, and recorded any crop damage observed. Cumulative records of each visit were determined to obtain total crop damage. Plants only partially damaged (in the case of cassava and coco-yams) were marked and not scored again for damage unless they were observed to have been totally destroyed in subsequent visits. The difference in yield between non-destroyed crop and a partially destroyed crop is equal to the quantity damaged when both are harvested at maturity, while yield of totally destroyed crop is assumed equivalent to that of non-destroyed crop harvested at maturity. I estimate percentage crop loss by taking into account the final yield of each crop and the initial stock in the garden.

Cash crop (cocoa)

During each visit 4–6 people spread out from the south-eastern corner of the plantation along a base line cut in the plantation's southern edge. They walked through the plantation, along the centre of a transect line, observing a strip of plantation of standard width, and recorded any pods damaged. Observers were careful and methodical, and it is assumed that very few or no damaged pods in the strip were unnoticed during observations. Again percentage cocoa loss was estimated, taking into account final estimated yield and the proportion of pods damaged.

Facilitating factors

Facilitating factors investigated included age of crops:

- maize: shoots, tassels, immature and mature cobs
- cassava: shoots, young tubers, mature tubers
- cocoyam: as for cassava
- melon: shoots, creeping, young fruits, mature fruits
- cocoa: okra sized fruits, immature fruits, ripe fruits.

Farming and land tenure systems, crop associations, distances of gardens or plantations *vis-a-vis* the villages and forest, hygiene of gardens (clean, dirty, very dirty) and the vegetation surrounding the gardens and plantation (other crops, fallow, secondary forest, virgin forest) were also investigated.

Identification of raiders

Crop raiding commonly occurred at night, and animals were rarely observed raiding. I identified raiders by using signs left behind such as footprints, teeth impressions, dung, hairs, etc. Where signs were similar and confusing for two or more raider species (e.g. feeding signs of porcupine and civet cats on cocoa pods), I spent nights in the field until the raiders were observed directly with the aid of searchlights, and the typical micro distinguishing signs were established.

Protection of gardens/plantation

Fencing, trapping hunting, mounting scarecrows, guarding, drumming in the farms and the use of fire and smoke are some methods commonly used to protect crop gardens/plantations against wildlife damage. I recorded the presence or absence of these and any other methods of crop protection observed in the gardens/plantation. Where a protection method was present we also noted whether it was effective or not in keeping away the raiders.

Results

Land tenure and farming practices in the study area

Land in northern Banyang-Mbo is communally owned and under the control of the village head and the traditional council. Any indigene wishing to own forested land simply chooses a suitable area, starts cultivating it, and notifies the village authority. There is no limit to the amount owned until some other person(s) join him in the area, and then both parties agree the amount each can own. Once this has been determined, the area becomes private land inheritable by a person's children. He practices a 4 – 5 year fallow within this piece of land for food crop production, and can also put part under cash crop production. Farming here is characterised by mixed cropping in small gardens that are encircled by different vegetation types that range from complex fallows to mature secondary forests (virgin forest). The machete and hoe are the main tools used in forest clearing and land preparation for crop production.

Crop production in study sites

Food crops

Food crops are produced on small gardens (size range 387.6m^2 to 4080.9m^2) which are characterised by a high level of mixed crops (3 – 5 crop species) of no regular pattern. The total cultivated land included in this study was 16,387m^2 in Defang and 24,915m^2 and 14,172m^2 in Fotabe and Tali 1 respectively. The total estimated crop production was 2,133.2 kg of maize, 13,096 kg of cocoyams, 8,789 stems of cassava, and 39,702 stems of melons in Defang; 2,798 kg of maize, 10,977 kg of cocoyams, 13,040 stems of cassava, and 43,736 stems of melons in Fotabe, and 2,240 kg of maize, 12,544.7 kg of cocoyams, and 8,056 stems of cassava in Tali 1.

Cash crop (cocoa)

Cocoa plantations were larger than food crop gardens. Mean plantation sizes were 20,982.6m^2; 17,458.5m^2 and 25,070.5m^2 respectively in Defang, Fotabe and Tali 1. Total estimated cocoa production was 10,579 kg in Defang, 7,734.7 kg in Fotabe and 13,078.1 kg in Tali 1.

Crop loss

Food crops

Loss of maize to wildlife ranged from 1.9% in Fotabe to 21.9% in Tali 1. However, stunting was the main cause of maize loss, and accounted for about 22.5% - 25.1% loss of the total estimate. Cassava loss to wildlife was 2.4% - 15.1%. Generally loss of food crops to wildlife was greatest in Tali 1.

Cane rats and birds were common raiders at all study sites, but cane rats were the most notorious, causing the greatest loss of maize and cassava in all villages. The impact was greatest in Tali 1, where cane rats accounted for about 20.5% loss of the total maize and 15.1% of total cassava, and more than 85% of maize in some individual gardens. Birds, monkeys, and bushbuck were not observed to raid cassava. Bugs defoliated much of the melons shortly after germination, and unpredictable rainfall caused melon rot in more than 95% of the gardens in the area, thus monitoring was stopped.

During this study we did not observe any damage to cocoyams from wildlife other than bushbuck that nibbled the leaves occasionally. However, farmers reported that francolins, cane rats and buffaloes sometimes damage their cocoyams. Bush pig destruction has not yet

been observed in gardens being monitored but it has been observed opportunistically to cause 15.8%, 27.4%, 40.2%, 92.4% and 100% damage, in 5 respective instances, to available mature stock of cassava during single forays in Tali 1. Monkeys and cane rats were opportunistically observed to raid plantains and bananas in all the villages.

Food crop raiding by stages of growth

The degree of damage to various crops varied widely according to their stage of maturity. Cane rats raided maize and cassava at all stages of maturity. Cane rats' damage to maize crops peaked during the time when immature cobs were available, and then declined as the cobs matured. Other raiders damaged crops only at specific stages.

Food crop damage and distances from the villages

Gardens were located at a distance of 70m – 4,213m from the village of Defang, 225m – 1,893m from Fotabe and 244m – 2,550m from Tali 1. Cane rats raided crops to almost the same magnitude at all distances from the villages. Bush pig, buffalo, bushbuck and monkey raided crops beyond 1,000m distance from villages. Birds occurred haphazardly and raided at random.

Vegetation surrounding gardens and crop raiding

Birds raided crops in 30% of the gardens in the area and these were mostly surrounded by fallow and young secondary forest. However, they were not observed to raid crops in gardens surrounded by other crops or mature secondary forest (virgin forest). Monkeys raided only in one garden and this was bordered by mature secondary forest. Cane rats occurred and raided in all vegetation types, but the degree of damage they caused was more (mean loss of maize 14.5%) in gardens surrounded by fallow and young secondary forest compared to 4.7% in all the others.

Cash crop (cocoa) loss

Cocoa loss to wildlife was between 0.97% in Defang and 5.05% in Tali 1. However, it was observed that more than 30% loss of cocoa in the area was due to black pod disease. The monkey, squirrel and porcupine were the most notorious cocoa raiders in all the villages, accounting for 3.16%, 3.03% and 1.77% of total cocoa loss in the area. Squirrels raided cocoa in all plantations. Elephants and buffalo were observed to raid in one plantation in Tali 1, and two plantations in Fotabe, and accounted for about 0.32% and 0.01% of cocoa loss in these villages. The most surprising cocoa raider was the civet cat, an animal that is known to

be an omnivore. It accounted for about 0.63% loss of cocoa raided in the sites observed during the study. Farmers also reported that black snakes (cobra) raid cocoa but we neither observed this nor have sufficient evidence to prove it.

Cocoa raiding and distance from the villages

Plantations were located at a distance of 756m – 4,634m from Defang, 87m – 3,051m from Fotabe and 1,171m – 5,132m from Tali 1. Squirrels, porcupines and civet cats damaged cocoa in all plantations irrespective of distance from the village. Elephant and buffalo raided plantations lying beyond 2,000m from the village, and monkeys caused damage to crops beyond 1,000m from the village.

Cocoa raiding and stages of pod maturity

Duiker and buffalo were observed to raid cocoa pods only when they were of okra size. Squirrel, porcupine, monkey and civet cat raided pods when they were mature or approaching maturity. Elephants caused damage at all stages of maturity.

Cocoa raiding and surrounding vegetation of the plantation

Buffalo, elephant and monkey raided mostly in plantations surrounded by matured secondary or virgin forest. Squirrel, porcupine and civet raided in all vegetation types, but caused more damage to plantations surrounded by fallow and secondary forest.

Crop protection

We observed only five attempts made to fence the gardens to prevent cane rat damage when maize was tasseling. These were two each in Defang and Tali 1, and one in Fotabe. One of these was inter-spaced with snares to trap cane rats. One lady laid fresh banana/plantain leaves along the garden edge, and another person used fresh palm fronds to prevent cane rat damage to their crops. Bunches of bananas/plantains were observed covered with old clothes to prevent monkey raids. One cocoa farmer occasionally drummed in his plantation to scare away monkeys. A few snares set by hunters who were not farmers were observed in the farmland vicinity. These were not specifically for defence of crops against animals, but were mainly for trapping meat. No other attempts to defend crops from other raiders were observed.

Discussion

The difficulty faced in using the machete and hoe to fell big trees and prepare the ground prevents people from cultivating large tracts of land. The need to have many crops, despite having a small garden, accounts for the high crop mixture. The land tenure system is simple and straightforward to allow individuals to acquire land fast. Unfortunately, people have tended to amass large areas of land and impose restrictions, which prevents uniform agricultural development. This farming system promotes the presence of secondary forest that is a preferred habitat for small mammals, even when close to human settlements. This in turn encourages crop damage. Young men returning to farming from the cities because of the present economic conditions, have to go far from the village to acquire land. This means moving into areas occupied by the larger mammals that will raid almost all crops once they visit these farms. This situation does not seem to give any hope for a successful solution to the issue of crop damage in the area.

This study has also shown that the greatest and most regular raiders of principal food and cash crops in the area are small mammals, especially rodents (cane rat, porcupine, squirrel) and the civet cat, and not the large mammals (elephant and buffalo) which people often complain about. These smaller species are less well studied, and even the farmers have often underrated their impact, maybe because of their small size.

It was observed and recorded on several occasions that buffalo, bushbuck and duiker walked through several gardens/plantations in Defang and Fotabe without raiding any crops. However, the presence of these large mammals, especially buffalo, in farmlands was a source of fear in farmers, especially women, and they would run back home with complaints of insecurity after observing fresh footprints. In Tali 1, five cocoa plantations located beyond 3 km from the village have been abandoned by their owners because they dreaded attack by elephant or buffalo that they believe are unpredictable visitors though the movement of these animals into the area is apparently seasonal.

Maize and cassava are among the most intensively raided crops while cocoyams do not seem to be vulnerable to damage while in the garden. In almost all the gardens more monitored maize was lost to stunting than from damage by wildlife. This may be due to poor soil conditions and much shade on the maize from the trees in the area. It would be interesting to encourage the farmers to grow more cocoyam in preference to maize, which is most vulnerable to damage and does not do very well in the area.

It was surprising to find that few people took measures to protect their crops, especially against the notorious raiders – cane rat, porcupine and bush pig. These species are not totally protected by the conservation laws of Cameroon and could be killed. However these animals do not provide much meat or trophies that can be sold, unlike the elephant and buffalo.

In the next phase of this study we will experiment by fencing some gardens, and trialing several trapping methods to evaluate them as potential management strategies to cope with troublesome raiders in gardens and plantations in the area.

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Crop raiding around the Parc National des Volcans, Rwanda: Farmer's attitudes and possible links with poaching.

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Introduction

The Parc National des Volcans in NW Rwanda is known for its mountain gorillas and the tourism associated with these animals. More than forty years of research in this park, much of it based from the Karisoke Research Centre, has focussed on the mountain gorillas but little is known about the broader ecology of the park. There has not been much work on the other animals that occur in this park, although a study of the larger mammals was undertaken in the late 1980s (Plumptre 1991, Plumptre & Harris, 1995). This research showed that buffalo and bushbuck densities were high in the park and that these two species formed the bulk of the large mammal biomass (Plumptre & Harris,1995). At this time, buffaloes were being cited as a problem by the people living around the park because they came into their fields to raid crops. Between 1990 and 1994 the civil war in Rwanda, that eventually led to the genocide, prevented further work on these animals. During 1996 I carried out a survey of the impact of the Rwandan civil war and genocide on the ungulate populations and, at the same time, interviewed households living around the park about crop raiding problems and hunting of the animals for meat (Plumptre and Bizumuremyi, 1996; Plumptre *et al.*, 1997). This survey

raised some interesting questions about the potential link between crop raiding and poaching, and a summary of the findings is presented here.

Methods

Two people were identified (one living near the western part of the park and one near the eastern half) who were not employed by the Karisoke Research Centre, or the park authorities. These two were trained to carry out a questionnaire survey amongst the people living around the PNV. The advantage of using such Research Assistants was that they came from the local community, knew who many of the hunters were, and could more easily approach people to ask them delicate questions about any illegal activities they might undertake. The questionnaire aimed to investigate three main subjects:

1. Provide a breakdown of the economic status of people living around the park.
2. Estimate the frequency with which animals from the park raid crops.
3. Determine the extent to which people hunt animals on their land or in the park.

The order of the questions was designed to lead the interviewee through the first two subjects in a way that aimed to encourage the interviewee into responding to questions about the last subject (i.e. if the interviewer did not express concern/surprise following the admission of a minor offence the interviewee might be encouraged to admit to more major offences). Nobody accompanied the interviewers because we did not want any person associated with the park to be present. Not all people interviewed were prepared to answer questions about hunting however, and some may have replied that they were not involved when they were. It is likely therefore that the results presented here are minimum estimates. Any questions that people refused to answer were recorded as missing values in the data. The questionnaires were practised with several households in the village of Bisate before the Research Assistants went off on their own.

The two Research Assistants each walked 8 transects of 2.5 km length perpendicular to the park edge (Fig. 1). Two houses were selected for the questionnaire within each 500 metre interval along these transects so that the effects of distance from the edge of the park could be analysed on crop raiding and hunting. In addition extra houses were visited where it was known that people involved in hunting lived. A total of 181 households were visited by both assistants.

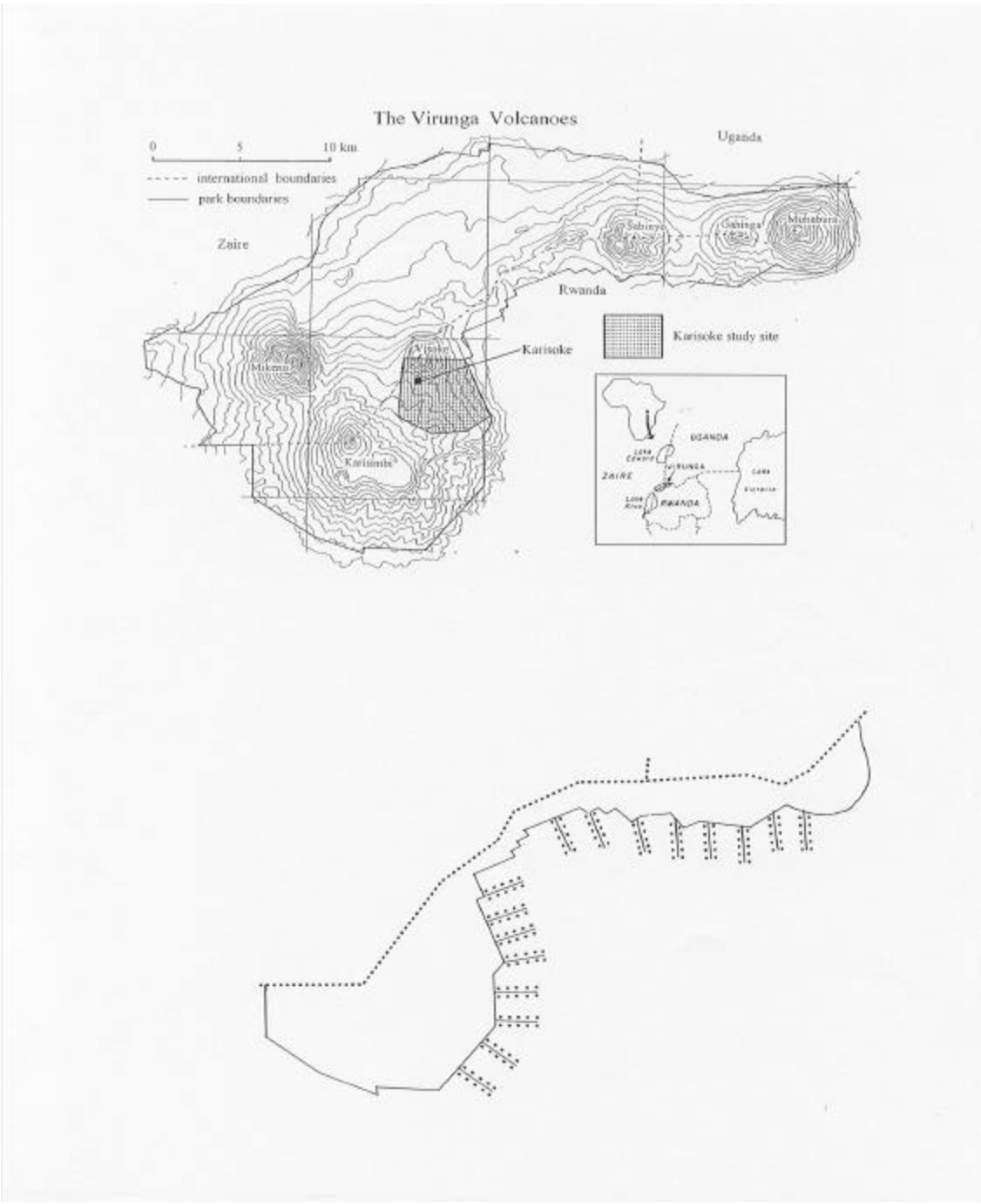

Figure 1. A map of the Virunga volcanoes with a second outline of the Parc National des Volcans showing the location of the transects used to survey the 181 households.

The human population density around the PNV is between 300-600 people per square kilometer, and consequently the park has a very definite edge separating the forest from cultivation. It was therefore possible to investigate the effects of distance from the park boundary on people's perceptions of the crop raiding problem.

Results

Measures of wealth and crops grown

Several measures of wealth were made when interviewing each household to enable later analyses of the differences between richer and poorer households' responses; area of land cultivated, livestock owned, regular income from employment and ownership of a bicycle or a radio were all recorded (Table 1). This analysis showed that in general people living to the east of the park were wealthier than those living in the west. Three main crops are grown in this part of Rwanda: potatoes, sorghum and wheat. These were the only crops identified by the households as being their most abundant crop. These three crops with tobacco and maize were identified as being the most valuable crops and this is probably because these five fetch high prices away from the area. Potatoes in particular fetch a high price if sold in Ruhengeri (nearest town to the park) or Kigali, the capital city.

Table 1. A breakdown of the community, its composition and measures of wealth, in the west and east of the park and for all respondents combined. The percentage involved in hunting in their fields and in the park and the percentage buying meat are also given.

	West of park	East of park	Combined
Number interviewed	90	91	181
Mean no. adults/house	2.3	2.7	2.5
Mean no. children/house	4.4	5.3	4.8
Mean no. years lived here	23.4	32.5	28.0
Mean no. goats/house	1.7	1.6	1.6
Mean no. sheep/house	2.2	1.0	1.6
Mean no. cows/house	1.4	0.8	1.1
Mean area of land (ha)	1.3	1.5	1.4
% with employment	3.3	18.7	11.0
% with bicycle	4.4	31.9	18.2
% with radio	35.6	57.1	46.4
% hunting in fields	20.0	37.4	28.7
% hunting in park	7.8	14.3	11.0
% buying wild meat	18.9	47.3	33.1

Crop raiding animals and distance from the park boundary

Almost all respondents (91.2%) faced problems from crop damage caused by wild animals. The vast majority of respondents (71.3%) claimed that the buffalo was the worst offender

followed by the bushbuck as the second worst offender (40.3%). Responses changed however with distance from the park boundary (Fig. 2). Buffalo, bushbuck, duikers and porcupines (those animals that crop raid most frequently) all showed strong negative correlations (Spearman rank: $P<0.001$ for all species) between crop raiding frequency and distance from the park boundary. Both potatoes and wheat plants are consumed by buffalo and bushbuck; however sorghum tends not to be consumed except by cane rats.

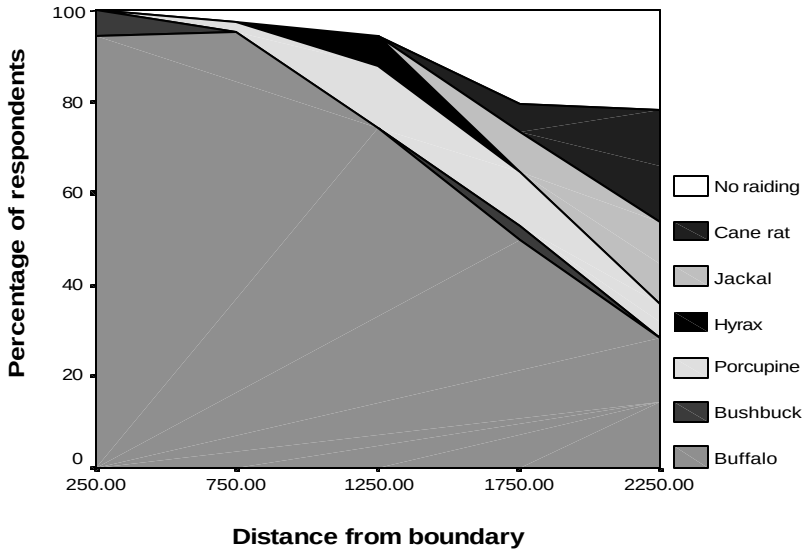

Figure 2. Variation in household responses with distance from the park boundary to the question of which animal is considered by them to be the worst for crop raiding in their fields.

Percentage of community involved in hunting

A reasonably large percentage (28.7%) of people admitted to killing animals that venture out of the park into their fields, and more people admitted to doing so near the eastern half of the park (Table 1). 11% of people interviewed admitted to hunting in the park. 33% of interviewees admitted to buying meat from hunters.

Hunting in fields

Bushbuck and buffalo were the two most commonly caught species in farmer's fields although their contribution has declined over the period of the war (Plumptre *et al.* 1997). The methods used to hunt animals in fields is by snare or pitfall trap, although farmers will opportunistically hunt with spears or even throw rocks to try to kill a crop raider.

Hunting in the park

All of the hunting admitted to in the park was by the use of snares. The only animals that hunters admitted to catching by trapping were bushbuck and duiker. It is known that buffalo traps[5] are also set in the park, but these animals are rarely caught.

Who hunts?

What type of people become involved in hunting? In an attempt to answer this question the measures of wealth in Table 1 and the distance the farmer lived from the park edge, were tested to see if there was a difference between those that admitted to and those that denied hunting in their fields and hunting in the park. People hunting in the park were significantly poorer (had fewer livestock, and less land) and lived close to the park boundary (Table 2). Although 11% of people questioned admitted to hunting in the park this rises to 27% for households within 1 km of the park.

Table 2. The mean values of measures of wealth for people who admitted and those who deniedhunting in the park.

	Non-hunters	Hunters	Significance
Distance from park (m)	1,166	695	**
No. children	4.9	4.2	Ns
No. sheep	1.7	1.0	*
No. goats	1.7	1.0	*
No. cattle	1.1	0.9	Ns
Livestock biomass (kg)	300	225	*
Area of fields (ha)	1.5	1.0	**
Time lived there (yr.)	28	29	Ns
With employment (%)	12	0	-
With radio (%)	47	45	Ns
With bicycle (%)	19	10	ns

Livestock biomass was calculated as: no.cows*200 kg +no.sheep*25 kg + no.goats*20 kg. The results of Mann-Whitney tests and Chi^2 tests (employment, radio) are given (ns=no significant difference. *=P<0.05; **=P<0.01; - = untestable because of 0 score).

People hunting in fields were those who had significantly more children (mean of 5.4 vs. 4.6; P<0.05) and had lived longer in the region (mean of 32 years Vs 27 years; P<0.05). Number of children was correlated with the time spent living at a house, however (r=0.31, P<0.001). Interestingly there was no difference for these categories in any measure of wealth and even people who were employed hunted an animal if it strayed onto their land. There were no

[5] A buffalo trap consists of a circular ring of spikes attached to a large log which traps the leg of the animal and the weight of the log prevents it from moving away, rather than a wire or rope noose on a tensioned piece of bamboo.

significant correlations between farm area and distance from the park edge or time spent living there.

Buying and selling of bushmeat

The mean frequency of buying bush meat in June 1996 was 3.5 days/year for all households asked. However some people may have been reluctant to admit to buying at present. A more realistic figure of buying may be 7.4 days/year which was the mean number admitted to during the period of the civil war. If only those people who admitted to buying meat are analysed then the rates increase to 10.7 or 22.3 days/year. By comparison, on average people ate goat 3.0 days/year; mutton 4.2 days/year and beef 2.9 days/year or a total of 10.1 times a year. Consequently bushmeat consumption, for those who buy, doubles their annual intake of meat and may triple it.

The price of meat has decreased significantly for bushmeat and increased significantly for domestic meat following the war (Plumptre et al. 1997). The animal most commonly bought as bushmeat is the bushbuck (77% of respondents) followed by the duiker (23%).

Who buys bushmeat?

Households that bought bushmeat were those that had fewer domestic animals (Table 3). All other tests of wealth were not significant. People with some form of employment showed a greater tendency to buy bushmeat (50% vs. 31%) than those who only farmed their fields (Chi^2=2.89, df=1, P=0.09).

Table 4. The mean values for measures of variables that differ significantly between households who buy bushmeat and those who do not.

	Do not buy	Buy	Mann-Whitney U
No. cows/house	1.26	0.75	P<0.05
No. sheep/house	1.84	1.08	P<0.05
Biomass of stock	333.8	205.8	P<0.01

Discussion

Great care must be taken when interpreting questionnaire data, particularly when questions are fairly sensitive as was the case here. It is probable that estimates of hunting frequencies are on the low side in this study because the two trained interviewers reported that some people questioned were not keen to continue the questionnaire once questions about hunting were asked. However, the two trained interviewers were requested to ask these questions

from anyone who they knew to be a hunter operating in the park and consequently for these people it is likely that answers were true.

Crop raiding

The local community interviewed around the PNV were mainly subsistence farmers (89% of people interviewed). They concentrated their agricultural production on crops that were not only valuable for feeding their families but also were valuable economically should they produce excess. As so many of the people were reliant on their crops for their livelihood they were, not surprisingly, concerned about crop raiding by animals from the park. Buffalo were considered the major pest as they were in 1984 (Towner 1985; RRAM 1987) but whereas in 1984 elephant was considered the next most important pest, nowadays these animals are not mentioned in this context, indicating a probable decline in their numbers. Elephants are often perceived to be the major crop pest where they occur in other parts of Africa (Thouless & Sakwa 1995; Lahm 1996; Tchamba 1996) indicating that in the PNV their population must be very low.

Whether the animals perceived to be the worst crop raiders actually cause the most damage needs further study. Buffalo are large and can be dangerous, and may be considered to be "bad" because people are afraid of them rather than because they cause more damage (Hill 1997). Animals can pass through their fields on most nights for those farmers living adjacent to the park boundary although this does not necessarily mean that they cause damage in their fields. A system of compensation to farmers for crop damage used to exist in theory around the PNV, but many people who were talked to claimed that they never received anything when they tried to claim this compensation. Often in the past, damage to crops was exacerbated by people trying to kill animals entering their fields (either to deter them or to obtain meat), and sometimes damage was increased in order to try and claim compensation (A. Plumptre pers. obs. 1988/89). Consequently it was often difficult for the park authorities to determine who to give compensation to. It is recommended that a study is carried out of current crop raiding levels and the actual damage measured on farms at different distances from the park to assess how much impact and economic loss is actually faced by the local population. Farmers around the park are never going to look favourably on the park if the perceived level of crop raiding found in this study continues, unless some form of compensation is received, or unless they can benefit from it in some way. One possibility might be to allow people to kill ungulates in their fields for domestic consumption (not for sale). This type of hunting (which already goes on) will have some impact on the ungulate

populations, and will reduce the crop raiding but would not wipe out the population. However, it may be difficult to monitor this type of hunting as proving that an animal was killed on a farm and not in the forest would be difficult.

Hunting

Crop raiding and hunting may be closely linked. A large percentage of people interviewed admitted to hunting crop raiding animals and expressed great dissatisfaction with the park authorities for not doing anything to prevent crop raiding. People who admitted to hunting in the park have small farms located near the park edge and are consequently likely to be most affected economically by crop raiding animals. This is because their farms will be visited regularly by animals, due to the proximity to the park edge, and because losses from their farms have a relatively greater impact because the owners rely on a greater percentage of the crops in order to survive. The loss of domestic animals during the civil war (either stolen, killed by feral dogs or died of starvation) has probably contributed to the increase in hunting in the PNV following the war (Plumptre *et al.* 1997), although this is also due to the difficulties the parks staff currently face in patrolling the park and arresting hunters (Plumptre 1996). Domestic animals are used as insurance around the PNV and in other African communities to pay fines, marriage costs and school fees (J.B. Bizumuremyi pers. comm.). Therefore, hunting in the PNV may be used as a fallback means of survival when economic losses are too great.

Conclusion

The setting of snares in the PNV was carried out by the poorest households living adjacent to the park boundary. These were the people who were probably most affected by crop raiding animals. This hunting may be a direct result of their economic status and it is recommended that future community development projects focus on helping these people. Households that buy bushmeat tended to have some employment but few domestic animals. Therefore care must be taken with any community development project that increased economic wealth does not lead to an increased demand for bushmeat.

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A Spatial Analysis of Wildlife Crop Raiding Around the Banyang-Mbo Wildlife Sanctuary, Cameroon

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Introduction

Located in the south-west Province of Cameroon, the Banyang-Mbo forest is a biologically-rich mix of lowland rain forest to sub-montane savanna. It provides habitat for a relatively high density of forest elephants (*Loxodonta africana cyclotis*) and forest buffalo (*Syncerus caffer nanus)*, as well as threatened species including chimpanzee (*Pan troglodytes*), Preuss' monkey (*Cercopithecus preussi*) and drill (*Mandrillus leucophaeus*) (Powell, 1994). This region contains 70,000 of Cameroon's estimated 20 million ha of remaining forest (Besong, 1992), and is an important conservation area for both biological and cultural diversity. In March of 1996, Cameroon's Ministry of Environment and Forest (MINEF) officially designated the Banyang-Mbo Forest as a wildlife sanctuary, the first of its kind in Cameroon (Nchanji and Lawson, 1998). The "wildlife sanctuary" designation protects endangered species from hunting and restricts logging, but allows local communities to hunt non-endangered species, gather forest resources, and participate in the management of the sanctuary. This designation follows Cameroon's national forest use policy to protect soils, habitats and the environment, and provide rural communities with economic benefits deriving from non-timber resource extraction (Besong, 1992). In contrast, a "national park" designation would restrict all use by local communities. Following the designation, MINEF invited the Wildlife Conservation Society (WCS) to assist in the formation of a management plan for the sanctuary and to perform all relevant field research. Currently, teams of WCS staff are gathering social and ecological data to support a community-based management plan. They are surveying the flora and fauna within the sanctuary, measuring the impact of local resource use (including bush meat hunting), and assessing the impact of the creation of the sanctuary on local communities.

A key local concern in Banyang-Mbo's management is human-wildlife conflicts, particularly between humans and large mammals. To manage and ameliorate human-wildlife conflicts, field assessments of the pattern and amount of crop damage caused by wildlife are underway, with special emphasis on destruction caused by forest elephants and buffalo. The present human-wildlife conflict study began with field visits and informal interviews conducted in seven villages around the sanctuary between January and April 1999. Following this pilot

survey, an intensive crop monitoring study was initiated in five of the seven villages. The study will extend through December 2000. The long-term study uses both opportunistic and systematic data collection schemes. The opportunistic data collection depends on farmers' reports of recent elephant and buffalo damage, while the systematic data collection regularly monitored three to four fields in each village for damage by any animal.

The underlying hypothesis of the monitoring program was that two factors led to higher incidences of elephant crop raiding: 1) field distance from the village, and 2) vegetation surrounding the field. Specifically, fields farther than 2km from the village and surrounded by secondary forest were expected to experience higher incidences of elephant and buffalo crop damage than those closer to the village or surrounded by other fields or young fallow areas. The goal of the monitoring is to validate the influence of these two spatial variables and ultimately develop a predictive model of elephant crop raiding.

The field monitoring study at Banyang-Mbo, along with a previous crop raiding study by WCS field biologist Anthony Nchanji and Dwight Lawson (1998), show four compelling results about the pattern and amount of crop raiding by elephants and buffalo. First, damage is seasonal, occurring mainly during the rainy season from August to October. Second, damage is concentrated on particular fields and villages due to their location and surrounding vegetation. For example, fields close to the sanctuary edge (and thereby close to secondary forests) or those surrounded by old fallow were more prone to elephant damage. Third, the data show that the pattern of land-use for farming is pushing new fields closer to the sanctuary edge, leading to more incidents of elephant and buffalo crop raiding. Finally, while damage on an individual field may be quite high, and in some cases may force the farmer to abandon the field (Nchanji and Lawson, 1998), the majority of crop destruction was caused by large rodents, such as cane rats (*Thryonomys sp*), domestic goats and grasshoppers. This result contradicts the views held by local farmers who complain most bitterly about elephants (Nchanji and Lawson, 1998). Perceptions held by local farmers have resulted in elephant crop raiding becoming a highly politicized issue that threatens the relationship between conservation authorities and local communities.

Methods

The villages selected for this study were Tali I, Fotabe, Akiriba, Defang and Sumbe. All five villages were located within a three-hour drive from the WCS research station and could be reached throughout the rainy season. Farmers in these villages followed similar farming

practices and all granted approval for the study during community meetings. Finally, these five villages were thought to be equally representative of the human-elephant conflicts around the sanctuary. This was based on results from the pilot study during which all villages complained of recent elephant damage and were able to guide researchers to previously damaged fields.

The research design depended on two types of data collection: systematic and opportunistic. The systematic data collection used a matched-pair design to isolate important variables within a highly varying agroecosystem. In a farming system with numerous variables, the matched-pair sampling design helps control for the variability in the agroecosystem which otherwise might confound our analysis. Within each village, pairs of fields were selected that matched in age, type, and size, but differed in one factor, either surrounding vegetation or distance from village. For example, two fields of similar age, type and size were selected, one located close to the village and one located far from the village. The matched pair design enabled the use of a paired ANOVA to assess the effects of the independent variables on crop damage.

In the systematic survey, three to four fields within each village were selected and monitored once a month for crop damage. Field selection was based on three criteria:

1. location from the village (near and far from village),
2. vegetation surrounding field (field/young fallow enclave and old fallow/secondary forest enclave), and
3. type of field (the main crops monitored were maize, cocoa yams, and melons).

For each village, researchers selected two fields near the village and two fields far from the village (closer to the sanctuary). Researchers used a hand-held GPS to determine the distance from the field to the village. Of the two fields near the village, one was predominantly surrounded by other fields or young fallow (*field/young fallow enclave*), and the other was predominantly surrounded by old fallow and secondary forest (*old fallow/secondary forest enclave*). Similar to the fields close to the village, one distant field was a field/young fallow enclave and the other was an old fallow/secondary forest enclave. All fields selected for systematic monitoring were mixed food fields (cassava, cocoa yam, maize, and melon). Except for Akiriba, all village fields selected were located between the village and the sanctuary. Akiriba has taken some steps to reduce the impact of crop raiding by locating all food fields on the non-sanctuary side of the village. Therefore, the fields selected are located

on the opposite side of the village and only three were selected due to a lack of secondary growth near the village.

For the nineteen fields (five villages) selected for systematic monitoring:

- field size ranged from 218.7m^2 to 2808m^2 with an average size of 1221m^2,
- all fields contained the same crops (maize, cocoa yam, melon),
- fields varied by proximity to village (close fields averaged 631m from village, distant fields averaged 2380m from village), and
- fields varied by surrounding vegetation (field/young fallow enclave or old fallow/secondary forest enclave).

During the first season of systematic crop monitoring, these 19 fields were monitored on a monthly basis for crop damage by any mammal greater than 2 kg. A WCS field assistant (Arrey Walters) along with village guides assessed the amount of damage by counting the number of stems damaged per field. Field assistants used tracks and teeth marks to determine the wildlife species that caused the damage. The data were then analyzed according to wildlife species, crop species and field condition, with the results presented below.

Given the unpredictable nature of elephant and buffalo crop raiding, the systematic sampling was supplemented by opportunistic observations. The opportunistic data collection was designed to collect data on any elephant or buffalo damage occurring in the five study villages. The data collection depended on a reporting system set up with each village in which any occurrences of damage over the past month were reported to the village chief. Each month, when the researchers arrived in the village, a guide took them to the fields that suffered crop damage and measurements, such as GPS location, type of field damaged, size of field, amount of damage and vegetation along the edge of the field, were made. The results were incorporated into a GIS for final analysis.

Phase One of this study collected data from June 1999 through October 1999. This time frame corresponded to the local rainy season which is the only time elephants reportedly enter crops around the sanctuary. The second phase is scheduled to occur during the rainy season of 2000. Preliminary results from the first season of crop monitoring are presented in the following section.

Results of the first season of crop monitoring

Overall, five different wildlife species damaged crops. Cane rats damaged more stems on more fields than any other animal, followed by buffalo and porcupines. Elephants did not cause any damage to the fields selected for systematic sampling. This was unexpected, given farmers' reports of repeated damage in every preceding year. Table 1 shows the amount of damage, the frequency of damage per month and the number of different fields damaged by each species. The total number of stems was determined by multiplying the average planting densities for the three main crops damaged (cocoa yam, melons and maize) by the area of each field and summing for all fields (N=19) in the study. The average frequency of damage represents the number of fields damaged by a given wildlife species divided by five months.

Table 1: Crop damage by wildlife around Banyang-Mbo Wildlife Sanctuary, June - October 1999

Animal	Total Stems Damaged	Percent Damaged (n=284488)	Frequency of Damage (avg. # of fields/month)	Number of Different Fields Damaged
Cane rat	1293	0.455%	6.0	13
Buffalo	168	0.059%	0.6	2
Porcupine	43	0.015%	1.0	3
Antelope	20	0.007%	0.6	2
Bush pig	6	0.002%	0.2	1
Forest elephant	0	0.000%	0	0

The number of stems damaged per field for each month was recorded and the results were summed for all nineteen fields in the five-month period (Table 2). Although all crop types were planted at the same time, maize matures first and is usually planted a second time during the season. Therefore, it was a more readily available target for crop raiders, especially early in the growing season (Figure 1).

Table 2: Amount of damage by crop type, Banyang-Mbo Wildlife Sanctuary, June 1999 – October 1999

Crop	Number of Stems Damaged	% Damaged	# of Fields Damaged (N=19)	Frequency (avg. # of fields damaged/month)
Maize	1253	1.26%	13	3.4
Melons	200	0.54%	3	0.8
Cocoa yams	85	0.08%	5	1.4

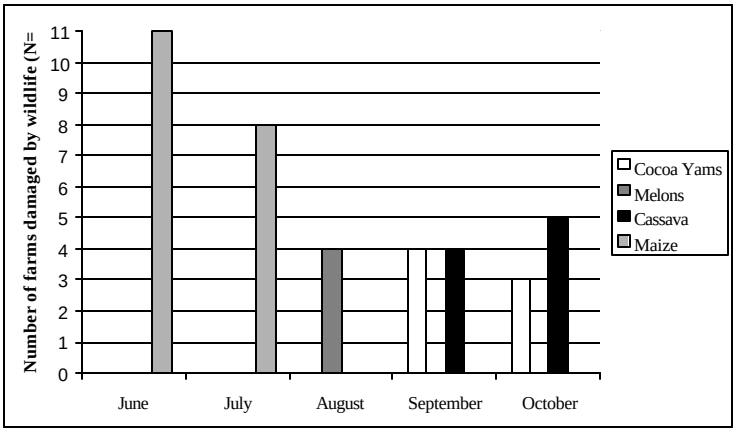

Figure 1: Monthly pattern of wildlife damage to crops at Banyang-Mbo Wildlife Sanctuary, Cameroon (June – October 1999)

The data were grouped by field condition (field enclave close to village, secondary forest enclave close to village, field enclave far from village, secondary forest enclave field from village) with the results presented in Table 3.

Table 3: Crop damage according to field condition, Banyang-Mbo Wildlife Sanctuary, June – October 1999

	Fields Close to Village		Fields Far from Village		
	Field Enclave	Secondary Forest Enclave	Field Enclave	Secondary Forest Enclave	ANOVA
# of stems damaged	411(0.51%)	406 (0.56%)	366 (0.50%)	200 (0.34%)	ns
# fields per month	2.6	1.8	1.8	1	ns
Total Number of Fields Damaged	4 (n=5)	4 (n=5)	4 (n=4)	2 (n=5)	

Using a factorial ANOVA test on both distance from village and surrounding vegetation, both variables were shown to be non-significant in predicting crop damage. However, there is a trend toward greater crop damage by cane rats close to villages, and greater crop damage by larger animals further from villages. Also, all buffalo damage occurred in the "distant - field enclave" category. This result suggests that larger mammals may avoid areas of high human densities.

Turning to the opportunistic data, there were no reported incidences of elephant damage in any of the 5 villages over the 5 month study, but 9 events of buffalo damage were recorded in 3 villages (Table 4). Of the nine events, 6 were found >2km from the village and 8 were surrounded by secondary forest. All damage occurred on either cocoa or mixed cocoa/food fields. This confirms expectations regarding the spatial distribution of large mammal crop damage in that the majority of the fields damaged were distant cocoa fields surrounded by secondary forest. Without any data on elephants it was impossible to draw the same conclusions about the patterns of elephant crop damage.

Table 4: Crop damage by buffalo gathered during the opportunistic data collection, Banyang-Mbo Wildlife Sanctuary, June – October 1999

Village	Animal	Field Type	Surrounding Vegetation	Amount of Damage
Sumbe	buffalo	Cocoa	Field	1 plantain tree
Fotabe	buffalo	cocoa/plantain	secondary forest	3 plantain trees
Fotabe	buffalo	cocoa/plantain	secondary forest	1 banana tree
Fotabe	buffalo	cocoa/food	secondary forest	25 cocoa yam stems
Tali I	buffalo	Unknown	secondary forest	unknown
Tali I	buffalo	Cocoa	secondary forest	20 cocoa pods
Tali I	buffalo	Cocoa	secondary forest	2 cocoa pods
Tali I	buffalo	cocoa/coffee	secondary forest	52 cocoa pods
Tali I	buffalo	Cocoa	secondary forest	7 cocoa pods

Discussion/Conclusion

While the systematic data show a relatively even distribution of damage across all farms the opportunistic data on buffalo also suggests confirmation of the pattern of large mammal (buffalo) crop damage. During the crop monitoring study, locations of buffalo damage were consistently reported on fields farther from the village surrounded by secondary forest. However, the results of elephant damage were contrary to expectations. According to farmers' reports, elephant damage had been so severe in the study villages it was forcing people off their fields. Yet no incidents were recorded during the predicted peak five months of raiding. This discrepancy is likely a result of the unpredictable nature of elephant raiding, as well as the tendency for local communities to inflate damage reports, and /or to feel heightened vulnerability to elephants due to other factors. Perceived vulnerability likely reflects the dangerous nature of elephants, the large amount of damage an elephant can cause in one foray, and promises of compensation for elephant damage made by local government officials.

The integration of spatial data was an important aspect of this project. A handheld GPS allowed researchers to quickly identify locations of farms, measure distances between features and prepare data for inclusion within a GIS. Once collected the data were analyzed within a GIS. The GIS helped visualize the relationship between the damaged farms and the spatial predictor variables. Furthermore, the GIS was and will continue to be an integral part in the management of the spatial data obtained through the study.

Further research should include continued systematic field monitoring in the study villages. Opportunistic data collections should also continue in the selected villages and incorporate other villages around the sanctuary. Finally, remote sensing data may be used to describe the land use patterns around the sanctuary and determine the influence of land use on locations of buffalo and elephant damage.

References

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