Moving Away From Prescriptive Pachyderm Palliatives: Toward an Integrated Assessment of Farmer-Elephant Conflict in Gabon

by

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Dedication

For my parents, Don and Trudi
For providing me a solid foundation, inspiration,
and unwavering support of my dreams

And to Miguel, for his patience

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Chapter 1.

Introduction: an overview of the dissertation

I began this dissertation research after three years as an Environmental Educator with the Peace Corps in Lopé National Park, Gabon. If the occasional elephants in my backyard and the constant buffalo in the driveway in Lopé were not enough to clue me in on the potential difficulties of sharing space with large wildlife, farmers in the neighboring villages I visited made sure to remind me at every opportunity. Gabon had just formalized a network of 13 national parks, of which Lopé was the most experienced forerunner. Despite relatively intact infrastructure and research programs, however, Lopé still faced many obstacles to becoming the tourism success President Bongo envisioned (Bongo 2002).

This dissertation work was motivated in part by my own passion for understanding and optimizing people/protected-area interactions, and in part by request of several of my colleagues at Wildlife Conservation Society, who were concerned with the negative community-park relations caused by farmer-elephant conflict. My specific questions and methods were most influenced by conversations with farmer-elephant conflict experts elsewhere in Africa. One particular e-mail neatly summarizes the view echoed by many:

> *"The only people in a position to address crop loss is the individual farmer. It seems in Gabon that people are some way from accepting responsibility. I believe that low tech methods made from material that can be sourced on site is the only way any method or deterrence system will be taken up by a farmer or village. …I don't even sympathize with a farmer who lost their crops to elephants if they were not guarding their fields- They are growing food in elephant habitat, of course the animals will eat it- they know that. People have to change."*

This perspective has inspired great creativity and helped many farmers throughout Africa to discover and implement such low-tech methods. My intent is not to villainize this perspective; however, I do hope to expand it by adding tools to assess the conditions under which such low-tech methods may or may not be taken up by farmers, and to explore other potential mitigation options in the case of the latter.

The need for more tools became apparent to me as I looked around Gabon, at these experts' urging, for farmers innovating or using low tech methods to protect against elephants; I found almost none[1]. I did not look everywhere, and certainly there are innovative farmers in Gabon, although innovation might not always lead to the kinds of protection concerned agencies may hope for[2]. Likewise, while I observed some small projects implemented by agencies to help farmers protect crops against elephants, most notably fencing projects by World Wildlife Fund and fenced community gardening projects by a few groups affiliated with the Ministry of Agriculture, these projects suffered notable lack of uptake and follow-through by farmers. Electric fencing projects failed due to lack of maintenance by the farmers involved[3]; donated fencing materials were not transferred to new parcels the subsequent year[4]; community garden projects deteriorated due to disagreement over who would pay for fencing and other materials the following year[5].

Farmers' lack of innovation, uptake, and continuation of methods to protect crops against elephants may suggest that elephants are not a real threat to agriculture in Gabon. The few available reports regarding assessments of actual damages seem to support this possibility. Languy (1996) estimated that elephants destroy less than one percent of crops near the Gamba complex. Although reporting substantial variation in estimates for the same area, Blaney et. al. (1998) produce a maximum estimate of 6% loss, which still may be low enough to provide farmers with little motivation to protect crops. However, both of these studies involved small sample

[1] The protection methods I did find, aside from a few projects funded by outside agencies, consisted of string-and-tin-can fences and burnt tires, which the proprietors themselves claimed did not work.

[2] For example, innovation can also lead to the conversion of D-batteries into "elephant bullets" for shotguns, which I witnessed more often than I witnessed other effective protection methods against elephants.

[3] Electric fences installed by World Wildlife Fund in Sette Cama and Gamba in 1997 failed after the first few years due to lack of maintenance (Mba, pers. com). Throughout Africa, electric fences have seen mixed success in deterring elephants (Thouless & Sakwa 1995; de Boer & Ntumi 2001; Omondi et al. 2004); however, they are generally inhibitive due to initial expenses and maintenance demands (Osborn & Parker 2002; Okello & D'Amour 2008).

[4] For example, logging cable donated and installed by World Wildlife Fund in Moukoualo and Mourindi effectively deterred elephants during the year of study (Mba, pers. com; farmers, pers com) but was not continued in subsequent years when farmers' own labor was required for installation. Despite this lack of uptake, projects following the same framework were being set up in Panga when I visited in 2006.

[5] For example, the community garden of Ayem in 2007, supported by the Ministry of Agriculture

sizes over relative short periods of time. Both also conclude that crop-raiding intensity varies substantially by location; while most farms are relatively unaffected by elephants, some are at high risk. A study by Lahm (1996) extends this observation to the national level; although farmers cited cane rats more frequently than elephants as a primary raider, elephant raiding was widespread in three provinces and observed raiding events often resulted in destruction of a large percentage of the farmer's crops. Despite these losses, over a third of farmers who lost crops to elephants did nothing to deter them.

In the decade following these preliminary studies, little seems to have changed in Gabon regarding the methods used by farmers and agencies to deter elephants from raiding crops, although it is clear that some areas are hard hit by crop-raiding. Most farmers I met knew of low-tech options yet chose not to implement them. Why would farmers who lost crops to elephants choose not to implement low-tech protection methods that were available to them? This was the driving question behind the research presented here. By exploring decision-making by Gabonese farmers in the context of farmer-elephant conflict, my goal was to gain insight into the characteristics and circumstances of adoptable protection strategies and to thereby assess the potential for various methods to mitigate farmer-elephant conflict in Gabon.

I spent two years in the field between 2005 and 2008 exploring farmer decision making and farmer-elephant conflict through various frameworks and methodologies. Most of my time was spent observing and interviewing farmers in villages throughout Gabon (Figure 1.1). I also interviewed other agents interested in farmer-elephant conflict including hunters, agricultural technicians, and conservation practitioners. In my time between villages, I interviewed urban residents to help situate my understanding of Gabonese agriculture and farmer-elephant conflict in their larger social settings.

Although planting practices have remained remarkably static, culture surrounding agricultural systems has changed drastically in the several generations spanning independence, from shifting camps that grew crops as a compliment to hunting (Lahm 1993; Pourtier 1989), to sedentary villages practicing swidden agriculture within walking distance. This process was initiated by colonial and Gabonese governments as the direct result of a *regroupement* policy that forced people to move to villages along the roads for better governance and access to services (Pourtier 1989). As common throughout Africa (Berry, 1993), post-colonial tends in labor diversification and migration to urban centers for schools and jobs have left farmers with scarce labor resources. These processes thus bring to the forefront the issue of labor in farmers' decision-making.

The implicit assumption that a low-tech method of protecting crops from elephants is low cost generally only applies if labor costs are not considered. The next three chapters are dedicated to this subject. In chapter two, I develop a theoretical model to allow for accounting for labor costs in addition to monetary costs when assessing costs and benefits of farm protection. In chapter three, I test this model against empirical observations and elaborate on other factors that impact the likelihood of a farmer using one of various strategies for protecting against or coping with raiding. Because I observed so few cases of protection, I move from the empirical to the hypothetical in chapter four, to explore farmers' willingness to pay different kinds of costs for protection strategies that might one day become available.

The fact that the majority of my work focuses on the level of the individual farmer reflects the fact that solutions presented in the farmer-elephant conflict literature almost invariably focus at this level, as do organizations interested in mitigating farmer-elephant conflict. However, if we find that farmers are unwilling to accept the extra costs, or "responsibilities," yet would like them to continue farming or to farm even more (Ministère de l'Agriculture 2007; République Gabonaise 2001, 2003), and to stop practicing the potentially cheaper strategy of killing elephants (Blake et al. 2008), a new strategy may be required. Colleagues studying farmer- or rancher-wildlife conflict in the developed world could offer new insight and tools; such literature generally takes for granted that farmers do not take responsibility for costly wildlife protected by the State[6] (e.g. Moberly et al. 2004; Naughton-Treves et al. 2003); tools used in these contexts, such as benefit-cost analyses and integrated assessments, could help decision-makers imagine other options.

The applicability of many solutions proposed for other parts of the world is not immediately apparent in the context of the developing nations faced with farmer-elephant conflict, however. The potential for and consequences of new strategies need to be explored within the specific context where they might be applied. In Chapter five, I discuss some of the processes and issues that decision-makers would need to consider as they begin shifting focus out to village- and landscape-level solutions. Specifically, I explore how mobility and modern concepts of "village" have influenced and might continue to influence farmer-elephant conflict in Gabon.

Methods of focusing out even further, to explore potential solutions at larger geographical and temporal resolutions, might include using GIS and agent-based modeling. For the purpose of this work, however, I conclude with recommendations for an Integrated Assessment in chapter six, to begin the process of imagining new strategies to move forward in addressing farmer-elephant conflict in Gabon, taking into account the mandates and needs of the various stakeholders and interested parties.

Such an Integrated Assessment is ambitious. However, I do not believe that it is more ambitious than trying to change farmers' behaviors if they are indeed acting rationally. Integrated problem-solving, involving multiple stakeholders and perspectives, offers a more fruitful path to finding lasting solutions and to developing the institutions and skills necessary to adapt to constantly changing social-ecological systems (Berkes et al. 2003; Costanza et al. 2001; Folke et al. 2002).

[6] I have yet to come across a serious solution proposal to human-carnivore conflict in the United States entailing ranchers sleeping with their sheep or cattle as their ancestors used to do.

The title of this dissertation borrows from a work of another expert on farmer-elephant conflict:

> *"Most attempts to tackle cases of elephant crop raiding are searches for an effective palliative -- an aspirin for that particular situation. But the elephants will always return unless a long-term solution is found by addressing the underlying causes of the problem."* (Barnes 2002)

Here, I provide some tools to help distinguish between aspirin and real solutions. If we find that we are really pushing palliatives, or even proposing solutions that further aggravate farmer-elephant conflict in Gabon, we need to be willing to dig deeper into the underlying issues. I provide some tools and perspectives, but I do not provide the miraculously simple, low-cost solution that my colleagues might have hoped for; the solution, I believe, lies in the will of the decision-makers.

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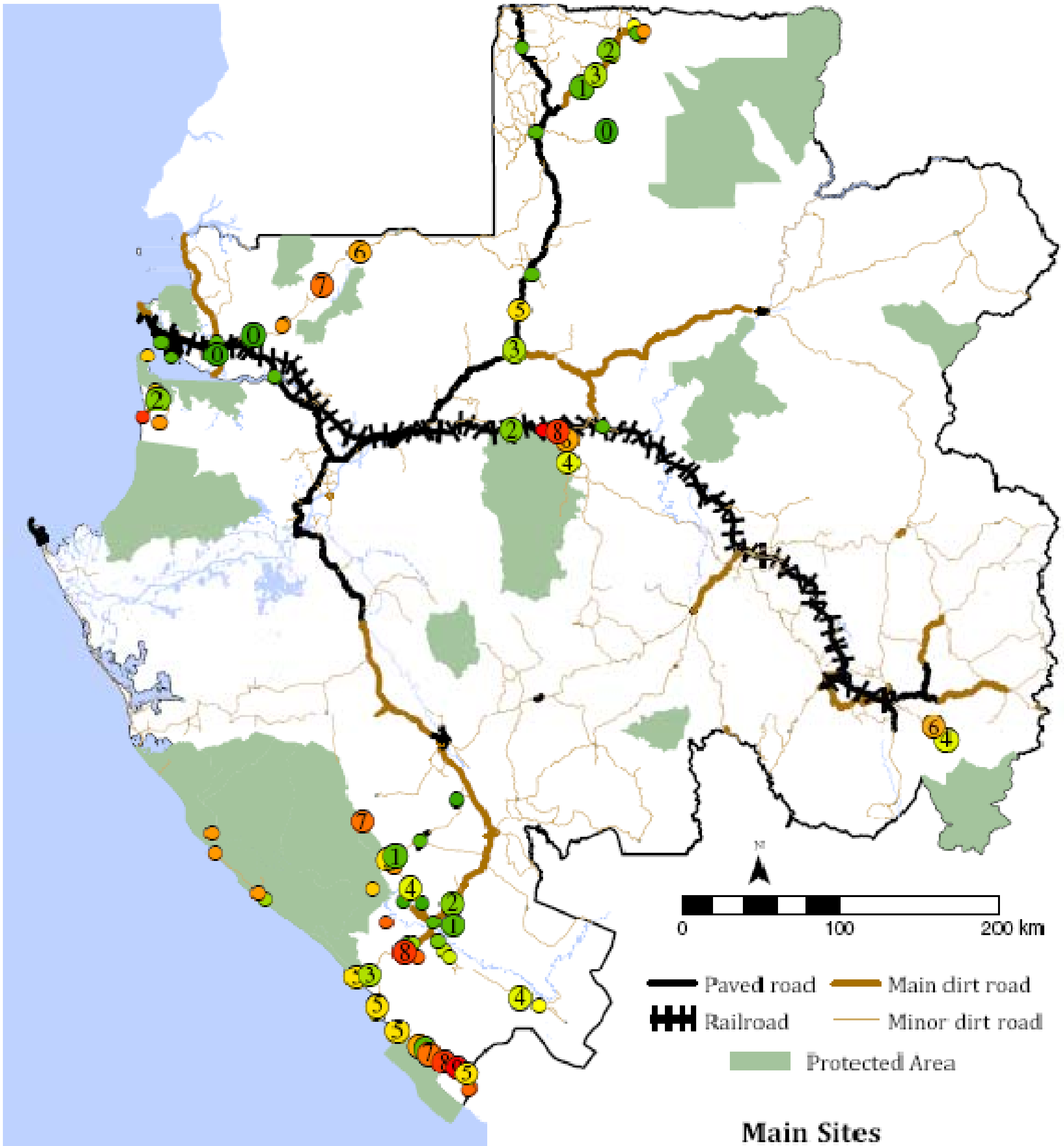

Fig 1.1: Farmer-elephant conflict study sites in Gabon. Main sites are the 36 sites in which I stayed and sampled methodically. Minor sites are sites I visited, interviewed farmers, and visited some farms, but did not sample methodically. Colored circles represent my assessment of risk and intensity of elephant raiding.

Chapter 2

Benefit-cost analysis of methods to reduce crop-raiding by elephants in Gabon

Abstract:

Crop-raiding by elephants can be a major risk for farmers in central Africa. Despite overwhelming consensus on the need to reduce crop-raiding and decades of research invested, efforts have had little success. Such efforts have consistently involved prescriptive "low-cost" protection methods at the level of the individual farm, assuming that rational farmers will adopt such methods once provided required knowledge and skills. Here, I present a benefit-cost analysis that considers both monetary and labor costs of such strategies in comparison with the alternative coping strategy of planting more to compensate expected losses. I find that proposed protection strategies are generally inferior to coping strategies in situations where farmers expect to lose less than half of their unprotected crops to elephants. Where expected losses are higher, proposed protection strategies may be superior, depending on technological efficiency and cooperation among farmers. This analysis is based on interviews and farm observations with 426 farmers in 36 villages in Gabon, but frames a general reflection process regarding technology adoptability that applies anywhere.

Introduction:

Elephants can destroy an entire year's work of crops in a single visit, threatening not only farmers' livelihoods but also the elephants themselves when angry farmers retaliate. While formal research on methods to mitigate farmer-elephant conflict is in its infancy in Gabon, several localities across Africa offer longstanding experiments from which concerned agencies can garner much. When considering farm-level protection methods (the most popular mitigation technique) however, transferability of technologies should be examined with care before encouraging farmers to adopt them. Questions of transferability take two forms: 1) functionality and efficiency of the technologies in a new ecological setting, and 2) feasibility and adoption potential in different social and economic situations. Ideally, both types of transferability should be assessed simultaneously for each proposed solution in each locality; constraints on time and resources, however, render such a thorough assessment unrealistic. Here, I use a simple economic framework, narrowing the range of possible solutions to ensure that limited time and resources are spent researching those methods with the highest likelihood of being adopted by farmers.

The success of a mitigation scheme depends as much on farmer adoption as it does on effectiveness of the technology. A solution that is effective in keeping elephants out, but is unattractive to farmers for cultural or economic reasons, is as useless as an ineffective solution. Economic benefit-cost analysis provides a framework for predicting likelihood of adoption using the principles of 1) economic threshold: act only if the benefits of acting outweigh the costs, and 2) input/output optimization: when choosing among multiple options, choose the one that maximizes net benefits. Under this framework, farmers can be expected to adopt a given protection method if: the expected benefits exceed the expected costs, or in other words, if the expected losses without the protection strategy are greater than the expected losses with the protection strategy minus the costs of implementing the protection strategy, *and* if these net benefits are higher than for any other available option.

Economic threshold and input/output optimization are prominent principles in the agricultural decision-making literature, spanning insect management (e.g. Mumford & Norton 1984; Pedigo et al. 1986), weed control (e.g. Wiles 2004; Wilkerson et al. 2002), and crop choice (e.g. Janssen 2007). Such theories are clearly applicable to farmer-decision making regarding wildlife (Moberly et al. 2004) and have been used to assess the tradeoffs of farming in areas of high elephant densities versus areas with lower densities (Kamonjo et al. 2007). Economic considerations appear often in farmer-elephant conflict literature in the sense that "high-cost" protection methods requiring expensive materials are generally dismissed as impractical for individual farmers (de Boer & Ntumi 2001; Osborn & Parker 2002, 2003). Broadly missing from the farmer-elephant conflict literature, however, is a discussion of the economic value of labor and the need to account for labor costs in addition to monetary costs when predicting farmer uptake of protection methods.

Household labor is one of the most important inputs to small-scale swidden agriculture (Ruthernberg 1976) and has been shown to substantially impact agricultural decision-making and output under conditions similar to those in Gabon (Elad & Houston 2002). It is therefore not surprising that labor costs and constraints influence farmers' decisions about adopting new technologies (White et al. 2005). When calculating input/output ratios for plantation protection methods, it is just as reasonable to expect farmers to choose a method that maximizes outputs for a given level of labor input as it is for a given level of monetary input.

Incorporating traditionally-unmeasured labor costs in a benefit-cost analysis framework provides insight into why farmers have rejected proposed crop protection methods in the past and helps predict whether they are likely to accept similar solutions under development for the future. While some methods, such as fences or guards, might be relatively effective in reducing losses, the costs of implementation may be such that less effective coping strategies, such as planting multiple parcels to distribute risk or planting larger parcels to buffer against losses, offer greater net benefits and thus more appealing options. More appealing does not mean ideal, however; farmers who opt for coping strategies will likely still be upset when elephants raid their crops. However, convincing a farmer to adopt a protection method with a lower net benefit is probably futile. Below, I demonstrate the role of benefit/cost analysis in predicting farmer uptake of farm protection methods using data on small-holder farming systems in Gabon.

Methods:

RESEARCH LOCALITY: I observed farms and interviewed farmers in 36 villages across Gabon, mostly in the northern, central, and southwest regions. These sites included 26 villages with current exposure to elephants and ten control sites having no current contact with elephants. Gabon is primarily forested and contains one of the densest populations of African forest elephants, *Loxodonta cyclotis* (Barnes 1997; Blake et al. 2008). Gabon's human population, however, is among the least dense, with an average of four persons per square kilometer. Over 70% of people live in a handful of urban centers (République Gabonaise 1993), leaving the rural countryside very sparsely populated. Despite this small rural population, rural farmers are responsible for 80% of Gabon's agricultural production (Nguema 2005). Rural agriculture is almost always rain fed and swidden, with a one to two-year production cycle and a five to thirty-year fallow period. Men clear the new farm and are traditionally responsible for protecting it against wildlife, while women do most of the planting, weeding and harvesting. Although farmers have battled crop-raiding wildlife for generations in Gabon, recent government protection of conspicuous crop-raiding animals such as elephants has brought farmer-wildlife conflict issues to the spotlight. Other top raiders include cane rats, mandrills, gorillas, chimpanzees, buffalo, and bush pigs (Lahm 1996).

MODEL OVERVIEW: Based on my own observations and reports from various institutions, I estimated costs (monetary and labor) of different strategies of protecting crops from elephants as well as benefits of such protection. Under the general basis of benefit-cost analysis, a farmer is expected not to choose a given protection strategy $(\boldsymbol{k})$, unless the net benefit of doing so ($\boldsymbol{NB_k}$) is positive. The net benefit of protection is the product of the value of the crop per unit of area ($\boldsymbol{V}$), the area planted ($\mathbf{A}$), the expected percentage of crop lost without protection ($\boldsymbol{L}$) and the efficiency of the protection strategy ($\boldsymbol{E_k}$) in terms of the percentage of L averted, minus the costs of implementing the protection strategy ($\boldsymbol{C_k}$).

Net benefit of protection strategy: $\boldsymbol{NB_k = V * A * L * E_k - C_k}$

This equation allows us to not only identify fruitless strategies where costs outweigh benefits, or $NB_k < 0$, but also to compare strategies to maximize NB_k . A rationally acting farmer is expected to opt to protect his or her crops using method k if NB_k is positive. When choosing between strategies, however, a farmer will choose that with the larger net benefit, or NB_k value. Strategies to be weighed include not only protection methods but also coping strategies such as planting multiple parcels to distribute risk, planting extra crop to buffer against losses, or planting closer to the home (in less fertile soil). By taking into account such coping schemes when comparing net benefits, this model allows us to determine whether a proposed protection strategy will theoretically be adopted by a farmer in a given situation.

	Table 2.1: Variables used in benefit-cost model
$\boldsymbol{V}$	Crop value ($/m² = kg/m² * $/kg at market)
$\boldsymbol{A}$	Total area planted (m²)
$\boldsymbol{C_p}$	Marginal costs of planting ($/m²)
$\boldsymbol{L}$	Percent of unprotected crop farmer expects to lose to elephants
$\boldsymbol{A_{BUF}}$	Extra area planted to compensate 1m² of loss due to L (m²)
$\boldsymbol{k}$	Protection method
$\boldsymbol{E_k}$	Efficiency of *k (*percent of L prevented)
$\boldsymbol{C_k}$	Cost of *k ($)*
$\boldsymbol{NB_k}$	Net Benefit of *k ($)*
$\boldsymbol{NB_{px}}$	Net Benefit of planting extra *($)*

PROTECTION STRATEGIES : I chose to analyze protection strategies (k) based on those most prominently discussed in the human-elephant conflict literature or by organizations or individuals in Gabon. I grouped similar strategies to represent the wide spectrum of options without overwhelming the presentation. Other strategies can always be added into this framework. Those evaluated here are:

- THREE "LOW-COST," HIGH-MAINTENANCE STRATEGIES:

  PG) Hot pepper grease applied along a wire fence with cloth strips. Methods follow with those presented by Ongognongo and Stokes (2006), with weekly reapplication of the grease.

PB) Hot pepper and sawdust bricks burnt weekly. Methods follow with those of Ongognongo and Stokes (2006), with bricks burnt weekly at 50m intervals along the perimeter.

S) Sleeping nightly in the plot to chase away raiding elephants. Includes building a simple hut and encircling the farm with a simple wire alert system.

- **ONE "HIGH-COST", LOW-MAINTENANCE STRATEGY:**

  BW) a two-strand barbed-wire using live trees as posts

- **ONE COPING STRATEGY:**

  PX) Planting extra crops to buffer against losses. The cost of this strategy is the cost of planting a given unit of area ($\boldsymbol{C_P}$) times the extra area needed to buffer losses ($\boldsymbol{A_{BUF}}$)**.** Depending on the situation, A_{BUF} can follow different functions in relation to the expected percentage of crop lost (L):

  - **Linear $\boldsymbol{A_{BUF}}$:** In many cases, elephants enter the farm sporadically, take a small percentage of the crop, and leave the rest standing. In these cases, one could presume that planting extra would not increase the amount eaten, as the elephants could have just as easily eaten the crop that was left standing. The amount a farmer would need to plant to buffer against losses would thus equal the amount s/he expected to lose originally: $A_{BUF} = A * L$, where A represents the original area planted.
  - **Power $\boldsymbol{A_{BUF}}$:** In other situations, elephants take a higher percentage of the crop at a time. In these cases, one could presume that elephants would eat a similar proportion of the extra crop planted. Thus, the amount a farmer would need to plant to buffer against losses would follow a power series function: $A_{BUF} = A * \sum_{n=1}^{\infty} L^n$
  - **Compromise $\boldsymbol{A_{BUF}}$:** For this general analysis, I compromised between these two situations by estimating the amount one would need to plant to buffer against losses as the average of the linear and power-series estimates. Thus extra area planted to buffer against losses is thus:

$$\boldsymbol{A_{BUF} = A * (L + \frac{\sum_{n=2}^{\infty} L^n}{2})}$$

A secondary component, cooperation among farmers, can be applied to any of the above strategies to reduce individual risk and minimize costs. Gabonese farmers often clear land in clusters such that each farmer's parcel borders those of fellow farmers. Farmers generally explain clustering as both a means to enhance personal safety by decreasing isolation and a strategy to decrease individual losses to wildlife by reducing edge effects. In theory, an additional benefit of clustering is substantial reduction of protection costs by reducing each farmer's share of perimeter for fencing projects or by distributing responsibilities, such as sleeping in the farm, among multiple individuals. I therefore evaluated the above strategies at different raiding intensities as well as varying levels of farmer cooperation.

CROP VALUE: To estimate crop value, I focused on the three most typical cropping systems in Gabon:

- ***Plantain*)** dominant crop of plantain or banana with a mix of taro, sweet potato, or yam as minor crops
- ***Manioc*)** dominant crop of cassava with squash or yam as minor crops
- ***Nut*)** first-cycle dominant crop of groundnuts with corn as a minor crop, followed by a second-cycle dominant crop of cassava

To create a representative prototype for each system, I visited the farms of 426 households in 36 villages throughout Gabon and measured fields with a handheld GPS unit to calculate average percent cover for each crop. To estimate the average value per square meter of each system, I multiplied the percent cover yield estimates and value of each crop in the market. Lack of systematic agricultural data for Gabon render precise estimates for yield and value unrealistic; I estimated upper and lower error bounds where possible to convey degree of certainty and provide sources for yield and value estimates in appendix A.

EXPECTED LOSSES: Expected percentage lost without protection (L) varies widely depending on site. To explore the range in raiding risk, I interviewed 304 farmers in 26 sites with current exposure to elephants and 122 farmers in ten control sites having no current contact with elephants. To assess risk perception, farmers were asked to: recount all raiding incidences in the past 12 months, indicate on a visual Likert-like scale their level of certainty that a raid will occur in the next 12 months, and remove pebbles from a 10x10 grid to illustrate percentage of crop lost per raid.

It is common for farmers to exaggerate losses (Bell 1984; Languy 1996; Malima et al. 2005), either consciously, for example in an attempt to draw attention and compensation funds, or unconsciously due to psychological phenomena of risk aversion (Anderson 2003). A farmer's decision is based on his or her perception of risk, whether empirically accurate or not; the latter source of exaggeration is thus not a problem for analysis of decision-making. Conscious exaggeration can lead to faulty calculations, however, as a farmer's decisions are based on different information than that which is reported. To reduce conscious exaggeration, I clearly explained my role as a researcher, lived about a week in each village and developed a rapport with the community, and observed elephant signs and crop health in the surrounding area to substantiate farmers' reports and inform follow-up questions.

COST OF PROTECTION (C_k) generally entails both a monetary and labor/temporal component. I estimated the monetary cost to protect one hectare based on the market value of required materials and information from farmers and organizations regarding the lifespan of such materials in the field. Although farms are rarely neatly square in Gabon, I assume that farmers are able to make square farms, and would choose to do so if building a fence, based on observations of fencing projects. I therefore used 4√Area for perimeter-based calculations such as fencing length. For clustered farms, I divided this value by √N, with N representing the number of farmers sharing a fence, to estimate an individual's share of the perimeter. I estimated labor costs in man-hour equivalents by observing the time required for an adult male (or adult female for culturally female-specific work) to complete necessary tasks. I used the reported market value of labor for similar work to convert these temporal costs to monetary costs.

EFFICIENCY (E_k) is also a highly variable parameter; it is difficult to determine for many protection systems, and probably impossible on a national scale. The initial model is based on the assumption that E_k is 100% for all methods, or that an elephant will not touch crops if the protection method is properly implemented (all estimated costs are paid). While unrealistic, setting E_k to 100% for all methods yields important initial insights. I later relaxed this assumption to examine the expected effects of imperfect efficiency on farmer decision-making. Setting the net benefits equal to zero and solving for E_k reveals the "break even" efficiency level, at which a given method becomes adoptable: $E_k > C_p VAL$.

Simply yielding positive net benefits, however, is not a sufficient requirement for a solution to be optimal. Other strategies, such as the readily available alternative of planting extra to buffer against losses (PX), may have higher net benefits. The net benefit of planting extra equals the value of the expected losses averted (VAL) minus the cost of planting the area required ($C_p * A_{BUF}$).

Net benefit of planting extra: $\boldsymbol{NB_{px}} = (\boldsymbol{VAL}) - (\boldsymbol{C_p A_{BUF}})$

A protection strategy, k, is superior to PX when it has a higher return rate, or when:

$$\frac{VALE_k - C_k}{C_k} > \frac{VAL - C_p A_{BUF}}{C_p A_{BUF}} \text{ or: } C_k < E_k C_p A_{BUF}$$

From the above equation, we can derive the break-even efficiency level at which a protection method, k, becomes adoptable over the alternative of planting extra:

Break-even efficiency: $E_k > C_k / C_p A_{BUF}$

Table 2.2: Summary of optimal strategies in benefit-cost model	
Optimal strategy:	**"Break even" efficiency**
▪ Do nothing if: $(VALE_k - C_k) < 0$ & $(VAL - C_p A_{BUF}) < 0$	$E_k > C_k / VAL$
▪ Adopt k over PX if: $C_k < E_k C_p A_{BUF}$	$E_k > C_k / C_p A_{BUF}$
▪ Adopt PX over k if: $C_k > E_k C_p A_{BUF}$	$E_k < C_k / C_p A_{BUF}$
▪ Adopt strategy k with highest $\frac{(VALE_k - C_k)}{C_k}$	

Results:

RAIDING RISK: Estimated annual losses to elephants averaged 35% of total crops planted among farmers in the 26 sites with exposure to elephants (Table 2.3). Although all of these 26 towns received at least one visit by elephants in the year, intensity of elephant raiding varied greatly; barely half (157) of the farmers interviewed in these 26 sites considered elephants to be their worst pest. Among these 157 farmers, estimated annual losses to elephants averaged 45%, with most estimates falling between 30% and 63%. Although there was some within-village variation, individual's estimates and village-level averages both showed strong correlation with my ordinal ranking of elephant intensity from independent field observations (Spearman's rank correlation, rho=.62 and .86 respectively, p<.0001 for both).

Table 2.3: Farmers' estimated expected crop loss to elephants and rodents

	Mean	Median	first quartile	third quartile
Expected % crop loss to elephants:				
All farmers (N= 426)	26%	20%	0%	42%
Farmers in towns with elephant exposure (N= 304)	35%	36%	15%	55%
Farmers who consider elephants worst pest (N=159)	**45%**	41%	30%	63%
Expected % crop loss to rodents:				
All farmers (N= 426)	27%	24%	10%	38%
Farmers who consider rodents worst pest (N=183)	**38%**	37%	25%	50%

CROP VALUE AND COSTS OF PLANTING: The 426 farmers interviewed had planted a total of 924 plots in the 12 months prior to the interview. Of these plots, 276 fell under the general plantain cropping system, 576 fell under the manioc cropping system, and 72 fell under the nut system (Table 2.4). The plantain cropping system requires more fertile soil than the other two and is grown with an average fallow period of 22 years compared to 14 for manioc and 9 for nuts. Due to this increased fallow period, plantain parcels are farther from the home (two kilometers compared to one kilometer for the other two systems) and require more initial labor to cut, often requiring a chainsaw, which costs substantially more than typical axe methods used in areas with shorter fallow periods. This initial investment is somewhat balanced by the lower costs for preparing and planting a plantain system, however, because weeding requirements decrease as fallow period increases.

Based on my observations of farming activities, farmers' recollections of time and or money spent on different tasks, and parcel measurements, I estimated the cost of planting one square meter (costs of planting extra to buffer against losses) as $0.24 for plantain systems, $0.19 for manioc systems, and $0.20 for nut systems, each within an error bound of ±$.04 (Table 2.5). Although farmers often pay temporary laborers, these costs are entirely labor-derived and require no financial investment (with the exception of seed material for farmers who have no carryover material and gender-specific labor costs for farmers who have no corresponding labor capital). Because farmers often pay temporary laborers, however, there is a general consensus on the value of labor for different tasks, allowing for easy conversion of labor-value to monetary-value and vice-versa.

Table 2.4: General information and value estimates for prototype crop systems

	N	Fallow (yrs)	size (ha)	dist. (km)	cluster size	Main crop		Secondary		seed mat. (cfa/m²)	Total value (cfa/m²)	**Total value[b] (US$/m²)**
						yield[a] (kg/m²)	price[a] (cfa/kg)	yield[a] (kg/m²)	price[a] (cfa/kg)			
Plantain	221	22 (±3)°	0.40 (±0.04)°	2.0 (±0.2)°	3.3 (±0.4)°	1.42 (±0.79)	361 (±161)	0.06 (±0.02)	617 (±36)	30 (±8)	575 (±406)	1.13 (±0.8)
Manioc	389	14 (±2)°	0.31 (±0.02)°	1.1 (±0.1)°	3.9 (±0.6)°	1.48 (±0.97)	130 (±20)	0.06 (±0.02)	448 (±29)	25 (±0)	244 (±146)	0.48 (±0.29)
Nut	155	9 (±2)°	0.20 (±0.02)°	0.9 (±0.1)°	4.9 (±0.6)°	0.09 (±0.02)	883 (±68)	1.48 (±0.97)	130 (±20)	12 (±0)	268 (±150)	0.52 (±0.29)

a See Appendix A for data sources and summary methods. °mean and 95% confidence intervals of data from 426 farmers.

Table 2.5: Costs of planting for prototype crop systems

	seed mat. (cfa/m²)	**Cutting**		**Clearing**		**Weeding**		**Planting**		Total time (hr/m²)	Total cost (cfa/m²)	**Total cost[b] ($/m²)**
		Labor (hr/m2)	value (cfa/m²)	Labor (hr/m2)	value (cfa/m²)	Labor (hr/m2)	value (cfa/m²)	Labor (hr/m2)	value (cfa/m²)			
Plantain	60	0.01 (±0.004)	12.0 (±1.5)	0.02 (±0.01)	10.7 (±4.9)	0.07 (±0.02)	30.9 (±9.6)	0.02	9.2	0.13 (±0.04)	123 (±16)	**$0.24** (±0.03)
Manioc	25	0.02 (±0.003)	9.7 (±1.4)	0.03 (±0.01)	11.7 (±4.2)	0.11 (±0.02)	45.7 (±8)	0.01	5.0	0.16 (±0.03)	97 (±14)	**$0.19** (±0.03)
Nut	5	0.01 (±0.002)	6.1 (±1.2)	0.03 (±0.01)	12.9 (±3.5)	0.15 (±0.04)	70.3 (±18)	0.02	10.0	0.21 (±0.05)	105 (±23)	**$0.20** (±0.04)

All means and 95% confidence intervals of data from 426 farmers. [b] $1 = 511cfa

Protection costs: Estimates for the costs of the four protection strategies studied are summarized in Table 2.6. Logging cable has by far the highest material cost at US$1.61 per meter of perimeter, even when reused over four years; barbed wire, pepper grease and pepper bricks follow at $0.90, $0.78 and $0.70 per meter, respectively. Sleeping in the field has the lowest materials costs for all but the tiniest gardens, at a rate of $0.02 per meter plus a flat rate of $35 for building a hut. Total material costs for the prototypic plantain plot of .40 hectares are thus USD$407, $221, $197, $177, and $40 respectively. Material costs for pepper buffer and pepper grease could be reduced by growing the required pepper one's self and thus converting material costs to labor costs. Labor costs follow a near-inverse pattern, with sleeping in the field being the most expensive at $1797 plus $0.01 per meter perimeter, followed by pepper grease at $2.20 per meter, pepper bricks at $0.21 per meter, and barbed wire and logging cable both at $0.17 per meter. Total labor costs for protecting the prototypic plantain plot are thus: $1,800, $557, $53, and $43 respectively, yielding a combined cost of $1840 for sleeping in the field, $753 for pepper grease, $450 for logging cable, and $271 for barbed wire and $230 for pepper bricks.

Table 2.6: Costs of five methods of protecting crops from elephants

	Materials		Prep. & Installation			Maintenance			Total costs (US$)[b]		reuse[c] (yrs)
	cfa (flat)	cfa/m	flat (WD[a])	WD[a]/ m	cfa/ WD[a]	flat (WD[a])	WD[a]/ m	cfa/ WD[a]	Materials	Labor	
Barbed wire (BW)	0	459	0	0.013	3000	0	0.020	2500	$0 + 0.90/m	$0 + 0.17/m	0
Pepper grease (PG)	0	400	0	0.067	3000	0	0.370	2500	$0 + 0.78/m	$0 + 2.2/m	0
Pepper bricks (PB)	0	358	0	0.000	2500	0	0.043	2500	$0 + 0.70/m	$0 + 0.21/m	0
Logging Cable (LC)											4
average	0	824	0	0.025	3000	0	0.005	2500	$0 + 1.61/m	$0 + 0.17/m	
LC – first year	0	2748	0	0.011	3000	0	0.005	2500	$0 + 5.38/m	$0 + 0.09/m	
LC – subsequent yrs	0	275	0	0.025	3000	0	0.005	2500	$0 + .54/m	$0 + 0.17/m	
Sleep in farm (S)											4
average	18000	10	2	0.002	3000	365	0.000	2500	$35 + 0.02/m	$1797 + 0.01/m	
S – first year	40000	10	2	0.002	3000	365	0.000	2500	$78 + 0.02/m	$1797 + 0.01/m	
S – subsequent yrs	10000	10	2.5	0.002	3000	365	0.000	2500	$20 + 0.02/m	$1800 + 0.01/m	

[a] WD = 6 hours of adult labor (a typical Gabonese work day). [b] US$1 = 511cfa

[c] # of years core material can be reused in new field, according to farmers

Benefit-cost analysis: In this model, costs of protection strategies do not vary with raiding intensity. However, costs of the coping strategy of planting extra to buffer against losses does vary with raiding intensity, as the higher the expected losses, the greater the area that must be planted to compensate. Under the (unrealistic) assumption that all protection methods are 100% efficient, a farmer's decision could be predicted from Figure 2.1. For example, a farmer growing the prototypic plantain parcel of .4 hectares who expects to lose 30% of her crop to elephants could be expected to choose to use pepper bricks, as this has the lowest associated cost (Figure 2.1A). If this option is not available or does not have a high enough efficiency rate, the farmer might choose barbed wire. If this is also deemed infeasible or inefficient, the farmer would be expected to choose to plant more to buffer against losses over the remaining options, even if the other options are truly 100% efficient. For a farmer growing the same prototypic plantain plot who expects to lose 63% of her crop to elephants, all of the options with the exception of sleeping in the farm become adoptable over the alternative of planting extra at high efficiency levels. For the farmer growing the prototypic manioc parcel, only pepper bricks are the only rational option until expected losses are above 30%, regardless of the efficiency of the other methods (Figure 2.1B).

Relaxing the assumption that all methods are 100% effective, Figure 2.2 illustrates the break-even efficiency level at which a given protection method would have to perform to be appealing to a farmer. For example, in a situation where a farmer growing the prototypic .40 hectare plantain plot expects to lose 30% to elephants in the absence of protection, pepper bricks or barbed wire would be better than doing nothing if they reduced crop loss by 20% or more. Likewise, logging cable would be reasonable if it reduced crop loss by 33% or more, and pepper grease would be reasonable if it reduced crop loss by 55% or more. In situations where expected losses without protection are higher, minimum efficiency levels are considerably lower, suggesting that proposed protection methods can be worthwhile even when

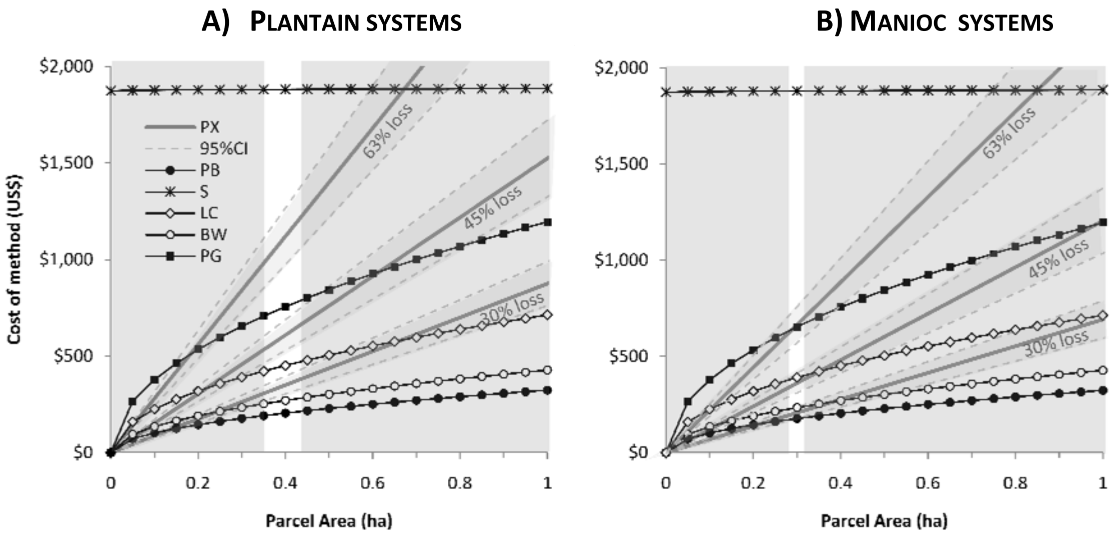

Figure 2.1: Costs of protecting A) plantain and B) manioc parcels for five protection strategies compared with costs of planting extra to buffer losses at three levels of raiding intensity. The three intensity levels represent the mean and first and third quantiles for estimates of expected crop loss to elephants given by the 159 farmers who cited elephants as their worst pest. Dashed lines show confidence in cost of planting estimates. Vertical white bars highlight size of prototypic systems.

relatively inefficient. The bottom row of Figure 2.2, however, illustrates the minimum efficiency level at which a protection method would be expected to be adopted over the alternative of planting extra to buffer against losses. Here, we see that only pepper bricks and barbed wire can outperform planting extra for a .4 hectare plantain parcel when expected losses without protection are 30%. For pepper bricks to be preferred over planting extra, efficiency must be around 65% or higher. For barbed wire to be a feasible alternative, efficiency must be around 75% or higher. For a .4 hectare parcel at a raiding intensity of 45%, pepper bricks and barbed wire are optimal strategies if they reduced crop loss by around 50%. Logging cable can also be optimal over planting extra if it reduces crop loss by 70%. At a raiding intensity of 63%, pepper grease also becomes a potentially optimal strategy at high efficiency levels.

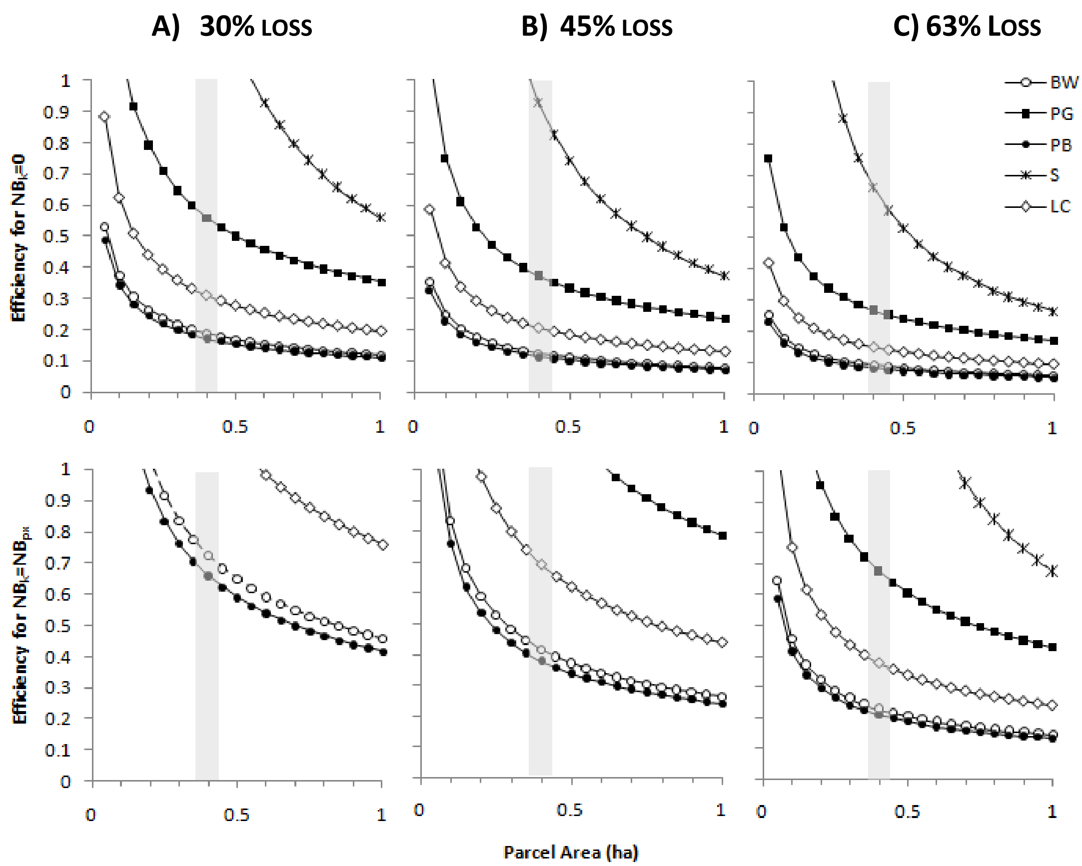

Figure 2.2: Efficiency level at which net benefits of protecting plantain plots are positive (top row) and outweigh net benefits of planting extra (bottom row) for varying farm size and raiding intensity. The three intensity levels represent the mean (B) and first and third quantiles (A and C, respectively) for estimates of expected crop loss to elephants given by the 159 farmers who cited elephants as their worst pest. Vertical gray bars highlight the average sized plantain parcel.

COOPERATION: The results thus far suggest that some methods, such as sleeping in one's farm, are almost never worthwhile. However, net benefits of protection methods can be significantly altered via cooperation. By clustering plots together, multiple households can reduce protection costs by reducing their individual share of the perimeter to be fenced or by sharing the costs of sleeping in the farm. Farmers growing .4 hectares of plantain individually and expecting 45% loss to elephants without protection would see a similar ranking of strategies if sharing costs among three farmers as if acting individually. As cooperative groups increase to five or ten farmers working together, however, other methods become more attractive, even at relatively low efficiencies (Figure 2.3).

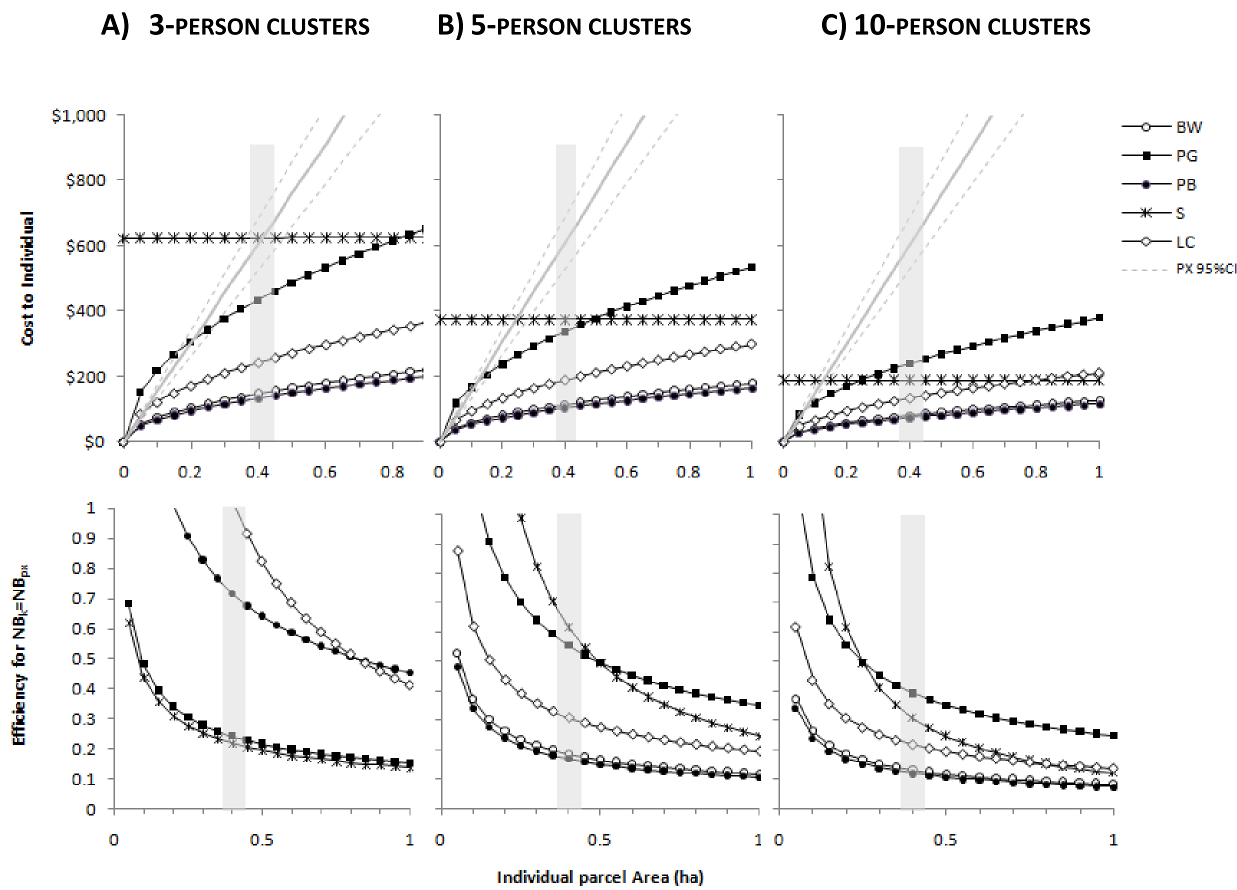

Figure 2.3: Effect of cooperation on net benefit of protection methods for plantain plots where expected loss without protection is 45%. Top row compares costs of protection and planting extra from the perspective of an individual farmer for three levels of farmer cooperation. Bottom row directly compares the four protection methods to the coping strategy of planting extra (PX), illustrating the minimum efficiency level at which net benefits of protection outweigh net benefits of planting extra. Vertical gray bars highlight average sized plantain plots.

Discussion:

This analysis yields much insight into likelihood of adoption of crop protection methods. Knowledge of the efficiency of the proposed method in keeping elephants out is essential if the goal is to estimate the exact benefit of a method. However, reliable tests of technology efficiency require considerable financial and time investments. Here, I demonstrate that many methods can be ruled out for a given situation by starting off with the assumption that they are 100% efficient. By requiring this type of adoptability assessment, we can help ensure that limited resources are used to explore projects that are likely to succeed.

A simple first test of adoptability is whether a farmer expects a net gain from implementing the proposed method, in other words, if the value of the crops protected exceeds the cost of implementation. The paucity of agricultural data in Gabon, however, renders this a daunting task in and of itself. For example, fertilizer-free yield estimates for the staple crop, manioc, vary from 5.1 tonnes/hectare (FAOSTAT 2009) to 40 tonnes/hectare (Edou-Edou 2005) with little justification of methods in any account (see Appendix A for more details). Given this variation, the value of crops lost to elephants for a .3 hectare manioc plot at a 45% raiding-intensity could fall anywhere from $360 to $1455; a substantial difference when evaluating the value of an investment in materials to protect the crop.

Better agricultural data would benefit decision-making in Gabon in many ways. In the absence of such data, however, this analysis shows how this problem can be circumvented in many situations by focusing on costs of protection compared to the costs of the alternative strategy of planting extra rather than to the raw value of the lost crop. Only where expected crop loss is so high that the net benefit of planting extra is negative does the value of the crop become relevant, as the option of planting extra then becomes an unviable strategy against which to compare alternatives. The net benefit of planting extra is never negative if the extra amount required to buffer against losses (A_{BUF}) is a linear function of raiding intensity. If, however, A_{BUF} is a power-series function of raiding intensity, net benefit becomes negative when expected losses approach 82% for plantain and 72% for manioc. If the function falls somewhere between linear and power-series, as assumed in this analysis, net benefits of planting extra become negative when expected losses approach 89% for plantain and 81% for manioc.

Focusing on the alternative strategy of planting extra allows us to do much more than simply circumvent lack of data; it provides a mechanism for introducing labor costs into our accounting. When assessing economic feasibility of projects, it is common to consider only financial costs. Farmers also have constraints on their labor, however, and often reject projects because of their labor requirements (Graham & Ochieng 2008; Ongognongo et al. 2006). By comparing "low-cost" but potentially labor-intensive protection strategies to the alternative of planting extra to buffer against losses, we can directly explore payoffs in allocation of labor resources, as planting extra requires little to no financial capital. If the net benefit of a different strategy is less than that of planting extra, it is fair to say that a farmer will probably find it unattractive. Caution should be taken when combining financial and labor costs into one total cost, however. There is good reason to consider financial costs separately from labor costs, as most swidden farmers do not have much financial capital to invest in projects. Exercises such as this one may make projects that require heavy financial capital, such as barbed wire, appear more feasible than they actually are for certain farmers. I argue that that dropping labor costs from the equation entirely can be equally misleading. Separate analyses may need to be done for farmers with financial capital and those without to assess adoptability in a specific situation.

Although coping strategies such as planting extra to buffer against losses may yield the largest net benefits, they go undetected as strategies due to difficulty in distinguishing them from doing nothing. Other coping strategies include moving the farm closer to the house and switching from plantain systems to manioc or nut systems, which are less attractive to elephants and have less exposure time due to faster maturation. More information on soil fertility and local markets would be required to assess the net benefits of such strategies. Keeping a farm close to the house, for example, entails short fallow periods, which generally result in lower yields and substantially higher investment in weeding. Growing less plantain and more cassava, or less cassava and more groundnuts, likewise entails considerable losses, as each respective system has a considerably lower output/input ratio. Farmers often make these changes for reasons that have nothing to do with elephants, however. For instance, farmers with no access to male labor to clear large trees generally plant cassava over plantain. Farmers who are sick or tired may choose to plant closer to the house. Access to market also influences planting decisions, as cassava and groundnuts store longer and are much easier to transport than plantains. In the absence of knowledge regarding what a farmer would have planted if elephants were not a threat, it is difficult to say whether farmers are actually implementing coping strategies. However, failure to consider these strategies as alternatives in benefit-cost analyses can lead to overly optimistic technologies and overly pessimistic opinions of farmers.

Using a cooperative strategy to minimize costs shows much promise in theory but can be more difficult to implement in practice. Farmers do often cluster together in groups of three or four, but most interviewed expressed concern over free-riding problems when asked about the possibility of sharing materials or labor costs of protection. Those who thought sharing was a good idea generally agreed that groups of three or four were the optimal size, beyond which they believed conflict among farmers to be almost inevitable. I have witnessed the collapse of several pilot fencing projects largely because their implementers assumed that ten or more neighboring farmers would cooperate with one another in maintaining the project. This is not to say that there is no hope for cooperation, but that projects relying on cooperation to make payoffs beneficial to individual farmers need to think about mechanisms to facilitate cooperation and reduce free-rider hazards rather than to expect cooperation to occur innately.

The benefit-cost analysis presented in this paper does not consider many aspects at the village-level or household-level that might influence farmers' decision-making. Issues such as access to market, access to labor, access to financing, and barriers to cooperation should be taken into account when possible in evaluating a specific project. It also does not seek to identify the actual intensity of crop-raiding in a given area, which would be essential to evaluate costs and benefits for any given farmer. Through this analysis, however, I provide an initial sketch of the kinds of questions that should be asked before diving into costly analyses of specific technology or accusing farmers of laziness for not adopting a proposed solution.

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Chapter 3.

When coping with crop-raiding may be more rational than protecting crops: empirical findings in Gabon

Introduction:

Wildlife and farmers do battle with each other over scarce resources in all corners of the earth. A large portion of a farmer's job entails constant assessment and reassessment of the battle wounds to decide how much loss should be tolerated and how many resources should be invested in building fortresses or battling pests. I examined this phenomenon in Gabon, where my inquiries about crop-raiding often evoked an all-out war cry against the perpetrators, namely elephants (*Loxodonta africana cyclotis*), large rodents such as cane rats (*Thryonomys swinderianus*) and brush-tailed porcupines (*Atherurus africanus)*, and the occasional primate (e.g. *Mandrillus sphinx*, *Gorilla gorilla gorilla*, *Pan troglodytes*). Given the passionate response from farmers, observers are often surprised to see the paucity of methods used to protect farms from crop-raiding in Gabon.

Protecting crops from wildlife, especially strong and intelligent wildlife such as elephants, requires a heavy investment in resources in the form of money and labor. Chapter 2 lays out a theoretical model for evaluating costs and benefits of protection to predict adoption of farm protection methods. Based on this framework alone, we would expect farmers in Gabon to favor "invisible" coping strategies, such as planting extra to buffer against losses, over material- or labor-intensive protection strategies, such as building fences or sleeping in their farms, in most situations.

Individual situations vary much more than accounted for in the model presented in Chapter 2, however. Some farmers have more labor available to them and less financial resources, while others have income but little labor to spare. Cultural factors may cause a farmer to reject an economically optimal strategy or accept a strategy that is economically suboptimal. Variations in social capital make it easier or harder for some farmers to cooperate to reduce individual costs of protection, enabling them to adopt strategies that would be suboptimal if each farmer acted alone. The work presented here examines the role of such individual and town-level factors on farmers' decisions regarding crop protection. Specifically, I assess:

1) How well protection methods used by farmers align with the predictions of the model presented in Chapter 2. Specifically, I expect fence-building to occur among farmers with a higher payoff ratio for building fences versus planting extra to buffer against losses.
2) what additional factors make a farmer prone to adopting a given protection strategy,
3) whether there are indications of coping strategies where crop loss is higher: Are farmers who appear to be doing nothing to protect their farms actually planting extra to buffer against losses?

Methods:

This work is based on interviews and farm observations with 426 farmers in 36 villages across Gabon, mostly in the northern, central and southwest regions. I used a two-tiered sampling design, selecting villages to balance town-level variables, particularly intensity of elephant raiding, and selecting farmers randomly within those villages. Traditional village leaders were always included out of respect for cultural protocol. Target sample size was ten to twelve farmers per village, although fewer farmers were interviewed in some villages due to lack of available farmers. Interviews were conducted in a semi-structured format and included questions on personal and household demographics, farming practices, losses to wildlife, and protection methods. Interviews also included a visit to each parcel planted in the year (September to September), during which I observed crop damage and protection methods and estimated parcel size and coverage of individual crops by walking around them with a handheld GPS unit. To help ensure that I observed all principal crops (often difficult given the mixed cropping system typical to Gabonese agriculture), I first asked farmers to list the crops they had planted and to create a sketch of each parcel, showing the relative areas of each crop listed.

To estimate farmers' expected crop loss, I asked farmers to list the five animals that cause the most damage to their crops and estimate the damage caused by each. To encourage the most accurate estimates possible, I presented the farmer with three different tasks and informed follow-up questions with observations from the farm. The three tasks, repeated for each of the top five raiders, were:

T1) recount all raiding incidences in the past 12 months (for infrequent raiders) or the past seven days (for resident animals such as rodents),

T2) indicate on a visual Likert-like scale level of certainty that a raid will occur in the next 12 months (or next seven days for resident animals),

T3) remove pebbles from a 10x10 grid to illustrate amount of crop lost per raid (repeated for each crop planted)

With these responses and my own measurements of area of each crop planted, I estimated the value of the crop lost to each animal from the farmer's perspective as:

Loss to rodents and other small raiders:

$$(L_R) = \sum_{i=1}^{n} \mathrm{T1} * \mathrm{S_i} * \mathrm{T2} * \frac{\mathrm{T3_i}}{\mathrm{d_i}} * \mathrm{Y_i} * \mathrm{V_i}$$

Loss to elephants and other large raiders:

$$(L_E) = \sum_{i=1}^{n} \mathrm{T1} * \mathrm{S_i} * \mathrm{T2} * \frac{\mathrm{T3_i}}{100} * (\mathrm{A_i} * \mathrm{Y_i} * \mathrm{V_i} - L_{Ri})$$

where T1, T2, T3 represent the farmer's response to the three tasks above, S_i represents the growing season of the crop i, in weeks (for resident raiders), A_i represents the area planted of crop i, d_i represents the density of crop i, in number of plants per unit of area, and Y_i and V_i represent yield and market-value estimates of crop i per unit of area. These last estimates are discussed more thoroughly in chapter 2.

The distinction between large raiders and small raiders in the two equations results primarily from different behavior with the grid task (T3) for the two groups. Think-aloud exercises drew my attention to the fact that farmers tended to view the grid as a representation of their entire farm (and each pebble thus as multiple plants) when considering raiders that take many plants per visit, but tended to view individual pebbles as individual plants when considering raiders that take only a few plants per visit. For this latter case, I therefore divided the response to T3 by the area planted times the observed density crop density. I estimated this density by averaging the distance between a plant and its four nearest neighbors, repeated for five randomly selected plants.

Value lost to elephants was calculated after subtracting the expected losses to resident raiders from the total value of each crop, based on the notion that these losses are inevitable regardless of the farmer's choice of protection against larger animals. Not removing these losses would thus overestimate the total value of the harvestable crop under a given protection scheme.

To enable comparison of estimates among farmers, I converted estimated value of crop lost to each animal to percentages by dividing by the total farm value: (V_T) = $\sum_{i=1}^{n} A_i * Y_i * V_i$. I then averaged these estimates for all farmers in a given town to produce a general estimate of raiding intensity in the area. These averaged estimates were used in the protection models to reduce the confounding effect of protection: part of the theory being tested is that a farmer will be more likely to protect when raiding intensity is higher in the area, but use of an effective protection strategy is expected to lower raiding intensity for that farmer.

Models: I modeled farmer decision-making regarding protection first as a series of dichotomous response variables representing the principle protection strategies I observed in the field. For those farmers who did not implement one of the dichotomous strategies, I then modeled a series of continuous response variables to assess the presence of more subtle coping strategies. The specific dichotomous response variables were:

- RFENCE: presence/absence of a fence against rodents (any height, gaps <10cm)
- EFENCE: presence/absence of a fence against elephants (at least one meter high, of any material),
- SLEEP:
  - SLEEP.hut: presence /absence of a hut for sleeping in the farm
  - SLEEP.yes: yes/no response to the question: "Have you ever slept in your farm this year" *("Est-ce que vous avez dormi parfois en brousse dans votre plantation cette année")*? Follow-up questions were asked to exclude incidences where farmers only slept in the farm during cutting/clearing, as is often done to reduce walking time during this labor-intensive period.
- GIVEUP: Did farmer abandon farming or reduce farm size to that of a home garden during the year of study? Only applies to farmers who maintained larger farms within the past two years that I could observe and who claimed that the change in farming practices was due to wildlife.
- NOSTRAT: The alternative to the four strategies above: Yes if none of the above was observed

Positive cases from the NOSTRAT group were used in a series of models to examine "invisible" coping strategies, or strategies that are unobservable without knowledge of what the farmer would have done in the absence of the pest. The response variables of these models were:

- FSIZE: Size of farm, to assess whether farmers plant extra to buffer losses
- CLUSTER: Number of farmers sharing a contiguous space, to assess whether farmers group together more under higher risk

To assess whether farmers with a higher payoff ratio for building fences versus planting extra are indeed those building fences, I created the explanatory variables LCA_E and LCA_R, for elephants and rodents, respectively, as proxies for this relative payoff ratio. This payoff can be calculated as the cost of planting extra divided by the cost of building a fence, or $\frac{(L*A*C_p)}{4*\sqrt{A}*C_k}$, where L represents the percent of total crop lost to elephants (or rodents); A represents the total area planted; C_p represents the marginal cost of planting an extra unit of area (Chapter 2); and C_k represents the marginal cost of building a fence, per unit of perimeter. Marginal costs of building any given fence type are assumed to be constant for all farmers; thus the variable simplifies to: $\boldsymbol{LCA_E = L_E * C_p * \sqrt{A}}$ and $\boldsymbol{LCA_R = L_R * C_p * \sqrt{A}}$

To analyze the impacts of individual and town-level characteristics on use of protection and coping strategies, I included several such characteristics as potential predictive variables in the models (Table 3.1). Choice of variables to include was informed by farmers' responses to questions on rationale for various decisions as well as my own observations from the field.

Based on general differences in responses between older and younger farmers, I tested interaction effects of age with the other predictive variables. I also examined the square-terms of age and raiding intensity, based on the hypothesis that neither variable has a linear relationship to farm size. Observations suggest that older farmers are generally more active in their farming than younger farmers; however this relationship is unlikely to continue over the entire range (an eighty-year-old farmer is unlikely to be more active than a sixty-year-old farmer). Likewise, I expect farm size to increase with raiding intensity for farmers who choose to buffer rather than protect against losses, but there is clearly a level of raiding intensity at which this coping strategy becomes infeasible; at very high raiding intensity, the size of unprotected farms would likely drop as farmers opt for different strategies (such as planting closer to the house).

Statistical methods:

R statistical software, version 2.9.1 (R Development Core Team 2008) was used for all statistical analyses. I used the "glmer" method from the lme4 package (Bates & Maechler 2009) to fit a generalized linear mixed model with a binomial structure for the five dichotomous response variables. Towns were set as the grouping factor to account for the possible non-independence of individuals within towns. Infrequency of observation of each strategy prevented the use of a multinomial model. This rareness of positive events (implemented strategies) also limited the power of the models to detect relationships of individual variables; an event-to-predictive-variable ratio less than ten can result in biased estimates (Peduzzi et al. 1996), limiting some of my protection strategy models to two or three predictive variables. The relative rareness of positive events also called into question the theoretical fit of a logistic link. I addressed this by testing model fit, using exact regression methods from the elrm package (Zamar et al. 2007) to corroborate model results at the individual level, and modeling aggregated town-level data using zero-altered Poisson methods in the pscl package (Zeileis et al. 2008)to corroborate model results at the town level. Model fit details are provided in appendix B.

I modeled continuous coping responses (farm size and cluster size) for farmers with no observed strategy with linear or generalized linear Gaussian models. The potential non-independence of individuals within towns suggests a mixed model structure may be more appropriate; however, an ANOVA test between models with and without random town effects (West et al. 2007) indicated that the between-town variance was insignificant in most cases. Ordinary least-square methods also seemed to provide adequate fit for most models, although one case of heterogeneous variances observed in diagnostic tests (for elephant as worst pest) led to use of a generalized least squares structure for that particular model.

To compare the relative strength of predictors within models, I standardized the x-coefficients using the “standardize” method in the arm package (Gelman et al. 2009). This method rescales coefficients to have a mean of zero and standard deviation of .5, which enables comparison not only among coefficients for numerical predictor variables but also between coefficients for numerical and dichotomous predictor variables (which are not standardized) (Gelman 2008).

Table 3.1: Response and predictor variables in protection and coping models

	Variable	Description	Type	Range	Mean	Stdev
Response variables	**Efence**	1 = Fence against elephants (>1m high)	Dich.	0,1	1=4.5%	NA
	Rfence	1 = Fence against cane rats (gaps <10cm)	Dich.	0,1	1=12%	NA
	Sleep.hut	1 = Hut for sleeping present in farm	Dich.	0,1	1=6.8%	NA
	Sleep.yes	1 = Farmer reports sleeping in farm	Dich.	0,1	1=9.2%	NA
	GiveUp	1 = Abandoned farming due to raiding	Dich.	0,1	1=5.4%	NA
	Nothing	1 = Farmer did not do any of the above	Dich.	0,1	1=70%	NA
	FarmSize	Total area planted in past 12 months (ha)	Cont.	0-4.5	.48	NA
	Cluster	Number of farmers in contiguous area	Cont.	0-15	1.6	NA
Town-level variables	**Town**	Town of farm location (random-effect)	Nom.	N=36		NA
	TEth4	Main ethnicity: Punu, Fang, Vili, or Other	Cat.	P=136, F=126, V=76, O=88		
	TDistMkt	Road distance (km) to nearest big market (town with population >2000)	Cont.	5-87	45	20.5
	TCostMkt	=TDistMkt with roads weighted by quality	Cont.	15-403	124	75.3
	TRisk10	My assessment of elephant risk in area	Ord.	0--9	4	2.3
	TLossR	% crop lost to rodents (farmers' estimates)	Cont.	3--60	30	12
	TLossE	% crop lost to elephants (farmers' est.)	Cont.	0--78	30	24
	TLossAll	% crop lost to all animals (farmers' est.)	Cont.	24-130	80	29
Individual/farm-level variables	**LCA_E**	relative payoff of building elephant fence compared to planting extra	Cont.	0-17	3.15	2.7
	LCA_R	relative payoff of building rodent fence compared to planting extra	Cont.	0-28.5	5.17	3.8
	FEth	Farmer's ethnicity: Punu, Fang, or Other	Cat.	P=156, F=122, O=148		
	Age	Farmer's age	Cont.	16--80	52	13.5
	Income	Household income level (0=no off-farm income, 5=substantial income)	Ord.	0--5	1.2	1.2
	FullJob	If farmer has full-time off farm employment	Dich.	0,1	1=4.1%	NA
	Hhold	Household size (counted as .5 if home vacations/away school-year)	Cont.	1--18	3.1	2.4
	MHelp	# adult males from household helping on farm at least once/mo.	Cont.	0--3	.75	0.6
	FHelp	# adult females from household helping on farm at least once/mo.	Cont.	0--4	1.2	0.6
	MHelpYr	1= at least 1 adult male helps each mo.	Dich.	0,1	1=62%	NA
	Mhelp60	1 = at least 1 male >=60yrs helps each mo.	Dich.	0,1,	1=26%	NA
	Dist	Distance(km) from house to farm	Cont.	0--5	1.2	1
	Fallow	Fallow period of farm (farmer est.)	Cont.	0-50	15	12.4
	PerBan	% of crop that is banana/plantain	Cont.	0--100	28	34
	PerCMN	% of crop that is manioc/sugarcane/nuts	Cont.	0--100	80	47
	MAINPest	worst pest according to farmer (Elephant, rodents, primates, other)	Cat.	E=158, R=187, P=60, O=21		
	SleepPrnt	1 = farmer recalls parents sleeping in farm	Dich.	0,1	1=56%	NA
	SleepFut	1 = farmer might sleep in farm in future	Dich.	0,1	1=29%	NA
	SleepPast	1 = farmer has slept in farm in past	Dich.	0,1	1=37%	NA

Results

General: The average farm was just under half a hectare, distributed between one to two parcels (mean = 1.6), each sharing a contiguous area with that of three other farmers, on average Crops were dominated by manioc, followed by plantains and groundnuts. A more detailed description of cropping systems is provided in Chapter 2. The average farmer was 52-years-old (median = 60), and had a household size of 3.2, two of whom worked on the farm at least once a month (including the interviewee).

Of the 426 farmers interviewed, 347 were female and 79 were male. This unequal ratio reflects gender roles in farming more than the composition of the farming population; as it is generally considered the woman's role to plant, weed and harvest, I observed far more women in the farms in which I was interested (those already planted) than men. Due to the man's traditional role in clearing and protecting farms, access to male labor can heavily influence both farm size and protection strategies. Of the females interviewed, 134 (38%) did not have access to male labor in their household. Similarly, 29 (37%) of the 79 males interviewed did not have access to female labor in their household.

Protection strategies:

CROP PROTECTION AGAINST RODENTS (RFENCE): Of the 426 farmers interviewed, 50 built a fence to protect against rodents. Of these fences, 18 were constructed using traditional methods of interweaving palm fronds, 7 involved stacked logs, 21 used sheets of zinc roofing material, and 4 used fishing nets. Half of these fences (26) incorporated intentional gaps with traps intended to catch large rodents (*Atherurus africanus, Thryonomys swinderianus*) and other small animals for consumption. An additional 25 farms used traps but no fence. Although traps may provide some protection to the crop, they were not considered as a protection strategy here due to general consensus among farmers interviewed, including those who used traps, on their inefficiency in reducing crop raiding.

All Parcels[d] (N=666): branches A, B, C

All Farmers (N=426): branches D, E, F

	#YES	STRATEGY	SIGNIFICANT VARIABLES IN GLMM[a]				
			Variable	**β.coef[b]**	**Log odds**	**Log odds orig. coef**	**p.[c]**
AGAINST RODENTS							
A	50	RFENCE	**(Intercept)**	-3.61			<.001
			perCMN	2.14	8.50	0.019	<.001
			Dist	-1.60	0.20	-0.064	0.01
			LCA_R	1.27	3.56	0.166	0.014
			MHelp60	0.68	1.97	0.677	0.076
			TLossR	0.39	1.48	0.916	0.667
			TOWN effect: Var = 3.55, std. dev. = 1.88, p= 9.13E-7				
AGAINST ELEPHANTS							
B	19	EFENCE	**(Intercept)**	-9.74			<.0001
			LCA_E	3.09	21.98	1.77	0.02
			MHelpYr	1.45	4.26	4.26	0.09
			TOWN effect: Var = 35.04 , std. dev.=5.9 , p= 5.58 E-79				
C	29	SLEEP hut	**(Intercept)**	-5.11			<.001
			LCA_E	2.01	7.46	1.00	0.001
			Dist	1.06	2.89	0.00	0.068
			MHelp60	1.02	2.77	1.07	0.067
			TOWN effect: Var = 3.33, std. dev. = 1.82, p = 2.10 E-11				
D	44	SLEEP "yes"	**(Intercept)**	-3.88			<.001
			TRisk10	1.64	5.16	1.43	0.029
			MHelpYr	1.67	5.31	5.31	0.014
			SleepPrnt	2.5	12.18	12.27	0.006
			TOWN effect: Var = 1.54 , std. dev. =1.24 , p=				
E	19	GiveUp	**(Intercept)**	-6.45			<.001
			Income	1.52	4.57	1.91	0.037
			TRisk10	3.87	47.94	2.34	0.005
			TEth4Oth	0.21	1.23	1.23	0.916
			TEth4Pnu	0.69	1.99	2	0.727
			TEth4Vli	3.83	46.06	45.8	0.038
			TOWN effect: Var = 2.57 , std. dev.=1.60 , p=				
F	292	NoStrat	**(Intercept)**	2.56	12.94	1586	<.001
			SleepPrnt	-1.52	0.22	0.22	0.003
			TRisk10	-3.25	0.04	0.49	<.001
			TCostMkt	-1.36	0.26	0.99	0.012
			TOWN effect: Var =1.3 , std. dev.= 1.1, p=				

[a] fit by adaptive Gaussian Hermite approximation with "glmer" from nlm4 package in R (Bates, 2009)
[b] coeficients rescaled to have mean=0 and sd=.5; binary variables centered (Gelman, 2009)
[c] most conservative estimates: number of groups minus number of parameters(Bolker et al. 2009)
[d] Some farmers have more than one parcel

Figure 3.1: Significant variables for strategies of protecting from or coping with crop raiding, from generalized linear mixed model. Variables are summarized in Table 1. Model details and fit tests are provided in appendix B.

At least one rodent fence was observed in 19 of the 36 towns. Crop composition (PerCMN), distance to farm (Dist), relative payoff of protecting versus planting extra (LCA_R), and help from a male aged 60 or older (MHelp60) were the most significant variables in predicting likelihood of building a rodent fence (Fig 3.1A). Farms where manioc, sugar cane and groundnuts comprised over 90% of the crop (two standard deviations) had 8.5 times greater odds of having a rodent fence. Farms half a kilometer (two standard deviations) farther from the farmer's house had five times lower odds of having a rodent fence. Farmers with help from males aged 60 or older had twice the odds of having a rodent fence, although this relationship was only marginally significant. Access to help from younger males showed no signs of significance.

Increase in the relative payoff of protecting versus planting extra, LCA_R, significantly increased a farm's likelihood of having a rodent fence; a one-half-standard deviation increase in LCA_R increased the odds of observing a rodent fence by 3.56. Other variables of raiding intensity, such as TLossR, showed no significance. This indicates that it is the combination of farm size, planting costs, and expected losses from rodents that influences farmers' decisions to build rodent fences, rather than just intensity of rodent raiding in the area.

CROP PROTECTION AGAINST ELEPHANTS: Only 19 of the 426 farmers built any kind of fence to protect crops against elephants. Huts for sleeping were observed in 29 farms and 39 farmers claimed to have slept in their farm in the past year.

- **ELEPHANT FENCES (EFENCE):** The 19 observed elephant fences all consisted of relatively small investments with questionable efficacy, even according to the farmers who built them. The three observed fencing methods consisted of rope with tin cans, one meter high sheets of zinc roofing, and single strands of logging cable. Of the three methods, farmers rated the logging cable as having the highest potential of keeping elephants out. Town-effects were significant; all fences were observed in five towns, and 11 of the 16 fences were observed in just two towns, Assok and Kazamabika, both experiencing very high levels of elephant raiding and very small remaining farmer populations

The relative payoff of protecting versus planting extra, LCA_E, was a significant predictor of whether a farm had an elephant fence (Figure 3.1B). Farms with a two standard deviation increase in LCA_E had 22 times greater odds of having an elephant fence. Elephant-raiding risk variables alone (TRisk10 or TLossE) were insignificant in predicting presence of elephant fences. Access to male labor throughout the year (MHelpYr) showed a trend in increasing the odds of having an elephant fence, although this was not significant at the .05-level (p=.09).

- **SLEEPING IN FARMS (SLEEP.HUT & SLEEP.YES):**
  - **SLEEP.HUT:** Huts with sleeping equipment were observed in 29 farms, excluding short term "camping" events during the clearing season to reduce walking time. The relative payoff of protecting versus planting extra, LCA_E, was the only significant predictor at the .05 level, although distance to the farm (Dist) and access to male labor throughout the year (MHelpYr) both showed marginal significance (p=.07 for each) (Figure3.1C). A farm with a two-standard-deviation increase in LCA_E had 7.5 times greater odds of having a hut. Neither of the elephant-raiding risk variables alone (TRisk10 or TLossE) was significant in predicting presence of a hut.
  - **SLEEP.YES:** An additional 15 farmers claimed to have slept in their farms because of animals, although no hut was observed. Incorporating these farmers changed the dynamics in interesting ways: Risk of elephant raiding (TRisk10) became significant in the place of LCA_E, access to male labor became more significant, and memories of parents sleeping in their farms became a significant predictor of whether a farmer would claim to sleep in his or her own farm (Table 3.1D).

Alternative strategies:

- **GIVING UP ON FARMING (GIVEUP):** of the 426 farmers interviewed, 19 had farms in the past three years but decided not to farm in the year of the study (or substantially reduced their farm size to that of a garden next to their house) due to wildlife. These 19 farmers were distributed among 7 towns, thus making the random town-effect highly significant. The majority (17) lived in towns with elephants as the main raider, while two came from towns with primates as the main raider; none came from a town with rodents as the main raider.

  Risk of elephant raiding (TRisk10), ethnicity, and income were the strongest predictors of abandoning farming (Fig 3.1E). Farmers in towns with estimated TRisk10 two standard deviations above the mean had 48 times greater odds of abandoning farming. Those of Vili ethnicity had 46 times greater odds of abandoning than those farmers of other ethnicities. A two-standard-deviation increase in income level increased odds of abandoning by 4.5 times. LCA_E was not tested in this model because would-be farm size was impossible to estimate for those who had abandoned farming.

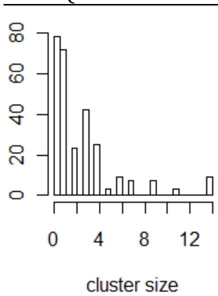
- **NO OBSERVED STRATEGY (NOSTRAT):** Aside from the 19 farmers who built elephant fences, the 39 who slept in their farms, and the 19 who abandoned, the remaining 349 farmers did not implement any obvious strategy to protect against elephants. The strongest predictors of whether a farmer fell into this category were risk of elephant raiding (TRisk10), memories of parents sleeping in their farms (SleepPrnt), and cost-weighted distance to the market (TCostMkt) (Fig 3.1F). A one-half-standard-deviation increase in TRisk10 increased the odds of a farmer using one the above strategies by 96%, from one in 22 for the null model to one in 11. Likewise, farmers whose parents slept in the farm had 78% greater odds of using one of the above strategies to protect against elephants, and those who lived in towns one-half-standard-deviation farther from a large market, in terms of distance weighted by road quality, had 76% greater odds of using one of the above strategies.

"Invisible" non-protection strategies: Aside from the immediately observable protection strategies of building fences and sleeping in the farm, farmers mentioned more subtle strategies of coping with elephants and rodents including planting less of the animal's preferred crops (plantain/banana for elephants, manioc, sugar cane and groundnuts for rodents), planting closer to or considerably farther from the house, planting extra to buffer against losses, and clustering together with other farmers to reduce edge effects.

- **CLUSTERING:** I found strong evidence of farmers preferring to cluster more where expected losses to wildlife are higher. TLossE showed a significant positive correlation with size of farm clusters (Spearman's rank correlation rho = .22, p = 0.02). For the subset of unprotected parcels with rodents as the worst pest according to the farmer (n=278), farm distance showed a significant, positive relationships with the likelihood of sharing a border with at least one other farm (Table 3.2A). This relationship was often explained by farmers as a greater need for safety with increased isolation. Once this tendency to have at least one neighbor was accounted for, however, distance was not a significant predictor of cluster size. Expected losses to rodents (TLossR), on the other hand, showed a significant relationship with cluster size: for clusters of at least

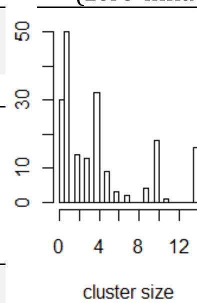
Table 3.2 Cluster-size models for farms without protection

A) Worst raider=rodents (N=278)
(zero-inflated negative binomial model)



Number in cluster if >1 (truncated neg. binomial)		
Variable	**Est.**	**p.**
Intercept	1.4	<.001
TLossR	**1.22**	**0.02**
Dist	-0.03	0.69
Log(θ)	-0.6	0.14
Likelihood of cluster >1 (binomial with logit link)		
Intercept	0.12	0.79
TLossR	0.29	0.73
Dist	**0.46**	**<.001**

B) Worst raider=elephants (N=192)
(zero-inflated negative binomial model)



Number in cluster if >1 (truncated neg. binomial)		
Variable	**Est.**	**p.**
Intercept	-0.24	0.65
TLossE	**2.37**	**0.013**
PerBan	-0.38	0.23
Dist	**0.33**	**0.005**
Log(θ)	-0.22	0.48
Likelihood of cluster >1 (binomial with logit link)		
Intercept	0.9	0.37
TLossE	1.93	0.32
PerBan	**-1.12**	**0.04**
Dist	<.001	0.34

two adjacent farms, cluster size increased as raiding intensity from rodents increased. Farmers explained the larger clusters as a means to reduce the total edge exposed to the forest.

For the subset of unprotected parcels with rodents as the worst pest according to the farmer (n=192), farms comprised primarily of plantain were less likely to be clustered (Table 3.2B). Increased farm distance and expected losses to elephants (TLossE) both had a significant positive relationship with the number of farms in a cluster.

- **PLANTING MORE TO BUFFER LOSSES:** Significant predictors of farm size for farmers who still farm but do not build fences or sleep in their farms were: distance to farm (Dist), expected losses to all raiders (TLossA), the amount of male help available (Mhelp), and age (Fig3.2). The best model yielded an average farm size estimate of .43 hectares for an average farmer. Farm size estimates increased by 8% for each year of age, but decreased by .1% for each unit of age-squared, such that farm size peaked at farmer age of 55 years. Farm size estimates increased by 21% for each male who helps in the farm and by 19% for each kilometer from the farmer's house. Farm size estimates decreased by .6% for each percent increase in expected crop loss.

  This last observation provides evidence against the hypothesis that farmers with higher raiding risk who choose not to protect their farms are planting extra to buffer against losses. Dividing cases by worst raider helps provide insight into where this hypothesis breaks down. For the 92 farmers who consider their worst pest to be elephants but who do not protect their farms (Fig 3.2B), farmers of average age (52 years) plant significantly less with increasing raiding intensity, although the interaction effect between age and raiding intensity is such that farmers above the age of 64 plant more with increased raiding intensity. For the 145 farmers who consider their worst pest to be rodents (Fig 3.2B), however, farms in towns with higher average

N=301

3.2) All Farmers with no apparent strategy

Deviance=165, Residual variance: .41 Number of obs: 300

log	Exp(coef)	coef.	[95% CI]		p.
(Intercept)	4316	8.39	8.115	9.125	<.0001
Age	1.08	0.077	0.042	0.112	<.0001
Age^2	.999	-0.0007	-0.001	0.000	<.001
Mhelp	1.21	0.192	0.051	0.333	0.008
Dist	1.19	0.178	0.082	0.274	<.001
TLossA	.994	-0.006	-0.010	-0.002	0.013

Random effects (TOWN, N=33): Variance=.05, std. dev.=.22, p=.005

N=92

3.2A) Worst pest = elephants

WLS Regression: Adjusted R-squared: 0.22, df=91, p-value=6.3e-05

log	Exp(coef)	coef.	[95% CI]		p.
(Intercept)	3072	8.030	7.820	8.240	<.0001
Age (centered)	.998	-0.002	-0.012	0.008	0.630
Mhelp	1.25	0.220	0.020	0.420	0.034
fullJob	.445	-0.810	-1.388	-0.232	0.007
TLossE (centered)	.991	-0.009	-0.587	-0.569	0.016
TLossE:Age	1.0007	0.0007	-0.005	0.007	0.015

Weights =1/TLossE; ANOVA with OLS model: p<.001

results of ANOVA test with model including TOWN grouping factor: p=0.50

N=145

3.2B) Worst pest = rodents

OLS Regression: Adjusted R-squared: 0.27 , df=140, p-value: 3.5e-09

log	Exp(coef)	coef.	[95% CI]		p.
(Intercept)	4964	8.51	7.76	9.240	<.0001
Age	1.11	0.104	0.047	0.161	<.001
Age^2	.999	-0.001	-0.001	-0.001	0.002
Eth_Punu	1.14	0.131	-0.183	0.445	0.410
Eth_Other	.499	-0.696	-1.068	-0.324	<.001
TLossR	1.014	0.014	0.004	0.024	0.011
Dist	1.197	0.180	0.045	0.315	0.010

results of ANOVA test with model including TOWN grouping factor: p=0.45

N=43

3.2C) Worst pest = primates

OLS Regression: Adjusted R-squared: 0.56, df=41, p-value: 1.48E-07

log	Exp(coef)	coef.	[95% CI]		p.
(Intercept)	3011	8.010	7.534	8.486	<.0001
Age	1.02	0.017	0.003	0.031	0.018
Hhold	1.12	0.115	0.056	0.174	0.003
Mhelp	1.44	0.363	0.057	0.669	0.025
PerBan	1.01	0.013	0.007	0.019	<.0001
TRisk10	0.91	-0.097	-0.195	-0.001	0.058

results of ANOVA test with model including TOWN grouping factor: p=0.45

Figure 3.2: Farm size models for existing farms without protection.

estimated losses are significantly larger, increasing by 1.2% with each percent increase in estimated losses. Finally, for the 43 farmers who consider their worst pest to be primates, (Fig 3.2C), farm size decreased considerably with higher estimated losses to pests.

Discussion:

The significance of LCA_E and LCA_R in the protection models suggests that they provide good proxies for estimating farmers' relative incentives to protect farms against elephants and rodents, respectively. Raiding intensity alone was not found to be a good proxy for incentive to protect; individual farm parameters, specifically size and crop composition, need to be taken into account.

Those who have relatively lower incentives to implement the labor-intensive strategies such as building fences or sleeping in the farm seem to be using a mixture of coping strategies. Older farmers in areas with higher raiding risk seem to plant more to buffer against losses, while younger farmers seem to plant less. One possible explanation for this phenomenon is that younger farmers tend to be more mobile and may have more opportunities to do small task-work (*bricole*), potentially at a higher payoff per unit of labor.

My results also suggest that the type of pest influences farmers' coping strategies: farmers with higher expected losses to rodents show evidence of planting more to buffer against the losses, while those with higher expected losses to elephants and primates seem to have more mixed strategies. This difference could be due to the fact that losses caused by rodents are regular and thus easily predicted, whereas those caused by elephants and primates are unknown risks. Farmers often explained to me that of every X plants they planted, one was for the rodents. It is therefore logical that they could plan ahead and plant X+1 plants for every X plants they want to harvest. In the case of elephants, however, farmers generally do not have a good idea of how many times they will raid or how much they will take at a given time. Risk adverse farmers might plant extra just to be safe, especially if they could bank any savings in good years. However, Gabonese farmers, especially in the remote areas where elephants and primates tend to raid the most, generally find it hard to bank surplus due to lack of transportation and access to market. It is not uncommon for farmers to watch stock after stock of plantain or pile after pile of cassava rot due to lack of clients (pers. obs., Pourtier 1984). Some farmers I interviewed almost seemed to fear having too much. Instead of planting more, farmers in such situations may use other strategies, such as planting farther away or planting back-up gardens right next to the house.

Although my results indicate that farmers with higher payoffs for building fences to protect against elephants versus planting extra (LCA_E) are indeed more likely to build fences, this does not mean that these fences are effective. The only fences I observed that were built by the farmers themselves, rather than by an organization on their behalf, were made of rope and cans, sheets of zinc roofing, or logging cable. I observed elephant prints inside farms with both zinc and rope fences within days of the construction of the fence. Logging cable may provide better protection, but is expensive (Chapter 2); the only cases I observed involved cable brought in by an NGO or left over from an abandoned logging camp in the area.

This study provides evidence of the overwhelming lack of strategies being used in Gabon to protect farms against elephants. Even where raiding is high, farmers are generally unwilling to sleep in their farms. Fence building is also extremely uncommon and those that are built are relatively cheap, in terms of both money and labor, and ineffective. This supports the idea that the costs of known methods of farm-level protection generally outweigh the benefits for Gabonese farmers. Characteristics that affect potential for adoption of similar protection strategies should be examined before too much effort is invested in developing such strategies. Looking beyond farm-level protection may prove more fruitful for mitigating farmer-elephant conflict in the long run.

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Chapter 4.

A choice experiment of farmers' willingness to pay for protection methods against crop-raiding elephants in Gabon

Introduction:

Crop-raiding by elephants threatens both human livelihoods and elephant populations as angry farmers retaliate. As concerned agencies seek to mitigate farmer-elephant conflict, they generally push for "low cost," low-tech strategies of protecting crops that farmers can implement with little assistance (Osei-Owusu & Bakker 2008). "Low cost" generally refers to monetary costs, under the assumption that smallholder farmers do not have much financial capital with which to pay upfront costs. The additional implicit assumption, however, that farmers can and will take on often extensive labor costs to implement a strategy with low financial costs, does not always follow (Graham & Ochieng 2008; Ongognongo et al. 2006).

Farmers' valuation of tradeoffs between monetary costs and labor costs differ across both individual and societal situations. One way to evaluate such tradeoffs in decision-making processes is to observe actual choices, or revealed preferences, of individuals (e.g. Bockstael et al. 1987). In the case of farm protection in rural situations, however, it can also be argued that farmers often lack the technical knowledge and/or access to resources to implement potential protection methods, and thus that current strategies provide limited insight into what farmers might actually choose if provided with more technical or logistical assistance from concerned agencies.

Choice experiments offer one mechanism by which to explore preferences in tradeoffs via hypothetical markets. In a choice experiment, a respondent is asked to choose between products or "packages", comprised of a set of attributes (features) with different levels in each package. For example, a respondent could be asked to choose among travel "packages", with three attributes: cost, time, and mode of transportation. One package could be a $50 trip by car taking 6 hours, another could be a $500 trip by plane taking 3 hours, and a third package could be a $200 trip by train taking 4 hours. By gathering the respondent's preferences for a number of different choice sets, one can gain much insight into how that person evaluates tradeoffs between time and money as well as into which factors most influence that person's decision-making.

Choice Experiments are attractive tools in their intuitive nature and ability to focus on different product attributes rather than valuation of one total product. Another advantage over many other preference solicitation techniques is their empirical grounding in behavioral theory and compatibility with random utility theory (Hanley et al. 1998; Louviere et al. 2000). Choice experiments allow for a level of irreducible variability or error, associated with each individual, such that no individual is assumed to be a perfect chooser who consistently uses deterministic choice rules. Accounting for variance in errors is always important for statistical validity, and is especially important in this case of hypothetical tasks, where responses may be more vulnerable to transient feelings or thoughts (Shogren 2006).

Choice experiments are common in marketing research and are growing in use in the environmental and health sectors (Alriksson 2008; Hanley et al. 1998; Louviere & Lancasar 2009). Despite their rapid increase in research in developed countries, choice experiments are still quite rare in the contexts of lesser developed countries (Mangham et al. 2008). These methods can be of particular value in such contexts, where the market value of services is often less apparent than it is in industrialized nations. However, the implementation of choice experiments requires great care, especially in the context of the lower literacy and education levels often encountered. When designing a choice experiment, one is presented with great tradeoff between the statistically sound design that will yield precision in estimated parameters (assuming that the respondents made realistic choices) versus the most intuitive or realistic design that will best assist respondents in making realistic choices.

Here, I present a choice experiment designed to gain insight into the characteristics that influence farmers' likelihood of adopting methods to protect crops from elephants in Gabon. Field observations reveal that Gabonese farmers rarely implement protection strategies despite substantial level of crop loss in certain locations (Chapter 3). It is clear that tradeoffs in allocation of labor (Chapter 2), as well as other cultural and demographic factors (Chapter 3), significantly impact farmers' decisions of whether to adopt known strategies. However, because the range of known strategies is quite limited, it is useful to identify the characteristics that would make future strategies attractive to farmers.

The purpose of this choice experiment was to evaluate the general characteristics of hypothetical crop protection strategies that most heavily influence their likelihood of being adopted by farmers, and to gauge farmers' valuation of tradeoffs in costs, particularly labor versus monetary. I also elaborate on decisions I made in the design and implementation process to balance statistical power and response validity. Because choice experiment methodology is constantly evolving (Louviere & Lancasar 2009), and choice experiments conducted in developing nations are so rare (Mangham et al. 2008), such transparent presentation of the process and current knowledge gaps is vital to advancing effective use of this method.

Methods:

This choice experiment comprised one component of a larger interview and observation process to understand farmer decision-making regarding strategies to protect crops from elephants. The design and pretest portion of this choice experiment was an iterative process involving nearly 200 farmers with whom I worked during the six months prior to administering the choice experiment. This process entailed: 1) identifying the attributes most likely to influence farmers' decisions of whether to adopt a protection method, 2) choosing the number of levels and range for each attribute, 3) creating a statistically efficient design, 4) creating an empirically efficient design, and 5) pre-testing and altering the design based on results.

- **IDENTIFYING ATTRIBUTES:** I used semi-structured interviews and farm observations with nearly 200 farmers to inform attribute selection. Questions on why farmers did not choose to adopt known strategies to protect crops revealed organizational issues (access to knowledge, access to materials) as well as preferences and constraints influencing decision-making. These latter components were considered as attributes in the choice experiments. The most frequent reasons given for abandoning or not implementing a particular crop-protection strategy were: not enough money, not enough labor available (especially male labor), inability to visit the farm during certain periods due to travel or other obligations, inability or unwillingness to sleep in the farm for various reasons, and disputes over or concerns about others not contributing their fair share in cooperative protection projects.

  The final attributes selected for the choice experiment were therefore: A1) monetary costs, A2) initial labor costs, A3) required visitation frequency, A4) ongoing labor costs, A5) whether it is a collective project requiring cooperation with other farmers, and A6) whether sleeping in the farm is required to successfully implement the protection method (Table 4.1).

Table 4.1: Attributes presented in choice experiment

		Units	**Levels**		
A0)	Protection from elephant raiding	no/yes	0*	1	
A1)	Monetary costs	1000cfa	0*	40	80
A2)	Initial labor costs	Hours	0*	16	32
A3)	Maintenance frequency	times/month	1*	4	20
A4)	Maintenance labor	hours/month	1*	8	16
A5)	Collective project requiring cooperation	no/yes	0*	1	
A6)	Sleeping in farm required occasionally	no/yes	0*	1	

* status-quo level and reference level in categorical statistical analyses

- **ASSESSING NUMBER OF LEVELS AND RANGES FOR EACH ATTRIBUTE:** Increasing the number of levels within an attribute produces a tradeoff between the complexity of the conclusions one can draw and the demands one places on the participants. A respondent's utility for an attribute with only two levels can only be interpreted as linear, while that for an attribute with three levels can be more complex. With increasing number of levels, the relationship can increase in complexity. However, this imposes a steep cost in terms of the number of packages that a respondent must consider for results to be conclusive.

  More important than having many levels is to ensure that the range covered by those levels maximizes information gained from each question. A range too small to be sensitive to most respondents' preferences, for example using levels of price differing by $100 in an experiment to assess preferences in car purchases, can misleadingly suggest that the respondent does not base choices on that attribute. At the opposite extreme, values so large that many of the participants automatically exclude any package with which they are associated cause loss of valuable information regarding tradeoffs in attributes.

  With the goal of minimizing the number of packages a respondent needed to evaluate, it was critical to identify the ranges that would yield the most informative responses. To assess these ranges, I asked farmers general iterative willingness-to-pay questions in the form: Would you pay X (or work X number of days, etc.) for a system that completely protects your farm against elephants? Such questions are riddled with pitfalls and are unlikely to produce accurate estimates unless conducted very strategically with a large sample (Flachaire & Hollard 2006). However, they provide a good starting point by which to gauge general ranges that can then be calibrated in further experiments, as was my goal here.

  About half of the farmers interviewed gave willingness-to-pay estimates of 80,000 to 100,000cfa, 30% gave estimates between 20,000 to 50,000cfa, and 20% were not willing to pay even 20,000. These results led me to choose three levels for monetary value: 0, 40,000cfa, and 80,000cfa (Table 4.1). Following a similar process, I chose three levels for initial labor costs (one day, two days, and four days), three levels for visitation frequency (once a week, twice a week, and five times a week), and three levels of ongoing labor costs (one hour per week, two hours per week, and four hours per week). Although many farmers who expressed willingness to cooperate with others on a protection project indicated that there was a maximum number of participants (generally three to five) beyond which they would less likely join, the fact that many others flatly rejected any cooperation led me to set is as a dichotomous variable: cooperation versus no cooperation. Similarly, the large number of farmers indicating that said they would flatly reject any project requiring sleeping in their farm led me to set that as a dichotomous variable: requires sleeping in the farm occasionally, or not.

- **CREATING A STATISTICALLY EFFICIENT DESIGN:** The statistical efficiency of a choice experiment refers to the level of precision at which one can estimate effects for the given number of packages presented. If one is not extremely careful with the design of the experiment, the effects of one or multiple attributes can confound the effects of other attributes. To avoid this, the options presented should be balanced (all levels presented an equal number of times for each attribute) and orthogonal (all pairs of attribute levels presented an equal number of times) whenever possible. Recent methods of designing optimally efficient choice experiments (Burgess & Street 2005; Street et al. 2005) demonstrate that relatively small choice experiments can have strong statistical power when balanced and orthogonal. The design choices I made in steps one and two result in a design with two attributes with two levels each and four attributes with three levels each, for which there is no orthogonal array. To produce the most efficient design possible under these conditions, I used the %choiceff macro in the marketing research application for SAS 9.2 (Kuhfeld 2009). A highly efficient design was identified using a total of 18 runs (packages), partitioned into six separate tasks in which the respondent chooses among three packages each time. This design is provided in Appendix C.

- **Modifying the design for empirical efficiency:** Although the above design is statistically efficient, it lacks empirical validity in that it requires that the respondent choose one of the proposed packages in each set; in reality the respondent may think all options are bad and prefer to stick with the status quo (no protection, in this case). By forcing choices, one risks artificially inflating a respondent's utility value for one or more attributes. This can be corrected by including a status quo option in each set, although by doing so, the balance, and thus statistical power, of the design is greatly reduced. Although work is still needed on methods for analyzing data with status quo options (Louviere & Lancasar 2009), I included a status quo option for the sake of empirical validity.

  Another problem with the most efficient design is that it assumes a perfectly consistent responder; with only six choice sets to analyze, one inconsistent response will likely prohibit convergence in the statistical model. One solution is to increase the number of observations by doubling the number of choice sets. This greatly increases the demand on the respondent, however, and risks introducing more inconsistency due to respondent fatigue. Another option for increasing the number of observations is to use Best-Worst scaling (Hensher et al. 1999; Louviere et al. 2008): instead of asking the respondents to choose only their favorite option from the choice set, one asks them to choose both their favorite and least favorite options. In this case of only three choices per set, this is no different than asking for a full ranking of choices, but is shown to be more empirically sound than full ranking in the case of larger choice sets (Louviere et al. 2005). I used Best-Worst scaling in the hopes of compensating for both the decreased statistical efficiency introduced by the status quo option and the lack of robustness caused by the small number of choice sets.

Implementation: I randomly selected sixty farmers within ten villages with endemic crop-raiding problems to participate in the choice experiment. I explained the activity, emphasizing the fact that the scenarios I was about to present were purely hypothetical. While there is empirical benefit to making participants believe that they are making real decisions, the moral implications of doing so strongly outweigh the benefits in this situation in consideration of both the farmers involved as well as of future researchers and development workers who must deal with jaded farmers. To reduce hypothetical bias, I worded questions clearly to ensure that participants knew I was asking what decision they would make *right now* rather than what they might do under some unknown set of circumstances (Blumenschein et al. 1998).

I presented each package as a string of simple images representing each attribute at its given level. I explained that this package represented the costs of a hypothetical method to protect a farm from elephants that was completely efficient (no elephants would enter) provided that the farmer paid all of the costs and accepted all of the conditions presented in the package. I first presented each new package by itself, asking the farmer to decide whether she or he would accept the corresponding costs and conditions portrayed in that package if an agency were offering to help set up an efficient protection system under those conditions, with only that one option to offer. After the three packages in the set were evaluated individually in this manner, I then asked the farmer to choose his or her preferred package from those valued higher than the status quo, then his or her preferred package from the remaining two if all three were valued above the status quo.

To ensure that the participants understood the activity, I began with a warm-up set (Scarpa et al. 2003). Because four of the attributes represent continuous factors with logically preferred directions (*ceteris paribus*, one prefers to pay less and work less), I was able to evaluate the participant's understanding of the task by creating logically inferior and superior situations. For example, the attributes of the first package were set at: 40000cfa[7], 2 days of initial work, 2 hours per week of maintenance, etc. while those of the second were set at: 0cfa, 1 day initial work, 1 hour per week of maintenance, etc. I stressed that fact that each package represented the costs of an efficient protection method; one was no more efficient than the other. If the respondent chose the first package, there was good indication

[7] $1USD= 511 cfa at the time of study

that she or he did not fully understand the task and more explanation was provided before continuing.

To gain maximum insight into interpretation and decision rules, I encouraged participants to think out loud throughout the process and often asked for explanation of rationale for a given choice. This interaction also helped to reduce satisficing, where participants may be tempted to randomly select choices or to make lexicographical choices in which they base choices on only one attribute and randomly select in the case of ties (DeShazo & Fermo 2001). This think-aloud interaction also provided much qualitative insight into the complexity of decision-making that cannot be garnered statistically in a reasonable number of choice sets.

During the interview, I collected information on demographic variables such as age, income, and household size to assess the influence of such variables on farmers' preferences (Table 4.2). I also assessed raiding risk at the town level through independent field observations to analyze whether intensity or risk of elephant raiding increased a farmer's willingness to pay different costs of protection. Raiding risk was recorded as an ordinal variable, from zero to nine, with zero representing no risk of elephant raiding and nine representing year-round presence of elephants in the village center. All towns included in this study had a risk rating above three, meaning that elephant raiding was a real risk for all participants but at varying levels of probability and intensity (Table 4.2).

Table 4.2: Characteristics of choice experiment participants

	Income level of farmer and spouse	**N**
0	No income outside agriculture	12
1	Irregular income, from hunting/fishing/odd jobs/small stipend (~$20-$40/month)	13
2	Regular income from hunting/fishing/task labor/small pension (up to $100/month)	12
3	Steady, salaried job or steady retirement income (>$100/month)	13
4	Relatively wealthy	2
	Age	
	<40 N=13 **40-59** N=13 **60-69** N=22 **>69** N=5	
	Risk of elephant raiding	**N**
4--5	Elephant raiding is real risk but occurs sporadically (temporally/geographically/both)	21
6--7	Elephants raid every year and in all farming zones, but rarely arrive in village center	16
8	Elephants are present many months out of the year and frequent village center	16

ANALYSIS: I analyzed ranked choices via an exploded logit model fit using PROC PHREG in SAS 9.2. PROC PHREG was designed as a survival analysis package but fits choice experiment data well when set to maximum likelihood estimation (Allison 1999; Kuhfeld 2009). One drawback of this procedure is that it assumes that each choice set is an independent observation rather than one of several made by the same respondent. I compensated for this in the results by estimating the variance-covariance matrix using the robust sandwich method to take into account multiple observations from the same farmer.

I analyzed both main effects and expected two-way interaction effects that farmers suggested during think-aloud activities. Particularly, I examined the interaction between the cooperation and sleep attributes and the cooperation and monetary cost attributes due to suggestion by many farmers that they considered both the sleep and monetary cost options differently depending on whether cooperation was involved.

In addition to attribute effects, I analyzed the effect of individual-level variables on odds of package rejection. Under the hypotheses that a farmer with higher income will be willing to pay more, that an older farmer will be more willing to sleep in the farm, and that a farmer under higher risk of elephant raiding will be more willing to accept higher costs, I examined the effect of income, age, and raiding risk on rejection rate.

To analyze rejected packages, I fit a binomial logit mixed model using PROC GLIMMX, allowing for different variances among individuals as well as towns. All packages rated higher than the status quo were assigned a one, and all packages rated lower than the status quo were assigned a zero. I analyzed all attributes as categorical variables to allow for identification of the particular level at which a given attribute causes a farmer to reject the package.

Results:

Of the original 60 participants, seven rejected the activity or dropped out early and four gave protest votes, rejecting every package including one requiring nothing but a few hours of work. The final sample size used for the analysis was thus 49. The average participant was 52 years old and had an income of 1.6, meaning that most participant households earned some money from non-agricultural sources such as hunting, fishing, odd jobs, or very small government stipends, but most had no steady income (Table 4.2). Average raiding risk was six, meaning that elephants habitually raided farms in all zones outside the core village area (Table 4.2).

The exploded logit model of ranked choices revealed highly significant negative odds of adoption associated with four of the six attributes tested: monetary costs, maintenance labor costs, and requirements of cooperating with others and sleeping in the farm (Table 4.3) An additional attribute, Initial labor, received a marginally significant negative estimate (p=.06). Only one attribute, frequency of maintenance, showed no signs of significance.

Setting the four three-level variables as categorical enables exploration of the linearity of the acceptance odds for these attributes. The ranking for the three levels of monetary costs followed a nearly perfect linear path, with an 80,000cfa monetary cost receiving a negative odds estimate twice that of a 40,000cfa monetary cost. Odds for Initial labor and monthly maintenance labor tended to plateau, however, with a relatively large difference between the middle level and the lower reference level, but little difference between the middle level and the highest level. Odds for maintenance frequency followed a curved path, with positive odds attributed to the middle level and negative odds attributed to the highest level. Neither of these levels was significantly different from the reference level, however.

Significant interaction effects were observed between cooperation and sleep and cooperation and monetary costs (Table 4.3). While a package had half the odds (exp(-.71)=.49) of being selected if it required sleeping in the farm occasionally, these odds were increased to .6 (exp(-.71+.3)=.6) if cooperation was required. The overall impact of cooperation on odds of package selection was significantly negative, however. This is due to the interaction between cooperation and other costs, particularly monetary. At the reference levels of zero monetary costs and low labor costs, farmers exhibited indifference to cooperation and many even preferred it. At higher labor costs and especially monetary costs, however, cooperation was strongly disfavored. Cooperation served to further decrease the odds of a farmer selecting a package involving monetary from -.007 per 1000cfa to -.009 per 1000cfa.

Table 4.3: Aggregate utility values for protection costs from exploded logit model

Lines highlighted with grey indicate results from model where A1-A4 were coded as continuous variables. White lines represent model where A1-A4 were coded as categorical variables.

	Attribute	utility	std. error	monetary equiv. (cfa)	p.
A0)	Protection from raiding	-2.190	0.438	336,923	<.0001
		-2.190	0.422	312,857	<.0001
A1)	Monetary (1000 cfa)	-0.007	0.001	-1,000	<.0001
L1)	40 000cfa	-0.007[a]	0.002	-1,000	0.001
L2)	80 000cfa	-0.007[a]	0.0001	-1,000	<.001
A2)	Initial labor (hrs)	-0.003	0.002	-462	0.06
L1)	16 hours	-0.004[a]	0.004	-625	0.18
L2)	32 hours	-0.002[a]	0.0002	-268	0.21
A3)	Maintenance frequency (times/mo)	-0.003	0.002	-462	0.24
L1)	4 (once a week)	0.020[a]	0.012	2,857	0.15
L2)	20 (five times a week)	-0.005[a]	0.004	-679	0.22
A4)	Maintenance labor (hrs/mo)	-0.020	0.008	-3,077	0.008
L1)	8 (two hours a week)	-0.054[a]	0.015	-7,679	0.0003
L2)	16 (four hours a week)	-0.033[a]	0.009	-4,643	0.0002
A5)	Must Cooperate	-0.335	0.11	-51,538	0.002
A6)	Must sleep sometimes in farm	-0.71	0.15	-109,231	<.0001
A5*A6)	Interaction : cooperate and sleep	0.3	0.118	46,154	0.014
A1*A6)	Interaction: cooperate and money	-0.002	0.001	308	0.03

[a] values represent a single unit of change in the units of the given attribute

ASSESSING THE MONETARY EQUIVALENTS OF ATTRIBUTES: The odds ratio assigned to each attribute can also be interpreted as farmers' collective utility for that attribute, or the value they place on that attribute relative to others. The linear nature of the monetary cost attribute allows for easy calculation of marginal rates of substitution to measure trade-offs between different types of costs in comparable units

(Lancasar et al. 2007). By dividing all utility estimates by that for monetary cost (.007) and multiplying by 1000 to get the original units for monetary costs[8], I converted all utility values into their monetary equivalents. Respondents collectively valued one hour of upfront labor at 462cfa, in near perfect alignment with the going market rate of 2,500 to 3,000cfa for a six-hour day of labor. Respondents collectively valued an hour per month of labor at 3,077cfa, or 256cfa per hour over the course of the year. Requiring cooperation decreased the value of 1000cfa by almost a third. Finally, sleeping in the farm was valued at an equivalent of -109,000cfa and having efficient protection over doing nothing was valued at an equivalent of 336,923cfa.

INDIVIDUAL UTILITIES: In the mixed model of package rejection versus the status quo, monetary costs, at both the 40,000cfa and 80,000cfa levels, and the requirement of sleeping in the farm both had significant positive influence on the odds of a package being rejected (Table 4.5). Of the individual-level variables, only income was significant at the .05 level: respondents with higher income had lower odds of rejecting packages entailing costs of 80,000cfa. Higher risk of elephant raiding showed weak evidence of reducing the odds of rejection of packages with higher costs (p = .1).

Table 4.4: Odds of package rejection model – logistic mixed model

	Attribute	Log odds	std. error	p.
	Intercept	-11.5	4.26	
A1)	**Monetary (1000 cfa)**	**0.074**	**0.017**	**<.0001**
L1)	40 000cfa	2.48	0.554	<.0001
L2)	80 000cfa	4.06	0.627	<.0001
A2)	Initial labor (hrs)	-0.008	0.009	0.42
A3)	Maintenance frequency (times/mo)	0.002	0.009	0.81
A4)	Maintenance labor (hrs/mo)	0.030	0.026	0.26
A5)	Must Cooperate	.126	0.25	0.61
A6)	**Must sleep sometimes in farm**	**2.23**	**0.28**	**<.0001**
Income	*Individual income level*	*-.470*	*0.51*	*0.35*
Risk	Risk of elephant raid	0.53	0.53	0.32
A1*Income	**Interaction: income & monetary**	**-.007**	**0.003**	**0.036**
A1*Risk	Interaction: risk & monetary	-0.004	0.002	0.10

[8]monetary costs were coded in thousands of cfa rather than single cfa

Although most ranked models did not converge at the individual level, a simple summary of farmers' decision behavior shows great heterogeneity in preferences (Table 4.6). Barely half (23) of the participants rated all packages presented higher than the status quo option of no protection, while four participants did not rate a single package higher than the status quo. Seven respondents rejected any package involving any amount of money and an additional four rejected any package involving 80,000cfa. Ten respondents refused any package involving sleeping in the farm while an additional three refused sleeping in the farm unless cooperation was a requirement and two refused sleeping in the farm if cooperation was required. Although visitation frequency was not significant in the aggregated model, four farmers refused any package requiring visiting their farms five times a week.

	Table 4.5: Decision strategies of choice experiment participants (N=53)
26	Yes to all packages relative to status quo
4	No to all packages relative to status quo
7	No to all packages involving any money
4	No to all packages involving >40 000 cfa
10	No to all packages involving sleeping in the farm
3	No to packages involving sleeping in the farm unless cooperation involved
2	No to packages involving sleeping in the farm unless cooperation not involved
4	No to all packages involving visiting the farm five days a week
53	**TOTAL number of participants**

Discussion:

The aggregated analysis gives a good indicator of the attributes that are most important for adoption of crop protection methods by the general farming population in Gabon. A method that costs more in terms of money and or labor has significantly lower odds of being chosen than a method that costs less; however, farmers are collectively willing to pay quite a bit for protection in terms of both money and time.

Initial labor costs are valued at 462cfa per hour, which coincides almost exactly with the going market rate in most rural settings in Gabon. With increased labor costs, collective valuation of an hour of labor decreases, however. This might reflect the fact that initial labor tasks require heavy, traditionally male labor. Many rural farmers have no access to such labor and thus need to pay wage laborers. Those farmers with access to such labor may value it lower than those without. Participants collectively valued an hour of labor per month across the year as about half of that of initial labor, which could be a phenomenon of discounting or over-optimism. It might also reflect other factors such as the generally less-intensive nature of monthly work compared to initial work, or the already limiting aspect of male labor during the critical field preparation period.

If a project requires sleeping in the farm, the odds are much lower that it will be accepted, although odds increase if it is part of a cooperative project. Projects involving money, however, have lower odds of being accepted if part of a cooperative project. This inverse effect of cooperation was explained quite simply by several participants: it is dangerous to sleep in the forest by oneself, thus cooperation must be involved if many are to agree to sleep in their farms. However, the more people involved in a project the more likely some are not going to pay their fair share or do their fair share of the work. This free-riding dilemma has been cited by many farmers as the reason protection solutions of the past do not work anymore. Communication (Ostrom & Walker 1991), and collective identity (Simon & Schwab 2006) help overcome such dilemmas; most villages, however, are experiencing a much higher turnover of people than in the past (chapter 5), thus making it difficult to build or maintain such institutions.

The aggregate utility model is not intended to imply that all farmers have the same utility functions. To the contrary, results show that farmer utility is quite heterogeneous. Although collective willingness-to-pay estimates are quite high, many individuals exhibited low personal willingness-to-pay estimates by accepting the status-quo of no protection over a package they deemed too expensive. The option to reject packages relative to the status quo prohibited the estimate and comparison of individual farmers' utility values because attributes that were consistently rejected resulted in utility estimates of negative infinity. Also, the differing number of tied or unranked packages resulted in different variance structures for different farmers, making comparison of estimates useless. A simple summary of status quo responses reveals the strong empirical necessity of including it, however. Many farmers used this option; had they been forced to choose one of the three non status-quo packages, resulting utility estimates would have been artificially inflated.

An ideal method to analyze heterogeneity of utility based on characteristics of individual responders for a choice experiment using the status quo option remains to be ironed out. Regardless, this process offers many advantages over other methods used to solicit willingness-to-pay information. The primary advantage is the ability to compare different attributes at once, thus assessing willingness-to-pay in monetary, labor, and more abstract values rather than relying on assumptions of the importance of one relative to the others. By conducting these experiments in person and incorporating a think-aloud component, one can also gain much direct insight into decision rules of the participants involved.

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Chapter 5.

Modern Gabonese use of "village" and implications for farmer-elephant conflict

In much of the world, escalation of incidences of human-wildlife conflict can be attributed to increase in human population and reduction in wildlife habitat, forcing wildlife into more frequent contact with humans (Kiiru 1995; Hill 1997; Boafo et al. 2004). In the case of farmer-elephant conflict in Gabon, however, escalated crop-raiding is more often accompanied by enhanced elephant habitat and decrease in local human populations. Rather than reduce elephant habitat, Gabon's rural farmers create an ideal habitat for elephants by maintaining the area around their villages in a perpetual state of secondary regrowth, which elephants prefer to primary forest (Barnes et al. 1991, Blake 2002). Although attracted to human-used lands, elephants are wary of human presence and tend to avoid large human settlements (Blake et al. 2008). Gabon's declining village populations, however, result in a situation where elephants are more at ease in their proximity, and thus potentially clash with farmers more often.

Trends in declining village populations may suggest that villages will soon die out and farmer-elephant conflict will no longer be an issue. However, my observations in the field suggest that the village still plays a key role in the lives of many Gabonese, including many who are not physically present at any given time. This absentee population can help villages to persist, and even thrive, conceptually while maintaining low physical populations ideal for elephants and detrimental to agriculture in Gabon.

Here, I present trends in physical and conceptual use of the village space to explore implications for farmer-elephant conflict. Following elaboration on the interconnectivity of farmer and elephant land-use patterns in Gabon, I discuss general trends in use of the village space and effects of such trends on agricultural production in general and crop-raiding by elephants specifically. I then present findings from interviews with 4500 Gabonese citizens to further insight into current and future use of the village space and inform discussion regarding implications for farmer-elephant conflict.

Farmer and elephant land-use patterns in the past and present

Although farmers and elephants would each likely be better off without the other, they find themselves sharing spaces frequently, with a degree of "intimacy" (Hardin 2008) beyond that shared with most wildlife. In many locations, this phenomenon is caused by limitations of suitable habitat for each (Boafo et al. 2004), but this is not the case in Gabon, where the abundant forest is very sparsely populated. Instead, affinity for one another's "forest gardening" (Graham 1973) habits seem to draw the two together.

In my interviews with farmers across Gabon, I occasionally found myself being escorted along an old elephant path to arrive at a farmer's field. Hunters also make regular use of elephant paths, although most subsistence or leisure hunters I interviewed claimed to fear elephant encounters and would prefer to hunt their smaller game in a safer area. Likewise, elephants seem to fear humans, evidenced by a strong preference for habitat farther from large settlements and roads (Barnes et al. 1991; Blake et al. 2008; Laurance et al. 2006), but are attracted to habitats that have been used by people in the recent past. Both logging and agricultural practices in central Africa generate rich secondary growth for which elephants show strong preference over the more open primary forest (Barnes et al. 1991; Lahm 1993). The bonus of encountering fresh crops and fruit trees in the mix makes the typical rural agricultural scene an ideal habitat for elephants.

Despite their affinity for human-used lands, elephants tend to avoid infrastructure and towns above a certain population threshold regardless of the surrounding habitat when alternatives are available (Buij et al. 2007; Sitati et al. 2003). In many situations throughout Africa, population increase and agricultural expansion limit these other alternatives, bringing elephants and humans in contact regardless of fear. In Gabon, however, the problem is the opposite: Village populations and rural agriculture have experienced rapid declines in the past few decades, evidently bringing many below the threshold population size that signals danger for elephants. Small villages are often hard hit by elephant raiding, creating a self-perpetuating decline as many farmers give up and move elsewhere. While this pattern feeds into the chronic rural exodus in Gabon (Pourtier 1989; République Gabonaise 2001), villages do not simply disappear. Those that do momentarily disappear often reappear years later, with the re-founding party frustrated or even outraged to have to cohabit their entitled space with elephants.

This dynamic between present and past human land use and elephant land use brings about questions of how Gabonese are currently using the rural landscape and how trends may play out in terms of agricultural production generally and farmer-elephant conflict specifically. General trends in urbanization, declining agricultural production, and aging of the rural population may suggest that villages and rural agriculture are on a path to extinction in Gabon. However, my observations in Gabonese villages suggest that this might not be the case.

General demographic and agricultural trends in Gabon

Gabon has experienced an unwavering trajectory of urbanization since independence in 1960. In contrast to the 14% reported in the 1960 census (INSEE 1961), around 80% of Gabon's population currently lives in urban areas (Cour Constitutionnelle 2005) (Table 5.1). This decline in rural population has been accompanied by a natural decline in agriculture, due to the fact that 80% of the nation's agriculture is still produced by smallholder rural farmers (Nguema 2005). Agricultural imports have thus risen steadily (FAOSTAT 2009); even the staple, cassava, is increasingly imported from neighboring countries such as Cameroon and Nigeria, despite the better growing conditions in Gabon (Nguema 2005).

Table 5.1: Urbanization trends in Gabon			
	1961 INSEE[a]	**1993** RGPH93[b]	**2003** RGPH03[c]
TOTAL population:	444,264	1,014,976	1,269,732
% urban based on:			
% living in Libreville	?	41%	45%
% living in towns with population >10,000	?	66%	72%
% living in 50 "urban" canton centers	14%	73%	80%
% rural (based on last definition of urban)	86%	17%	20%
rural population density [d] (persons/km^2)	0.76	0.61	0.57

[a] (INSEE 1961)
[b] (Bureau Central du Recensement 1993)
[c] Data reported by the census bureau (Bureau Central du Recensement 2003) and published by the Constitutional Court, along with the officially recognized alterations (Cour Constitutionnelle 2005). Given the general disbelief of the official figure (IRIN 2008), and inability of representatives of the Court to explain how specific changes were made, I report the original RGPH numbers here.
[d] global density estimate calculated by dividing total area outside urban centers by rural population

Not only has agriculture decreased overall in Gabon, but field size per individual has decreased as well. While the agricultural census of 1960 reported farm sizes of nearly one hectare per household (République Gabonaise 1969), I found an average farm size of about half this in 2007 (Table 5.2, more details in Chapter 2). Smaller studies in different locations have found sizes in line with this trend (Edou-Edou 2005; Lahm 1993). If one accounts for declines in production from other types of farms, such as coffee and cocoa, declines in average production per farmer have been much more severe than those reported here (Pourtier 1989). While changes in policy and institutions can explain the decline in cash crops such as coffee and cocoa (Anderson 1987; Nguema 2005), the decline in production of subsistence crops is more likely linked to demographic changes.

Table 5.2: Average farm size (ha) over time

1960[a]	1989[b]	2005[c]	**2007**[d]
0.975	0.632	0.5	0.491

[a] Agricultural census, N=960 farmers in 240 villages (République Gabonaise 1969) figure only includes type VI (*arachid*) and VII (*viviere*) farms.
[b] 45 farmers in the Ogooué Ivindo province (Lahm 1993)
[c] 72 farmers in the Ayeme region of the Estuaire province (Edou-Edou 2005)
[d] Personal data from sample of 426 farmers in 36 villages (Chapter 2)

One such demographic change is the aging of the farmer population. The reporters of the 1960 agricultural census expressed concern over the relatively elevated average age of farmers and the "*fuite des jeunes,*" or apparent tendency of the young to flee agriculture (République Gabonaise 1969). While only 8-11% of farmers were over the age of 59 at the time, that figure has increased to 38-60% for current Gabonese farmers (Table 5.3). This aging of the farming population does not seem to be responsible for the declines in farm size, because older farmers tend to plant more than younger farmers (Chaper 3); however, it does raise questions about overall agricultural output for Gabon. Will the younger generations take on the role of farming later in life, or is rural agriculture becoming archaic in modern Gabonese society? Even if the aging farmer population sustains itself, lack of a younger population in the villages limits options for protecting crops against wildlife (Lahm 1993, Goldman 1996).

Table 5.3: Age of rural farmers, 1960 vs. 2007

	1960		2007	
	popCensus[a]	*agCensus*[b]	*agCensus*[c]	*pers.*[d]
<30	22%	11%	7%	4%
30-59	70%	88%	54%	32%
>59	8%	11%	38%	64%

[a] Full population census, means of employment question (INSEE 1961)
[b] Agricultural census, N=960 farmers in 240 villages (République Gabonaise 1969)
[c] Agricultural census, N=7005 farmers in 100 sectors (Ministère de l'agriculture 2007)
[d] Personal data from sample of 426 farmers in 36 villages (Chapter 2)

Options for protecting crops, as well as need to do so (tendency of elephants to frequent a village), are also influenced by the size of a village. The typical Gabonese village has followed a trajectory of initial growth from the *regroupements* of the colonial period and shortly thereafter (Robequain 1956), followed by slow decline through the present. Gabonese villages were historically small and scattered throughout the landscape, with a tendency to shift location every several years as hunters depleted local wildlife populations (Pourtier 1989, Lahm 1993). The colonial and government-backed *regroupement* policies forced villages to group together along the principle roads, to facilitate governability and increase profitability of sedentary crops such as coffee and cocoa (Lahm 2001). Although the villages have remained by the roads, the coffee and cocoa projects have failed (Pourtier 1984), causing farmers to return to their swidden practices and thus create lush secondary vegetation around their towns. This factor, coupled by the general trends in declining rural populations and infrequent use of many of the roads, has likely resulted in increased crop-raiding in many villages. Today, the average Gabonese village has 50-100 people (RGPH2003, unofficial data), and many I visited had a considerably smaller population present.

Unless such villages happen to have a skilled elephant hunter in their ranks, they are unlikely to be able to ward off attracted elephants, especially given that most of the people who are present are usually in their sixties or older. Many farmers tend to move away from villages hard hit by elephant raiding, thus compounding the relationship between village exodus and farmer-elephant conflict. Despite this emigration, villages rarely disappear. Many that do disappear are brought back to life, only to experience similar issues, perhaps at a heightened level.

Survey of community and mobility in Gabon

To understand rural-urban mobility patterns and the functioning of the modern village, I interviewed 4500 Gabonese distributed throughout the urban and rural landscape in proportion with the 1993 census data (Bureau Central du Recensement 1993), the latest data available at that level of detail at the time. Although I could not replicate the distribution exactly due to time and logistical constraints, I shaped my sample to best represent the rural and urban populations of each province (Table 5.4), with the exception of the Nyanga, which I sampled at a finer resolution. Because the Nyanga showed no significant differences with the other grouped provinces for any of the variables reported here, I lump all provinces together for the purposes of this report.

The survey was in the form of a questionnaire in French, administered by myself or one of two trained assistants. Respondents could fill out the questionnaire themselves or opt to respond to questions orally; about 95% chose the latter. I pretested questions in both rural and urban settings and generated options for closed-form responses based on an open-form version administered to the first 500 respondents. The final questionnaire and IRB approval are provided in appendix D

Table 5.4: Composition of sample for community and mobility interviews

	Sample	RGPH[a]	Province**	Sample urban	Sample rural	RGPH93[a] urban	RGPH93[a] rural
average age**	28	24	Estuaire	38.3%	3.3%	42.2%	3.5%
female**	51%	51%	Haut O.	4.9%	1.1%	7.5%	2.8%
living in urban**	78%	73%	Moyen O.	0.2%	0.2%	1.8%	2.3%
living in village**	22%	27%	Ngounie	2.4%	0.1%	3.7%	4.0%
currently in school	54%	34%	Nyanga	14.4%	9.2%	2.1%	1.7%
formally employed	12%	17%	O. Ivindo	4.9%	3.7%	1.8%	3.1%
task workers	9%	13%	O. Lolo	1.5%	0.1%	1.9%	2.4%
not in school nor employed	25%	36%	O. Maritime	10.9%	0.6%	8.6%	1.0%
			Woleu-Ntem	0.9%	3.3%	3.5%	6.1%
N**	**4500**		**TOTAL**	**78%**	**22%**	**73%**	**27%**

** Parameter was purposely fixed by the sampling design
[a] (Bureau Central du Recensement 1993)

HOME IDENTITY: When asked about "home" (*chez vous*), most respondents immediately identified with a geographic location, to which they claim a strong bond, although *46% had never lived in that location* (Table 5.5). Although 78% of respondents resided in an urban center, 47% cited a rural village as "home." Most respondents' "homes" are locations to which they trace family ancestry. While this "home" is solely a social space for some, the physical location has a distinct role for many. Many youth spend vacations in the geographic "home" location and/or plan to return to this location when they are older. Fifty-five percent expect to live in their "home" village when they are "old," and 57% would live in a village if suffering financial hardship. These responses suggest that the village is far from dying out, but plays an important role at different stages of the lives of modern Gabonese.

Table 5.5: Identity with "home"*(Chez moi)* in Gabon

	current residence All	current residence urban	current residence rural	age <20	age 20-29	age 30-39	age 40-49	age 50+
"Home" is a rural village	47%	40%	78%	38%	44%	52%	62%	79%
Currently lives at "home"	22%	15%	46%	23%	15%	19%	31%	44%
Was born at "home"	49%	41%	79%	38%	42%	55%	74%	88%
Has never lived[a] at "home"	46%	53%	21%	60%	50%	38%	28%	14%

[a] greater than 6 months

VILLAGE ROLE AS A SAFETY NET: Many respondents expressed importance in the village as a safety net to fall back on when times are difficult. Given Gabon's urban unemployment rate of 27-30% (République Gabonaise 1993), this "natural insurance" (McSweeney 2003; Pichon 1997) is critical at one point or another in the lives of many. This role is evidenced by the responses from young adults living in a village: Of those between the ages of 18 and 24, 23% were "taking a break" from school due to pregnancy or hardships, 48% had recently dropped out of school due to pregnancy or hardships, and 23% had no source of funding to pay school fees. Most men (74%) between the ages of 25 and 35 had attempted to find work in a city without success. Most women between the ages of 25 and 35 were single mothers who had not progressed far in school. Most farmed, and many sent food to children who were in school in the city. Respondents almost unanimously agreed that life is cheaper in the villages, and many commented that food is free[9]

VILLAGE ROLE AS A PLACE OF RETIREMENT: The village also clearly plays a role as a retirement destination for many Gabonese. Fifty-five percent of respondents, including 42% of urban residents, expect to live in their "home" village when they are "old." Many explained their preference of the village for retirement with reasons similar to retirees of industrialized nations: "it's quieter and more peaceful in the village," or "the air is cleaner in the village." Others saw returning to the village as a personal duty or obligation: "I have to follow my ancestors and take care of their land," or "my grandmother farms so she can send me good food; I have to do the same for my grandchildren – that's the grandmother's job." While it is difficult to predict what the respondents will actually do 30-40 years from now, interviews with farmers in the villages confirm that many people do return to the village in older life stages, after having spent most of their life away. Of the 426 rural farmers included in the survey, 42% had returned to the village after living in an urban area. Farming is seen increasingly as a retirement activity (Franqueville 1984) and as a form of both social security and family obligation.

[9] Farmers clearly agree that there is a price to farming, however; see Chapter 4.

There is a notable difference, however, between the current farmers who took a break from farming and returned and the 21% of urban dwellers surveyed who believe that they will one day farm (Table 5.6): the majority of these latter (93%) have never farmed on their own, and 23% have never even helped on a farm. Of current farmers, on the other hand, 95% were farming or helping their relatives farm regularly by the age of 12. This lack of farming experience among the younger generations could help explain declining size of individual farms as well as increasing lack of use of traditional techniques in dealing with raiding wildlife.

Table 5.6: Farmers and experience farming, current and future

Current farmers					
Has own farm currently			Helped on a farm regularly by age 12		
	rural	Urban		rural	urban
no	17%	84%	no	4%	5%
yes	83%	16%	yes	96%	95%
Potential future farmers					
Will farm in the future			Have farmed in past		
	rural	Urban		rural	urban
Definitely not	4%	10%	no	7%	69%
Probably not	1%	3%	yes	93%	31%
Maybe	15%	44%	Has helped on a farm		
Probably	1%	6%	no	0%	21%
Definitely	54%	15%	yes	100%	79%

VILLAGE ROLE AS AN INVESTMENT: Gabonese speak often of a moral obligation to invest in one's village both to keep the village alive and to pass along the village inheritance to the next generation. Given the poor roads and very rudimentary infrastructure in most villages, it is tempting to ask "what inheritance," as did many younger respondents who expressed no interest in the village. However, many others, especially political leaders and elders who have witnessed the coming and going of enterprises and interests, have more nuanced perspective on the potential of the landscape and the importance of positioning oneself astutely. Even if they do not currently use the village space, such individuals may invest both socially and physically in that space as a means of guarding access to resources or preserving future ability to contest such access to resources that may become more valuable under different circumstances (Berry, 1993).

This sort of territorial claim-staking is accomplished both through membership in social networks as well as physical marking, typically via houses or fruit trees. As in other parts of Africa (Hill 1963; Berry, 1985), houses are commonly used as a symbol of belonging in Gabonese villages regardless of the current residence of the owner. Cinder-block houses "*en dur*" are awarded greatest respect as a means by which to "invest" in one's village, and are generally accepted as a valid claim to a location regardless of the state of apparent abandonment of the house. This phenomenon is especially apparent along the beach-front lots of Mayumba, where cement houses in various states of disarray litter the scenery, not so much as remanants of more prosperous days but as anticipants of such prosperity. Such cement houses are also common throughout villages in the interior of the country as a signal of village inclusion, providing owners and their families with means of access to land or other resources such as dividends from logging or access to future development projects.

Eighty percent of the rural residents interviewed own a house, versus only 11% of the urban residents. Of these home-owning urban residents, 20% own a home in a rural location. While the houses of rural residents tend to be of less durable materials, such as clay and wood, urban residents build more commonly with cement. Although 2% (20% of 11%) is a small percentage of the urban population, it represents a considerable number of people staking a claim in village landscapes relative to the small population currently residing in these villages. The relatively young average age of the sample population also probably leads to underestimation of this figure, as half of the sample population was school-aged and unlikely to have the resources to build a house.

Cheaper and more subtle than building a house, planting fruit trees can also be a powerful means of investing in the village landscape. It is not trivial that 38% of urban-dwelling respondents claim to have planted fruit trees in a village; fruit trees can provide a legitimate claim to a piece of land. In my work with rural farmers, I often heard entire sectors of forest ascribed to a person based on the presence of fruit trees he or she planted, regardless of whether that person currently lived in the village. Such land could almost always be borrowed, free of cost, for a cycle of farming, but the owner of the land was nonetheless acknowledged and would have to be consented regarding more permanent uses of the land.

Fruit trees are also notable in their role in reviving abandoned villages; the presence of trees such as oil palm and mango, which do not survive in the forest without human assistance (White & Abernethy 1997), often form the basis of proof for the existence of an ancestral village. In following up on complaints of farmer-elephant conflict, I visited seven such villages that had been completely abandoned and later reestablished based on claims of ancestry and evidence of fruit trees. While ancestral responsibility was generally evoked as the primary reason for reviving the village, this concept was applied so loosely that the ancestors' role in providing future kin with diverse means of access to resources was more apparent than the role of the kin in honoring their ancestors' land[10].

By formalizing villages, new leaders (*chefs)* receive access to government resources, including modest monthly stipends as well as often generous envelopes of money during election periods. Resource access generally extends farther, however, given that founding members almost always have current or past government affiliations which allow them to legitimize their village and afford the high costs of building with cinder block and running a generator (the characteristics that seem to distinguish reborn villages from permanent camps, which were banned during the *regroupement*s). In line with Bayart's *politics du ventre* philosophy, re-founding of villages provides a means for individuals with some political influence to expand and legitimize claims to resources by evoking tradition and ancestry. Such resources may include access to land and wildlife, a cut in a nearby forestry interest or development project, or simply more government resources to develop the newfound village.

[10] Ancestral responsibility can relate to anything from historical ethnic grounds to temporary dwellings of recent family members; three of the revived "villages" had in fact been temporary forestry camps where current founders recalled a parent or grandparent having lived, far from the traditional territories of their respective ethnicities.

Although revived villages represent a tiny percentage of the population, they can attract a disproportionally large amount of resources due to the political influence that village revivers generally wield. In the case of farmer-elephant conflict, these new villages can be especially draining on resources, as crop-raiding is typically chronic in these locations. Most residents of the revived villages I visited mentioned relentless elephant raiding as a major reason for the original demise of the village. Although two *chefs* I met were proud to announce ability to take care of their own problem via talented elephant hunters with apparently privileged political status[11], those of four of the other five villages were outraged by the high level of elephant raiding, and had or were seeking government funding for the problem. One *chef,* who had revived a village in an area currently used for elephant tourism, was seeking funding for a banana farm despite the fact that his new village consisted only of his family, who lived there only during vacations. Such reformation of villages by politically-connected individuals thus creates new incidences of farmer-elephant conflict and likely detracts attention and funds from situations of farmer-elephant that impact a larger number of current and future farmers.

Conclusion:

The changing village role in Gabon likely aggravates farmer-elephant conflict. The combination of smaller populations, fewer young men to ward off elephants and guard crops, less experienced farmers, and the constant repopulating of villages previously ceded to elephants, all contribute to the problem of crop-raiding. Because Gabonese spend increasingly less of their time in the rural landscape, many village populations have shrunk to levels that are not threatening to elephants. Because most of the people who do reside in the villages are older, villages have a difficult time actively warding off elephants via traditional techniques. Because new farmers have increasingly less experience farming, these traditional techniques are being forgotten regardless. However, because a larger proportion of Gabonese still

[11] In these cases, farmer-elephant conflict provides access to a different resource: elephants. This is similar to other situations I encountered where young men farmed small patches far away from their villages and evoked crop-raiding as justification for hunting elephants in the area.

identify conceptually with the "village" and invest in that identity, and because a smaller, but powerful, proportion re-create village spaces, small villages persist along with the problem of farmer-elephant conflict. Although Gabonese villages are unlikely to die out, elevated farmer-elephant conflict and continued agricultural decline are likely. Without large scale policy change, Gabon is unlikely to arrive at the government's goal of agricultural self-sufficiency (République Gabonaise 2001) in the near future.

Investment in improving the quality of existing roads may be the best way to promote rural agriculture while decreasing farmer-elephant conflict (Pourtier 1989). Although crop-raiding among the primary concerns, rural farmers I interviewed cited the bad quality of the roads and lack of transport more often than wildlife when asked about the worst problem faced by farmers in the area. The reporters of the 2007 agricultural census complain that they could not even arrive in some of their selected villages due problems with transport (Ministère d'Agriculture 2007). Urban residents who connect with these rural villages would likely spend more time in them if the transport were better, potentially maintaining a large enough human presence to ward off elephants. Improved roads would also benefit agriculture by facilitating transport of agricultural products to the urban markets, thereby increasing incentive for farmers to produce.

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Chapter 6.

Conclusion: Toward an integrated assessment of farmer-elephant conflict in Gabon

Crop-raiding by elephants threatens not only farmers' livelihoods but also elephant populations, as angry farmers retaliate, and national food security, as discouraged farmers give up on farming altogether. Farmer-elephant conflict is thus a key issue for policy-makers in Gabon concerned with a wide array of issues related to agriculture, rural development and conservation. As the oil reserves currently driving Gabon's economy dwindle, the government is expected to rely more heavily on its currently weak agricultural and ecotourism sectors (République Gabonaise 2001), thus increasing the pressure to address critical issues such as farmer-elephant conflict.

So far, little progress has been made in mitigating farmer-elephant conflict in Gabon despite general consensus regarding the high priority of the issue among farmers, agricultural agents and conservation representatives. Although each sector is making small investments in addressing specific instances of farmer-elephant conflict, most project leaders and experts I spoke with placed little optimism in the prospects of their projects making a significant impact in reducing crop raiding or appeasing affected farmers.

Several factors likely contribute to this lack of progress including:

- the diversity of the agencies involved and need for interagency collaboration to avoid pursuing contradictory strategies
- the complex nature of the problem and need for information on diverse topics ranging from farmer decision-making to forest elephant ecology

- the geographic heterogeneity of the conflict and potential need for different solutions at different scales
- the lack of data in Gabon, particularly pertaining to rural agriculture, and small number of trained personnel permanently stationed in Gabon to conduct such research and oversee long-term projects (Anderson 1987; FAO 2008; Stads et al. 2004).

Integrated Assessment (IA) offers a robust methodology to guide policy-making; it is designed especially for such complex problems that involve diverse actors and require information and perspectives from multiple disciplines. Although climate change policy currently constitutes the bulk of IA application and reflection (e.g. Intergovernmental Panel on Climate Change 2001), applications outside of climate change are increasing rapidly, due to the alignment of IA objectives with the needs of policymakers. While scientists are strongly involved in the IA process, the goal is not to arrive at some objective scientific "truth," but rather at a collective social agreement regarding a given issue (Hisschemoller *et al.* 2001). Knowledge is generated not for its intrinsic value alone, but rather to inform policy and decision-making (Tol & Vellinga 1998; Weyant et al. 1996). In this vein, it is especially important to consider what kinds of knowledge are generated and whose viewpoints are represented in the process.

Successful IAs include decision-makers and citizens at all levels in the design, creation, testing and use of the model or method (Jager 1998; Mitchell et al. 2006). While democracy alone justifies inclusive participation, involving stakeholders is especially critical in situations where the outcome depends on changes in stakeholder behavior. For example, if the success of proposed solution to farmer-elephant conflict is contingent upon farmers adopting a given method or otherwise altering their behavior, farmers should be key participants in the IA process.

When nonscientists are involved in an IA, it is often termed a Participatory Integrated Assessment (PIA). At its best, PIA not only strives to integrate knowledge and values of all participants into the policy *product* but also to enhance future decision-making skills through the *process* (van Asselt & Rijkens-Klomp 2002). This process-oriented approach is particularly important in this situation because elephants are known to adapt to new situations, requiring continual reassessment on the part of the planners (Osborn & Parker 2002). Process-oriented PIA could help decision-makers in Gabon to identify a cohesive, feasible strategy to address farmer-elephant conflict and to gain empowerment and stronger analytic and collaborative abilities for future decision-making.

In chapters one, two, and three, I demonstrate some types of questions that interested parties might pursue to gain insight into the scope of the problem and potential solutions before committing to a particular strategy. These chapters are limited to examining only one type of strategy, however: protecting individual farms from raiding elephants. A problem as complex as farmer-elephant conflict needs a robust set of strategies. Decision-making regarding both agricultural systems (Bland 1999; Nassauer et al. 2007b) and elephant conservation (Blake *et al.* 2008) benefit most from a complex systems perspective; it is no surprise that this conflict at the interface is not easily addressed by singular strategies (Barnes 2002; Hoare 2001; Osborn & Parker 2003). The IA framework is specifically amenable to incorporating diverse facets of such complex issues to allow for imagination of and comparison among diverse intervention strategies. In the remainder of this chapter, I outline the steps of an IA with particular emphasis on how a successful assessment might look for identifying and comparing a broad range of strategies to address farmer-elephant conflict in Gabon.

Recommendations for an Integrated Assessment on farmer-elephant conflict in Gabon:

PROCESS INITIATION:

The issue of farmer-elephant conflict concerns a diverse array of agencies and organizations, including those interested in planning/development, agriculture, and conservation. Successful Integrated Assessments are generally initiated and endorsed by an agency with the intentions and authority to implement the results (MSG&GESI 2009). In this case, the agency best positioned to oversee and implement an IA concerning such broad mandates would be the Ministry of Planning, who sets Gabon's development budget and passes down broad policy goals to the other ministries, including the Ministry of Agriculture and the Ministry of Waters and Forests.

Primary millennium goals set by the Ministry of Planning, in collaboration with the United Nations and World Bank, include reducing poverty, increasing agricultural self-sufficiency, curbing rural exodus, protecting the environment, and diversifying the economy via both agriculture and ecotourism (République Gabonaise 2001, 2003), all of which correspond to reasons for mitigating farmer-elephant conflict given by one or more of the individual organizations stating interest in the problem (Table 6.1).

Table 6.1: Goals aligning agencies in common interest to mitigate farmer-elephant conflict

Goals underlying G1 mentioned by representatives of organizations			MPPD[1] goals
G1)	**Reduce crop-raiding by elephants**		
	G2)	**Improve rural livelihoods**	MDG1, CCA-1.1.5b
		G2.1) reduce trends in rural exodus (migration to urban centers)	CCA-1.2.3c
		maintain villages at viable size for schools, health clinics, etc.	
		reduce urban unemployment (use village as security net)	MDG1
		G2.2) Improve health and nutrition	MDG1, CCA-1.2
	G3)	**Improve nation-wide agricultural production**	MDG1, CCA-1.7
		address steady decline in rural farming	
	G4)	**Maintain healthy elephant populations**	MDG7, SNPA-DB
		reduce retaliatory killings	
	G5)	**Increase revenues from tourism**	CCA-1.6.1
		G5.1) enhance community-park relations to improve tourism	
		G5.2) increase tourism revenues to benefit community	

[1]MPPD: Ministry of Planning and Development. Goals stated in three documents below:
MDG: Millennium Development Goals (Republique Gabonaise, 2003)
CCA: Common Country Assessment (Republique Gabonaise, 2001)
SNPA-DB: National Strategy and Plan of Action for Biodiversity Conservation, 2000

Ideally, the Ministry of Planning would initiate a request for the IA process, thereby demonstrating buy-in and commitment to the process. A facilitator should then be appointed to coordinate all events and serve as a moderator at meetings. With its mandate to oversee and coordinate research activities in Gabon, facilitate the sharing of scientific findings, and support research training, The National Scientific and Technological Research Center (CENEREST) is best positioned to facilitate the process. A diverse and representative group of participants should then be invited, including representatives of stakeholder groups and interested agencies as well as technical consultants. Some potential participants are listed in Table 6.2.

Table 6.2: Some* agencies/stakeholders interested in farmer-elephant conflict in Gabon
G1-G5 refer to goals in Table 1

Stakeholders / Organizations expressing interest		
Organization	**Type**	**sub-interest in G1**
Ministry of Planning	Government	G2.1, G3, G5
Ministry of Agriculture	Government	G2, G3
United Nations, Food and Agriculture Org. (FAO)	Intergovernmental	G2.2, G3
Ministry of Waters and Forests	Government	G4, G5
National Parks Council (CNPN)	Government	G4, G5
ECOFAC	NGO	G5, G4
Wildlife Conservation Society	NGO	G4, G5
World Wildlife Fund	NGO	G4, G5
Central Africa Protected Areas Network (RAPAC)	NGO	G4, G5
farmers and village authorities	Citizens	G1, G2
Additional expert consultants		
National Scientific and Technological Research Center (CENEREST)		
Tropical Ecology Research Institute (IRET)		
Social Research Institute (IRSH)		
Agricultural and Forestry Research Institute (IRAF)		
Gabonese Institute of Development Support (IGAD)		
Technological Research Institute (IRT)		
Center for International Forestry Research (CIFOR)		
International Agricultural Research Center for Development (CIRAD)		
General Direction of Statistics and Economic Studies (DGSEE)		
la Station d'Etudes des Gorilles et Chimpanzés (CIRMF)		

**This list is by no means comprehensive. Initial meetings can identify others.*

The primary advantage of including all interested parties in the process is to incorporate multiple viewpoints to arrive at one agreed upon cohesive strategy rather than the separate, often contradictory strategies that each agency may implement individually. In my conversations with representatives from several organizations expressing interest in mitigating farmer-elephant conflict in Gabon, the diversity of overarching goals and reasons for involvement was striking (Table 1). Not surprisingly, each organization's stated interests in addressing the conflict related directly to its mandates (Table 6.2): for conservation organizations, as a means to preserve healthy elephant populations and enhance tourism revenues; for agricultural organizations, as a means to improve agricultural production; and for development organizations, as a means to improve livelihoods. Acting separately, a conservation organization might choose to reduce farmer-elephant conflict by helping farmers find alternative means of employment in ecotourism while an agricultural agent might encourage more farming by providing materials to help farmers minimize risks and maximize output. Yet another agency might provide ammunition to ward off raiding elephants. While all three strategies may have the potential to reduce farmer-elephant conflict by themselves, the combined effect is counterproductive. By acting together and framing the question in a narrower sense to incorporate each other's broader goals these agencies could make a much greater impact in addressing the issue. The first step is to define this inclusive, policy-relevant question.

STEP 1: DEFINE A POLICY-RELEVANT QUESTION

The Ministry of Planning is in an excellent position to help participants frame the scope of the integrated assessment in a way that incorporates each agency's mandate, given its own mandate in setting the broad policy agenda for each of the ministries representing these diverse interests. Conservation representatives cannot endorse strategies that lead to declines in elephant populations; agricultural representatives cannot endorse strategies that lead to declines in agricultural production; development and planning representatives cannot endorse strategies that lead to increased unemployment or food insecurity. An appropriate question that encompasses all mandates might therefore be: What are plausible strategies to reduce farmer-elephant conflict while maintaining healthy populations of both farmers and elephants in Gabon?

STEP 2: ESTABLISH APPROPRIATE ASSESSMENT METHODS

Once the framing question is set, the next step is to begin identifying data needs and appropriate assessment methods. As the overall goal of the assessment is to evaluate different policy options, different kinds of data will need to be integrated into cohesive policy packages that can be compared. There are several ways to achieve this packaging, ranging from purely descriptive narrative scenarios to formal, quantitative models. More details on scenario-building and modeling are provided in step 6 below. It is crucial that the broader IA-participant group be involved at this preliminary development stage, even (*especially*) if the anticipated analysis methods are too technical for most participants to fully understand. Such involvement will lend legitimacy and credibility to the data and methods and will increase the interest and capacity of participants to provide valuable feedback in the final analysis stages. *A preliminary workshop should be held during which stakeholders and experts identify the gaps in knowledge most critical for assessing strategies and help calibrate methods that will be used to evaluate those data.* Key questions to consider are discussed in the next steps.

STEP 3: DOCUMENT STATUS AND TRENDS AND INVESTIGATE UNDERLYING CAUSES

The first data-collection step is to document relevant status and trends. One question that often comes up is what causes the perceived increase in conflict: have crop-raiding events actually increased, has farmers' tolerance and ability to cope decreased, or has increased attention toward tourism and elephants simply increased farmers' vocalization of the conflict? Proving one cause over another will not make the current conflict any less valid, but insights into the driving causes might help identify the most promising intervention strategies. If elephants are raiding more frequently in some areas, maybe there is an issue with habitat degradation or poaching driving them away from their traditionally preferred habitat. If farmers are not coping as effectively, identifying changes in farming systems and community structures or culture that have altered farmers' ability to cope may help uncover paths to improving coping strategies under current situations. If the recently established protected areas and (re)new(ed) focus on elephant conservation has elevated complaints from farmers, perhaps mechanisms for farmers to benefit more from tourism would be as effective in mitigating the conflict as addressing the actual crop-raiding problem. Research into the underlying causes is not likely to prove one cause over another, but rather reveal various degrees of each, differing with specific location and situation. Any exercise in identifying causes and trends should be oriented toward the implications the findings would have for specific intervention strategies, not toward who should be blamed for the problem.

There exist little quantitative data on the extent and intensity of crop-raiding in Gabon, thus documentation of trends in actual crop-raiding events rely on the recollections of the farmers' themselves, which are prone to exaggeration of the present (Hill et al. 2002; Languy 1996). Establishing the actual intensity of crop-raiding is not necessary to agree that it is a problem, but such data would help inform potential mitigation strategies. Unfortunately, this requires a long-term effort, because elephant behavior varies from season to season and year to year; quick surveys provide only snap-shot images which are dependent on the time the researcher happens to visit and thus tell us little about larger trends. Standardized, quantitative documentation protocols, such as that recommended by Hoare (2001) should be put in place around all of the national parks and locations where permanent staff is available to investigate raiding-events year-round. Because crop-raiding is clearly a problem in many areas, however, such quantitative data are likely unnecessary to proceed with the larger-scale planning outlined here.

STEP 4: DESCRIBE ENVIRONMENTAL, SOCIAL, AND ECONOMIC CONSEQUENCES

While the ultimate goal of reducing farmer-elephant conflict is explicit in the nature of this assessment, it is not enough simply to choose the policy that leads to the largest expected decrease in crop-raiding. Participants have other goals and values that affect the attractiveness of options, as each policy option brings a different set of environmental, social, and economic consequences. *During the preliminary workshop, participants should brainstorm mitigation strategies, potential primary and secondary consequences of such strategies, and gaps in knowledge most critical to evaluating these strategies and consequences.* Table 6.3 provides an example of such an exercise based on my observations and information from relevant literature; actual strategies and information gaps should be identified by the participants themselves, however.

Focus groups, workshops with break-out sessions, debates, and role-playing activities can be used to solicit perspectives from a diverse group of participants. If later analyses are to involve more technical modeling, this first phase might involve a system sketch model using user-friendly modeling software such as STELLA to stimulate participant input. This allows participants to get a feel for the modeling process while providing modelers a structured means by which to gather important input on potential model parameters (Costanza & Ruth 2001).

Regardless of the final packaging technique, feedback should be solicited from participants regarding the input and output variables that are most likely important. For example, if the product is to include a benefit-cost analysis, participants' values and perspectives regarding relevant types of benefits and costs should be discussed before data are collected. If only monetary costs are explored, "low cost" options that may appear attractive to modelers may be rejected by the end-users due to other unaccounted for costs (chapter 2). If the product is to include a spatial model of elephant land-use dynamics, loggers, farmers, and former elephant hunters can all provide valuable information on landscape characteristics influencing elephant movement in a given region that can greatly enhance sparse scientific data[12].

[12] For example, NZASSI Souami, current Ecoguard for Wildlife Conservation Society, and former elephant hunter, provided maps of elephant movement in the Banio lagoon region of Mayumba (author data) that elucidate the potential of a landscape-level solution in the region. Souami and colleagues should play an integral role in the exploration of such strategies.

Table 6.3: an outline of potential strategies and research needs to mitigate farmer-elephant conflict

G1, G2, G3, G4, and G5 refer to the goals presented in Table 1

POTENTIAL POLICY OPTIONS	TRENDS/CAUSES/CONSEQUENCES RELEVANT TO PRIMARY GOALS	POTENTIAL SECONDARY CONSEQUENCES	OTHER QUESTIONS TO CONSIDER
FARM-LEVEL PROTECTION			
• Passive barriers (chili-pepper fences[13] beehive fences[14], barbed-wire, etc.) • Passive repellants (e.g. pepper bricks[1,15]) • Active guarding of farms (could include active repellants)	**G1)** Are there known methods that effectively deter elephants? How effective are they in Gabon? **G2)** Will farmers be better off using proposed methods compared to alternative methods of coping with elephants? What are the opportunity costs? **G3)** Will farmers produce more using such methods? Would those who abandoned find it more attractive? **G4/G5)** What situations/characteristics would such a strategy require for farmers to support elephant conservation?	**Social:** Theft of materials, children being withheld from or missing school more often (if sleeping in farms), potential hazards of bees **Economic:** If farmers bear all of the monetary/labor costs, likely to resent conservation. If others take on too many costs, farmers may not "own" and maintain/apply methods effectively.	Who should/would bear the costs (monetary and labor)? Are passive barriers feasible with swidden agriculture, or will agricultural practices need to be changed also (refer to questions under "Agricultural Systems Change")
VILLAGE-LEVEL PROTECTION			
• Fencing agricultural zones for entire villages • cooperative farms / organized guarding	**G1)** Are there known methods that effectively deter elephants? **G2/G3)** Under what characteristics/situations would community members buy in to and benefit from such a strategy? What other cooperative management situations exist in Gabon that we can draw from? If fencing, how much space does each farmer need? **G4/G5)** What situations/characteristics would such a strategy require for communities to support elephant conservation?	**Social:** Enhanced community cohesion/ management capacity if successful. Likely community conflicts if unsuccessful. Need to consider high mobility in Gabon; the fixed capacity of fencing projects could bring about issues of immigration and village "belonging" **Environmental:** if fencing, may fence off habitat or migration corridors vital to wildlife.	Who should/would bear the costs (monetary and labor)? Who will maintain the fences? Can an area large enough for swidden agriculture be fenced off, or will agricultural practices need to be changed also (refer to questions under "Agricultural Systems Change")

[13] (Osborn & Parker 2002)
[14] (King et al. 2009)
[15] (Ongognongo et al. 2006)

LANDSCAPE-LEVEL PLANNING			
• zoning some areas as agricultural, others as conservation) • Subsidizing/assisting agriculture in certain zones to encourage migration • Largely ignoring agriculture near elephant zones	**G1)** Are there areas where elephants tend to raid less? What is it about these areas that make them less attractive to elephants? Are these zones good for agriculture? **G2)** Are there general rural mobility trends that can be utilized so as to minimize impact on livelihoods? **G3)** What locations would be most strategic for improving agricultural production and market availability? **G4)** Are raiding elephants present year-round or do they raid seasonally during migrations? If seasonal, what areas are most vital for elephant populations? **G5)** How can livelihoods be improved for people bordering Protected Areas (presumably already designated as elephant zones)?	**Social:** Neglect of villages outside of agricultural zones. Possible large-scale conflict if some ethnic groups are privileged over others **Economic:** Privatization of land in agricultural zones may become an issue, making agriculture less of a safety net for the poor than it is under dispersed system. **Environmental:** Wildlife habitat could become more fragmented. Need to consider more than just elephants.	How will elephants be kept out of agricultural zones? What will happen to villages in elephant areas? Is it fair to abandon them?
HABITAT MANAGEMENT			
• Ban logging of key food species for elephants • Plant key food species[16] for elephants in desired elephant zones • Build salines in desired elephant zones • Remove bamboo, mango, *chocolatier*, and other attractive species from villages	**G1)** Have key food species been significantly reduced in forest? Do elephants tend to crop-raid less in areas where there are still many fruit trees in the forest? What types of trees or foods do elephants follow throughout the year? How could this information be used to alter the attractiveness of agricultural areas? **G2)** If bamboo and fruit trees are removed from villages, will extra agricultural output be enough to offset these extra losses?	**Economic:** Protecting more tree species might reduce logging revenue. Would also mean higher costs or monitoring/enforcement. **Environmental:** Benefits may extend to many species, but habitat intervention may have unforeseen consequences. Concentrated elephant zones without monitoring may facilitate poaching.	If more rules are made, how will they be monitored and enforced?

[16] (Blake & Inkamba-Nkulu 2004)

AGRICULTURAL SYSTEMS CHANGE			
• Swidden to permanent (which can be protected with more permanent structures) • Promote tree/shrub crops (coffee, cocoa) that less prone to trampling • Promote crops not liked by elephants (i.e. pepper, *oseille*)	**G1)** What is the market potential for crops that elephants avoid? **G2)** What infrastructure/Institutions would need to be in place for farmers' livelihoods to improve with a switch to cash crops or permanent agriculture (e.g. roads, credit/microcredit, trainings on use of pesticides). What lessons can be learned from the fall of the *Caisse cafe-cacao* in the 1970s[17,18]? **G3)** If switch to cash-crops, what would export/import market look like? How might food security be affected? **G4)** What might deforestation trends look like under a shift to permanent agriculture? Would elephant habitat be affected?	**Social:** likely result in sudden privatization of historically communal resources **Economic:** Rural farmers would interact more with the market. More opportunity for taxation. **Environmental:** Pollution from toxic chemicals, lower carbon emissions, likely impact on forest? (Longer-term soil degradation leads to expansion by farmers without much capital for fertilizer)	How will poor farmers meet startup costs? How will communal land be allocated? How will subsistence farmers cope if far from markets? How will this affect food security?
CROP INSURANCE SCHEMES			
• Farmers buy premiums for crop-insurance • Government or NGOs subsidize crop insurance, based on intensity of raiding in area	**G2)** If farmers buy insurance, how can the system be managed to ensure that farmers' livelihoods improve in general? Are there similar insurance schemes elsewhere that we could learn from? **G3)** How might overall agricultural output be affected by such a system? Would the benefits outweigh the costs of managing/monitoring the payment scheme **G4)** Are there elephant-prone areas that farmers avoid now but would farm in and thus degrade under such a scheme? If so, how could this be prevented?	**Social:** moral hazards[19], increased incentives for corruption[20]. If funds are external (no farmer buy-in), can increase perception that raiding is solely others' responsibility. **Economic:** More interaction between rural farmers and the market. Could produce useful data on individual and nationwide agricultural production **Environmental:** Farmers may clear more forest than usual if payments are based on area planted	Who will manage insurance? How will the payment funds be managed? How will losses be monitored? How will farmers be encouraged not to take unnecessary risks?

[17] (Anderson 1987)
[18] (Hazell 1995)
[17] (Nguema 2005)
[18] (Anderson 2003)

Problem elephant control			
• Current system of *battue administrative* with the Ministry of Waters and Forests[21] • Revised version of similar system • Safari hunting of problem animals[23]	**G1)** Is crop-raiding the result of a few individuals? Mostly male bulls? If so, does removing them reduce raiding? What can we learn from the current system of *battue administrative*? **G2)** Do all farmers have equal access to the system? Would the benefits of reporting a problem outweigh the costs to the individual farmer? **G4)** What is the impact of such control on elephant populations? What mechanisms would need to be in place to ensure that only frequent raiders are targeted?	**Social:** Farmer who lost crops to elephant may get little benefit **Economic:** Effective system can cost a lot (e.g. to ensure that elephants targeted are the actual problem elephants). Issues distinguishing legal vs. illegal guns, ammunition and tusks facilitate market for the latter. **Environmental:** Can destabilize elephant herd dynamics[22]. Safari hunting needs organization; can create need to fill demand when there are no problem elephants	Would there be enough good elephant hunters in a given area to address problem animals quickly? Would these hunters have an incentive not to hunt illegally?
Indirect mitigation (Compensate losses in other ways)			
• Create jobs from conservation/tourism • Create community fund from tourism revenue	**G2)** Would the (would-be) farmers who suffer from crop-raiding be the same ones who gain from conservation? Would women gain as much? Elderly? **G3)** Would agriculture be increased elsewhere to compensate net decline? **G5)** Would village see benefit in conserving elephants over reverting to agriculture?	**Social:** Greater inequities in village if some benefit more than others. Potential for conflict. Issues with village "belonging" may arise if funds are given directly to community. **Economic:** More unemployed elderly (most farmers are 60 or older).	How will inter-village immigration affect the outcome? How are future farmers incorporated?

[21] (Lahm 1993)
[22] (Omondi et al. 2004)
[23] (Hoare 1999)

Once data needs are identified, the intensive task begins of amassing the data necessary to begin assessing feasibility of strategies and comparing among the proposed strategies. A preliminary triage is likely necessary to determine the most critical data gaps that would allow for the broadest range of policy options that can be reasonably assessed in the shortest possible timeframe. Less critical gaps could be made part of a less urgent, longer-term research agenda. *Small working teams should be assigned to specific research topics that fit within their domain of expertise*. In light of the ongoing need for data and the fact that Gabon's agricultural research capacity is among the smallest in Sub-Saharan Africa (Stads *et al.* 2004), *it is critical that teams include both current experts familiar with the required research and analysis methods and residents training to become future experts of these methods for Gabon.* As in process-based participatory Integrated Assessments, the goal should be as much to gather data in the present as to develop capacity to continue the process in the future.

CONSIDER VARIOUS SCALES:

The most powerful integrated assessments help planners anticipate effects of proposed policies at multiple scales (Scavia & Nassauer 2007; Verburg et al. 2006). Indeed, there is likely great variation in causes and effectiveness of potential intervention strategies throughout Gabon. There is great tradeoff in identifying strategies that are best fit for each location and arriving at a cohesive strategy that is best suited for a large-level player such as the Ministry of Planning, however, especially with limited personnel and resources. A reasonable compromise might be to *select a few strategic locations to focus on for the principle assessment process, aimed at defining a loose national strategy*. Once this national strategy is outlined, smaller regional assessments can be carried out to fine-tune and help identify the most appropriate course of action within this broader framework at specific locations.

Based on my observations, I would suggest the regions around Mayumba, Lopé, and Monts de Cristal for the initial assessment, as each embodies different issues and potential solutions that I encountered. With its status as a UNESCO world heritage site, Lopé represents Gabon's most fully functioning national park and stands to serve as an example for the development of other protected areas. A strategy for addressing the intense crop-raiding problems in neighboring villages, such as Kazamabika, would thus serve well for national-level policy planning. As a marine park, Mayumba does not generate the quantity of revenue from terrestrial wildlife-based tourism as does Lopé, nor could it really be blamed for the intense elephant raiding in the area. It provides insight into other factors at play, likely related to farming trends, microhabitat, and hunting pressure from neighboring Congo. These latter issues open potential for regional-level landscape management (e.g. Jackson *et al.* 2008) and could be used as an exemplary case of how to assess such strategies. The villages around the Monts de Crystal do not receive the same intensity of elephant raiding as the other two regions; however they experience enough raiding to discourage many people from farming. The proximity of this area to Libreville heightens the interest of the Ministry of Agriculture, which is looking to increase production in the rural areas surrounding the capital. A potential conflict of interest occurs between those interested in the conservation of the Monts de Crystal Region and those interested in agricultural development. A general strategy for balancing the two while taking into account the issues that occur at their interface could serve as an example for similar situations near other urban centers, such as Tchibanga.

Other regions, such as the Plateaux Batekés, Pongara, Ivindo, Woleu-Ntem, and the Ngounie all have unique experiences and situations which should be taken into account when developing a national strategy. Representatives from these areas should be asked to participate in brainstorming and information-sharing meetings to help account for their particular situations. General data should also be gathered from these areas, especially when assessing strategies such as national-level landscape planning. However, with limited resources, it is likely infeasible to conduct all aspects of the in-depth data collection suggested above in all regions.

STEP 5: DEVELOP ALTERNATIVE POLICY SCENARIOS; IDENTIFY DESIRED OUTCOMES

The goal of the data gathering step is to inform the construction of a range of policy scenarios and plausible outcomes of pursuing each policy path. Again, given the scarcity of data in Gabon, simultaneous evaluation of all potential policy options should not be the goal. A subset of options that appear most promising in balancing participants' needs should be identified during the preliminary assessment meetings. The research teams should then collect the necessary information to inform the potential impact and outcomes of this set of strategies. Once relevant data are collected, the participants can reconvene to assess the policy scenarios as in the next step.

STEP 6: EVALUATE VARIOUS POLICY OPTIONS

Once enough data have been gathered on the key underlying processes, *a second participant workshop should be convened* to project these processes into the future and evaluate plausible outcomes under the proposed policy interventions. The goal is not to predict the future, but rather to generate plausible scenarios to stimulate discussion. *At this stage, the focus should be on understanding stakeholders' priorities and values in weighing different solutions in terms of environmental, social, and economic costs*.

Various methods can be used to compare options and stimulate discussion between participants. Descriptive scenarios and role-playing can generate much insight into participants' perspectives and values (e.g. Caille *et al.* 2007). Images can offer an intuitive means by which to extract basic preferences and provoke discussion (e.g. Nassauer *et al.* 2007a). Various degrees of complexity can be added with a dynamic temporal component (e.g. Dockerty *et al.* 2006) and/or a broader spatial component based on GIS (e.g. Santelmann *et al.* 2007). This latter method could be particularly useful for comparing landscape options for mitigating farmer-elephant conflict.

More technical computer-based simulations or agent based models offer an attractive means to project processes and watch futures unfold under different intervention strategies. The intent of such an activity should never be to provide an exact model of what will happen, but to provide a plausible image to drive discussions about desired outcomes and most likely paths to arrive at such outcomes. Modelers need to be acutely conscious of the role of their model in this capacity to avert the dangers of stakeholders or decision-makers placing too much weight in specific model predictions or dismissing the model altogether due to debate over precision in the predictions (Hisschemoller *et al.* 2001). Although overly technical models are often too opaque, detail-rich simulation models tend to draw out more insightful discussion than more abstract models at this stage in the process (Costanza & Ruth 2001; Siebenhuner & Barth 2005).

The data gathering and analysis phases can be an iterative process: If research findings or discussions highlight other critical data gaps or bring other policy options to the forefront, the research teams may need to collect more data until the decision-maker is satisfied that there is enough data to evaluate plausible outcomes. “Plausible” is different from “certain”, however. We will never have enough data to be certain of the outcome of a policy; human and elephant behaviors are driven by complex systems that will always maintain a degree of elusiveness. As with all policy decisions, it is up to the decision-makers to decide when they have enough information to make an initial policy intervention, knowing that policies must be adapted constantly as systems change or unexpected results occur.

STEP 7: PROVIDE GUIDANCE FOR POLITICAL ACTION:

Based on all understanding gathered from both the data and the discussions, policy options can be assessed to maximize success in achieving the goal of mitigating farmer-elephant conflict while minimizing consequences judged unfavorable by stakeholders. *Stakeholders and experts should be drawn upon not only to identify preferred options, but also to generate a set of concrete steps to implementing those options and a list indicators to be used to measure the success of the policy in meeting* *stated goals*. Such indicators may include average rural farm production to assess success in meeting G2 (table 6.1), per-capita agricultural imports to assess success in meeting G3, or numbers of elephants sited during tourism safaris, to assess success in meeting G5.

STEP 8: ASSESS THE COMPARATIVE OVERALL PERFORMANCE

Given that this is an iterative process, the initial Integrated Assessment should compile lessons learned and gaps in information to inform the next round of assessment. It should wrap up with an evaluation of the process itself and recommendations for future assessments.

This Integrated Assessment process is ambitious and should not be judged solely on its ability to produce immediate results in reducing farmer-elephant conflict. Although end results are clearly important, they will unlikely be apparent immediately. In the short term, there are several other criteria by which to evaluate the success of an IA (Farrell & Jager 2006; Social Learning Group 2001). If these short-term criteria are met, there is far greater likelihood that the IA will be successful in meeting its longer-term goals. It is therefore useful to design the IA process around the goal of meeting the following short- and long-term criteria:

- Credibility/Technical adequacy: Were the methods used credible in the eyes of the scientific and stakeholder communities?
- Legitimacy/Fairness: Did a wide range of stakeholders participate in the process? Were they involved in all steps of the process? Do they perceive the process as fair?
- Salience/Value: Did the assessment address a policy-relevant question at a time that its recommendations could impact decision-making? Did the end user find the process and end product useful?
- Effectiveness: Did the process change how stakeholders and decision-makers understand or view the issue? Did the process and product influence policy? Did the resulting policy intervention influence outcomes in the desired way?

To establish credibility and technical adequacy, *the research teams involved should report their findings in the form most appropriate for their discipline or methodology, and subject these findings to peer review from other experts both within and outside of Gabon*. External review, which may include publication in peer-reviewed journals or presentations at conferences, helps ensure use of data collection and analysis techniques accepted by other experts in the field. Internal review by peers in Gabon helps ensure that sampling techniques and methods are accountable to on-the-ground realities. Such review may include reports of presentations subjected to review by the larger IA participant group or by a committee selected by the CENEREST.

To evaluate legitimacy and fairness, the diversity of perspectives incorporated in the end product should be considered as well as the participants' own perceptions of the fairness of the process in soliciting their viewpoints and of the end product in representing those views. *An external reviewer should be asked to conduct follow-up interviews with all participants to provide insight into the equity and fairness of the process*.

In this process-oriented approach, facilitated communication and improvement in understanding among a wide group of stakeholders should be considered a large achievement in and of itself. The impact of the immediate process on participants' understanding and views of the problem can be evaluated with additional questions on the follow-up interviews. *Preprocess interviews, designed to complement the follow-up interviews and detect changes in understanding and views, should also be conducted by the external reviewer.*

As with facilitated communication, increased capacity of local individuals or institutions to conduct research should be considered a tremendous accomplishment in Gabon and deserves a large focus of the investment. Standardization of research methods between institutions and establishment and training of in-country research teams dedicated to collecting data on various aspects of farmer-elephant conflict over time would greatly enhance the potential of meeting longer-term goals of understanding and mitigating farmer-elephant conflict.

Despite the potential for success in many dimensions, the most unfortunate possible outcome of an IA is that results are unusable or ignored (MSG&GESI 2009). To help ensure that this does not occur, it is critical that the IA be requested by an agency with the authority and intent to act on the findings at a time when it is able to do so. Until this point arrives, institutions and individuals interested in mitigating farmer-elephant conflict can continue to assess and address the situation individually, with a focus on generating quality data that can be used to inform such integrated processes in the future.

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Appendix A: Variation in estimates of crop value and yield for Gabon

Plantain prices

cfa/kg	95%CI	source	situation
522	29	IGAD ,	market price in LBV 2004-2005 (5 markets, 24 months)
400		EdouEdou 2007,	farmer price in Port Gentil
600		EdouEdou 2007,	market price in Port Gentil
200	20	Walker, raw data	reports from rural farmers who sell in bulk to transporters
314	66	Walker, raw data	reports from farmers who take own product to market
400		EdouEdou 2007,	farmer price in Ayeme
485		EdouEdou 2007,	market price in Ayeme
417	99	**Average value**	

Plantain yield

t/ha	95%CI	source	situation
6.3	0.63	FAOSTAT	
10		Edou-Edou 2007	Port Gentil area
16	2	Edou-Edou 2005	Ayem area
20	4	De Lannoy 2004	
22		Maman Oyan	
4	0	Tissier 1963	Woleu-Ntem, not much description of source of numbers
14.15	**7.85**		

Manioc prices

cfa/kg	95%CI	source	situation
357	14	IGAD ,	market price in LBV 2004-2005 (5 markets, 24 months)
115		Edou-Edou 2007	Roadside, FCV
190		Edou-Edou 2007	Roadside, LBV
130	20	Walker, raw data	reports from rural farmers who sell in bulk to transporters
130	**20**		

Manioc yield

t/ha	95%CI	source	situation
5.1	8.2	FAOSTAT	
35	5	Edou-Edou 2007	
33	7	De Lannoy	
14.8		Edou-Edou 2005	Survey in Ayem area, farms with >10yrs fallow, no fertilizer
6	2	Tissier 1963	Woleu-Ntem, not much description of source of numbers
14.8	**9.7**		

Nut prices (shelled)

cfa/kg	95%CI	source	situation
883	**68**	IGAD,	

Nuts yield (shelled)

t/ha	95%CI	source	situation
1.01	0.055	FAOSTAT	with shell
1.1		De Lannoy	Shelled
1.8		De Lannoy	with shell
0.62		FAOSTAT (derived)	shelled (derived)
0.86	**0.24**		

Appendix B:

Farm protection and coping models

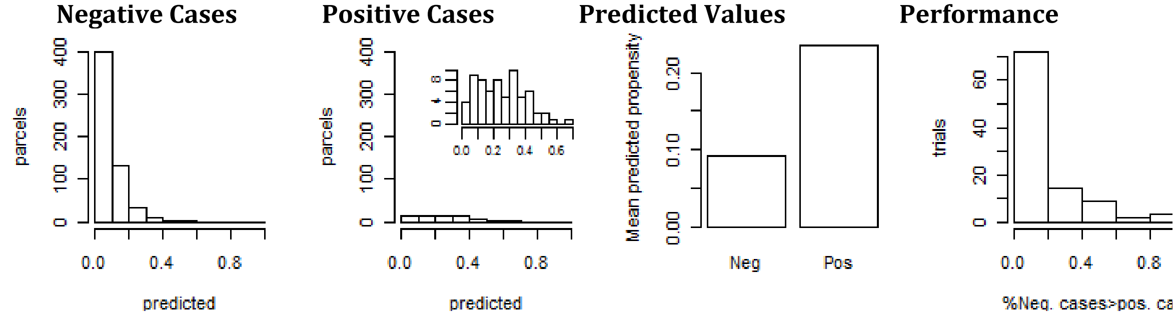
Significant predictors for presence of rodent fences in parcels (50 positive cases)

	Generalized linear mixed model fit by adaptive Gaussian Hermite approx. [a]							
	Deviance=325 LogLik=-155, AIC=311 Number of obs: 643							
	β values.[b]		**original values**				**p.[c]**	**Sensitivity[d]**
	coef.	**Odds ratio**	**Odds ratio**	**coef.**	**[95% CI]**			
(Intercept)	-3.61			-5.81	-5.06	-0.03	<.001	0%
perCMN	2.14	8.50	1.02	0.019	0.01	0.03	<.001	0%
Dist	-1.60	0.20	0.00	-0.064	-0.11	-0.02	0.01	0%
LCA$_R$	1.27	3.56	1.18	0.166	0.001	0.29	0.014	0%
MHelp60	0.68	1.97	1.97	0.677	-0.07	1.40	0.076	92%
TLossR	0.39	1.48	2.50	0.916	-1.79	0.02	0.667	100%
Random effects (TOWN, N=36): Variance = 3.55, std. dev. = 1.88, p-value[e] = 9.13E-7								

Tests of model fit

Observed values — **Negative Cases**, **Positive Cases**

Holdout simulations [f] — **Predicted Values**, **Performance**



[a] fit with "glmer" from nlm4 package in R version 2.9.1 (Bates, 2009)
[b] coeficients rescaled to have mean=0 and sd=.5; binary variables centered (Gelman, 2009)
[c] based on 32 df
[d] Percent of holdout trials (N=100, 5% of cases withheld) resulting in non-significant p-value (>.05)
[e] x^2 results from 1000 simulations comparing model to GLM with same fixed effects; based on methods in Bolker 2009
[f] Results from 1000 simulations with one positive case and five negative cases randomly excluded from the fitting of the model. Histogram on left shows average prediction for negative and positive cases. Histogram on right shows number of trials in which the model yielded higher predicted probabilities for zero (0%) to five (100%) of the negative cases compared to the positive case.

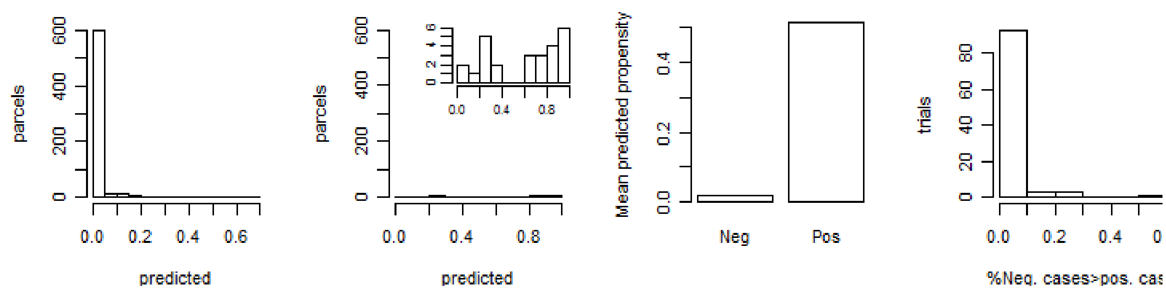
Significant predictors for presence of elephant fences (19 positive cases)

	Generalized linear mixed model fit by adaptive Gaussian Hermite approx. [a] Deviance=122 LogLik=-61, AIC=130 Number of obs: 666							
	β values.[b]		**original values**				**p.[c]**	**Sensitivity[d]**
	coef.	**Odds ratio**	**Odds ratio**	**coef.**	**[95% CI]**			
(Intercept)	-9.74			-12.47	-17.47	-7.48	<.0001	0%
LCA_E	3.09	21.98	1.77	0.57	0.13	1.02	0.02	2%
MHelpYr	1.45	4.26	4.26	1.45	-0.23	3.13	0.09	96%
Random effects (TOWN, N=36): Variance = 35.04 , std. dev.=5.9 , p-value[e]= 5.58 E-79								

Tests of model fit

Observed values — **Negative Cases**, **Positive Cases**

Holdout simulations [f] — **Predicted Values**, **Performance**



[a] fit with "glmer" from nlm4 package in R version 2.9.1 (Bates, 2009)
[b] coeficients rescaled to have mean=0 and sd=.5; binary variables centered (Gelman, 2009)
[c] based on 32 df
[d] Percent of holdout trials (N=100, 5% of cases withheld) resulting in non-significant p-value (>.05)
[e] x^2 results from 1000 simulations comparing model to GLM with same fixed effects; based on methods in Bolker 2009
[f] Results from 1000 simulations with one positive case and five negative cases randomly excluded from the fitting of the model. Histogram on left shows average prediction for negative and positive cases. Histogram on right shows number of trials in which the model yielded higher predicted probabilities for zero (0%) to five (100%) of the negative cases compared to the positive case.

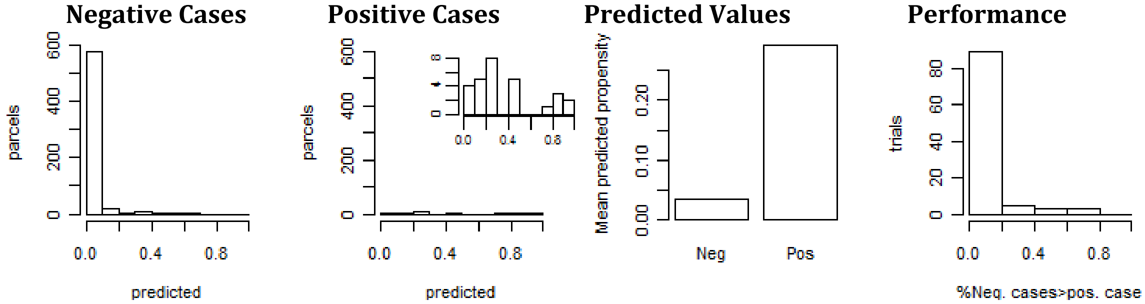
Significant predictors for presence of a hut to sleep in (29 positive cases)

	Generalized linear mixed model fit by adaptive Gaussian Hermite approx. [a] Deviance=165 LogLik=-82, AIC=175 Number of obs: 643[b]							
	β values[c]		**original values**				**p.[d]**	**sensitivity[e]**
	coef.	**Odds ratio**	**Odds ratio**	**coef.**	**[95% CI]**			
(Intercept)	-5.11			-7.14	-5.23	-7.34	<.001	0%
LCA_E	2.01	7.46	1.45	0.37	0.58	3.55	0.001	0%
Dist	1.06	2.89	0.00	0.04	0.09	1.89	0.068	82%
MHelp60	1.02	2.77	2.77	1.02	2.07	1.90	0.067	60%
Random effects (TOWN, N=36): Variance = 3.33, std. dev. = 1.82, p-value[e] = 2.10 E -11								

Tests of model fit

Observed values — **Negative Cases**, **Positive Cases**

Holdout simulations [g] — **Predicted Values**, **Performance**



[a] fit with "glmer" from nlm4 package in R version 2.9.1 (Bates, 2009)
[b] coeficients rescaled to have mean=0 and sd=.5; binary variables centered (Gelman, 2009)
[c] based on 32 df
[d] Percent of holdout trials (N=100, 5% of cases withheld) resulting in non-significant p-value (>.05)
[e] x^2 results from 1000 simulations comparing model to GLM with same fixed effects; based on methods in Bolker 2009
[f] Results from 1000 simulations with one positive case and five negative cases randomly excluded from the fitting of the model. Histogram on left shows average prediction for negative and positive cases. Histogram on right shows number of trials in which the model yielded higher predicted probabilities for zero (0%) to five (100%) of the negative cases compared to the positive case.

Appendix C:

Choice Experiment Design

STATISTICALLY EFFICIENT DESIGN:

2^2*3^3 design, produced in 36 runs
SAS D-eff = 1.07, D-error = .83

	Attributes 1	2	3	4	5
Package 1	1	2	2	3	3
Package 2	2	2	1	2	2
Package 3	1	1	3	1	2

	Attributes 1	2	3	4	5
Package 1	1	2	3	1	1
Package 2	1	1	1	3	3
Package 3	2	1	2	2	1

	Attributes 1	2	3	4	5
Package 1	2	2	3	3	1
Package 2	2	1	2	1	2
Package 3	1	1	3	2	3

	Attributes 1	2	3	4	5
Package 1	1	1	2	2	1
Package 2	1	2	1	1	1
Package 3	2	1	3	3	2

	Attributes 1	2	3	4	5
Package 1	2	1	1	1	3
Package 2	1	2	2	3	2
Package 3	2	2	3	2	3

	Attributes 1	2	3	4	5
Package 1	1	2	1	2	2
Package 2	2	2	2	1	3
Package 3	2	1	1	3	1

Where attributes equal:

1 Cooperation, 2 levels (1,2)
2 Need to sleep in plantation, 2 levels (1,2)
3 Monetary costs, 3 levels (1,2,3)
4 initial time costs, 3 levels (1,2,3)
5 maintenance time costs, 3 levels (1,2,3)

EMPIRICALLY IMPROVED DESIGN:

(FINAL DESIGN)

WARM UP	0	1	2	3	4	5
Status quo	1	0	0	0	0	0
Package 1	0	0	0	2	2	2
Package 2	0	1	2	3	3	3
Package 3	0	0	0	1	1	1

	0	1	2	3	4	5
Status quo	1	0	0	0	0	0
Package 1	0	1	2	2	3	3
Package 2	0	2	2	1	2	2
Package 3	0	1	1	3	1	2

	0	1	2	3	4	5
Status quo	1	0	0	0	0	0
Package 1	0	1	2	3	1	1
Package 2	0	1	1	1	3	3
Package 3	0	2	1	2	2	1

	0	1	2	3	4	5
Status quo	1	0	0	0	0	0
Package 1	0	2	2	3	3	1
Package 2	0	2	1	2	1	2
Package 3	0	1	1	3	2	3

	0	1	2	3	4	5
Status quo	1	0	0	0	0	0
Package 1	0	1	1	2	2	1
Package 2	0	1	2	1	1	1
Package 3	0	2	1	3	3	2

	0	1	2	3	4	5
Status quo	1	0	0	0	0	0
Package 1	0	2	1	1	1	3
Package 2	0	1	2	2	3	2
Package 3	0	2	2	3	2	3

	0	1	2	3	4	5
Status quo	1	0	0	0	0	0
Package 1	0	1	2	1	2	2
Package 2	0	2	2	2	1	3
Package 3	0	2	1	1	3	1

Where attributes equal:

0 Crop-raiding, 2 levels (1=yes, 0=no)
1 Cooperation, 2 levels (1,2)
2 Need to sleep in plantation, 2 levels (1,2)
3 Monetary costs, 3 levels (1,2,3)
4 initial time costs, 3 levels (1,2,3)
5 maintenance time costs, 3 levels (1,2,3)

Appendix D: Community and mobility questionaires

Femme

Vous Même | 1) **Nom et Prénom:** 2) **Ethnie:** 3) **Age:** ___ans

4) **Vous êtes d'où?** (*nom du village*) ______________________ (*ville la plus proche*): ____________
5) **Vous êtes née où?** (*nom du village*) ______________________ (*ville la plus proche*) : ____________
6) **Où habitez-vous maintenant?** ______________________ 7) **Depuis combien d'années?** ____
8) **Qu'est-ce que vous a amené où vous habitez?** (*Crochez un des suivantes*) :
☐ *C'est chez moi* ☐ *Mes études* ☐ *Mon travail* ☐ *La recherche du travail* ☐ *Le travail des parents*
☐ *C'est chez mon ami / mari* ☐ *Le travail de mon ami / mari* ☐ *Autre:* ______________________
9) **SVP écrivez le nom de la ville ou le village où vous avez fait chaque classe suivant :**
(*Jusqu'à la classe où vous êtes toujours ou vous vous êtes arrêté*) :

CP1 :	6eme :	Terminale:
CP2 :	5eme :	Université : Nombre d'années _____
CE1 :	4eme :	
CE2 :	3eme :	Centre: Nombre d'années _____
CM1 :	2aire :	
CM2 :	1ere :	

10) **Crochez un** : ☐ *J'apprends toujours* ☐ *Je prends un repos* ☐ *Je n'apprends plus*
11) **Est-ce que vous travaillez maintenant ?** ☐ *Oui* ☐ *Non* ☐ *Je bricole*
Si vous travaillez, qu'est-ce que vous faites? ______________________
12) **SVP, écrivez le nom de chaque endroit ou vous avez vécu pour plus de 6 mois:**

Ville/village :	nombre d'années ___	Ville/village :	nombre d'années ___
Ville/village :	nombre d'années ___	Ville/village :	nombre d'années ___
Ville/village :	nombre d'années ___	Ville/village :	nombre d'années ___

13) **Où sentez-vous le plus à l'aise?** ☐ *Ville* ☐ *Village* **Endroit précis:** ______________________
14) **Quand vous avez 60ans, où vivrez-vous plus probablement?** ☐ *Ville* ☐ *Village* **Endroit :** ____________
15) **Si vous (et votre mari) vous retrouvez sans emploi, où resteriez-vous?** ☐ *Ville* ☐ *Village* **Endroit:** ________
16) **Est-ce que vous faites des plantations?** ☐ *Oui, pour moi même* ☐ *Jaide mes parents* ☐ *Non* **Si oui, Où?**
17) **Ferriez-vous des plantations à l'avenir?** ☐ *C'est sur* ☐ *Probablement* ☐ *Peut-être* ☐ *Probablement pas* ☐ *Jamais*
18) **Avez-vous construit ou acheté une maison?** ☐ *Oui* ☐ *Non* **Si oui, Où?** ______________________
19) **Si vous pouvez construire une maison à l'avenir, où la construirez-vous?** ______________________
20) **Avez-vous planté des arbres fruitiers qui vivent toujours?** ☐ *Oui* ☐ *Non* **Si oui, Où?** ________________
21) **Pensez-vous que l'éléphant doit être protégé au Gabon?** ☐ *Oui* ☐ *Non* ☐ *Je ne sais pas*
22) **Pensez-vous que tout Gabonais doit avoir le droit de tuer les éléphants?** ☐ *Oui* ☐ *Non* ☐ *Je ne sais pas*

Votre Mère | 1) **Nom et Prénom:** 2) **Ethnie:**

3) **Elle est d'où** (*Nom du village*) ______________________ (*Ville la plus proche*) : ______________
4) **Où habit-elle maintenant?** (*nom du village*) ______________ (*Ville la plus proche*) : ______________
5) **Qu'est-ce q'elle fait/faisait comme travail ?** ________________ 6) **Fait-elle des plantations?** ☐ *Oui* ☐ *Non*
7) **Avec elle vous parlez:** ☐ *Plus en sa langue* ☐ *Plus en français* ☐ *Moitie/moitie langue/français* ☐ *En une autre langue*

Votre Père | 1) **Nom et Prénom:** 2) **Ethnie:**

3) **il est d'où** (*Nom du village*) ______________________ (*Ville la plus proche*) : ______________
4) **Où habit-il maintenant?** (*village*) ________________ 6) **Fait-il de la chasse?** ☐ *Souvent* ☐ *Parfois* ☐ *Non*
5) **Qu'est-ce q'il fait/faisait comme travail ?** ________________ **Est-il retraité/pensioné?** ☐ *Oui* ☐ *Non*
7) **Avec lui vous parlez:** ☐ *Plus en sa langue* ☐ *Plus en français* ☐ *Moitie/moitie langue/français* ☐ *En une autre langue*

Vos Frères et Sœurs | 1) **Nombre du ventre de votre mère** _____ **et de votre père** _____

3) **Avec eux vous parlez :** ☐ *Plus en langue* ☐ *Plus en française* ☐ *Moitie/moitie langue/français* ☐ *En une autre langue*
4) **Si vous parlez parfois en langue, quelle langue ?** ______________

Vos Enfants | 1) **Nombre des filles** ____ **Nombre des garçons :** ____

2) **Si vous avez des enfants: où habitent-ils?** ______________________
3) **Leur papa(s) est (sont) d'où?** ______________________ 4) **Il(s) est de quelle ethnie?** ________
5) **Avec vos enfants vous parlez:** ☐ *Plus en langue* ☐ *Plus en français* ☐ *Moitie/moitie en langue et en français*

Female

Yourself | 1) First and last name: 2) Ethnicity: 3) Age: ___yrs

4) Where are you from? *(name of village)* ______________________ *(closest city)*: ____________
5) Where were you born? *(name of village)* ______________________ *(closest city)* : ____________
6) Where do you live now? ______________________ 7) Since how many years? ____
8) What brought you where you live now? *(Check one of the following)* :
☐ *It's my home* ☐ *My studies* ☐ *My work* ☐ *Job search* ☐ *Parent's work*
☐ *It's my husband's/boyfriend's home* ☐ *My husband's/boyfriends work* ☐ *Other:* ____________
9) Please write the name of the village or city where you completed the following classes:
(Up until the class where you are still or where you stopped) :

CP1: (first grade)	6eme :	Terminale:
CP2 :(second grade)	5eme :	University
CE1 : (etc.)	4eme :	Number of yrs _____
CE2 :	3eme :	Centre :
CM1 :	2aire :	Number of yrs _____
CM2 :	1ere :	

10) Check one : ☐ *I am still in school* ☐ *I am taking a break from school* ☐ *I am no longer in school*
11) Do you work currently? ☐ *Yes* ☐ *odd jobs* ☐ *No*
If you work, what do you do? ______________________________________
12) Please write the name of each place where you have lived for more than 6 months:

City/village :	no. of yrs ___	City/village :	no. of yrs ___
City/village :	no. of yrs ___	City/village :	no. of yrs ___
City/village :	no. of yrs ___	City/village :	no. of yrs ___

13) Where do you feel the most comfortable? ☐ *City* ☐ *Village* Specific town: ________________
14) When you are 60, where do you think you will most likely be living? ☐ *City* ☐ *Village* Place : ________
15) If you (and your husband) find yourselves without a job, where would you live? ☐ *City* ☐ *Village* Place: ___
16) Do you have plantations? ☐ *Yes, for myself* ☐ *I help my parents with theirs* ☐ *No*
17) Will you have plantations in the future? ☐ *Definitely* ☐ *Probably* ☐ *Maybe* ☐ *Probably not* ☐ *No, never*
18) Have you built or bought a house? ☐ *Yes* ☐ *No* If yes, where? ______________________
19) If you could build a house in the future, where would you build it? ______________________
20) Have you planted any fruit trees (that are still alive)? ☐ *Yes* ☐ *No* If yes, where? ________________
21) Do you think that the elephant should be protected in Gabon? ☐ *Yes* ☐ *No* ☐ *I don't know*
22) Do you think that all Gabonese should have the right to kill elephants? ☐ *Yes* ☐ *No* ☐ *I don't know*

Your mother | 1) First and last name: 2) Ethnicity:

3) Where is she from *(Name of village)* ________________ *(closest city)* : ________________
4) Where does she live now? *(Name of village)* ______________ (closest city) : ________________
5) What does she do for work? ____________________ 6) Does she have plantations? ☐ *Yes* ☐ *No*
7) With her you speak: ☐ *More in her native language* ☐ *More in French* ☐ *Half&half* ☐ *In another language*

Your father | 1) First and last name: 2) Ethnicity:

3) Where is he from *(Name of village)* ________________ *(closest city)* : ________________
4) Where does he live now? *(name of village)* ______________ *(closest city)* : ________________
5) What does he do for work? ____________________ 6) Does he hunt? ☐ *Often* ☐ *Sometimes* ☐ *Never*
7) With him you speak: ☐ *More in his native language* ☐ *More in French* ☐ *half&half* ☐ *In another language*

Your brothers & sisters | 1) Number on mom's side _____ Number on dad's side _____

3) With them you speak: ☐ *More in a native language* ☐ *More in French* ☐ *Half&half* ☐ *In another language*
4) If you speak with them in a native language, which language? ______________

Your kids | 1) Number of daughters ____ Number of sons: ____

2) If you have kids: Where do they live? ____
3) Where is(are) their dad(s) from? ________________ 4) What ethnicity is he/are they? ________
5) With your child(ren) you speak: ☐ *More in a native language* ☐ *More in French* ☐ *Half&half*

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