F:/3-PAGINATION/PWC/2-FIRST_PROOF/3B2/0521825059C16.3D – 252 – [252–277/26] 18.3.2005 2:56PM

16

Socio-ecological factors shaping local support for wildlife: crop-raiding by elephants and other wildlife in Africa

LISA NAUGHTON-TREVES AND ADRIAN TREVES

INTRODUCTION

Human–wildlife conflict is often viewed as a local problem involving the misbehaviour of people or animals (e.g. elephants transgress park boundaries to raid neighbouring crops, or farmers plant crops in wildlife habitat). Framing the issue this way tends to promote technical solutions like fencing and buffer crops; useful but often inadequate measures for promoting the long-term coexistence of people and wildlife (Breitenmoser *et al.*, Chapter 4; Osborn and Hill, Chapter 5). Geographers, anthropologists and other social scientists can illuminate the deeper causes of conflict and help guide long-term management solutions in several ways. First, social scientists can reveal the driving forces of land use change that impel people to plant crops or raise livestock in high-risk areas. Additionally, they can also assess the severity of the conflict by documenting the spatial and social distribution of wildlife damage, and the varying capacity of individuals to cope with such losses. Finally and more broadly, they can illuminate the social factors that intensify human–wildlife conflict or favour coexistence (Knight 2001).

In this chapter, we analyse the socio-ecological factors that shape rural African citizens' tolerance of crop loss to wildlife, particularly elephants (*Loxodonta africana*). (Elephants are the focus of much human–wildlife conflict research in Africa. They deserve special consideration as an Appendix I CITES species and a tourist, 'flagship' species. We first survey 26 reports from 15 African countries to identify factors that intensify human–wildlife conflict, and to compare losses between elephants and other 'pests' at different scales. We also draw from the general literature on pests and risk in African peasant agriculture to better understand why some communities may be unable or unwilling to tolerate crop losses to wildlife. We then test the predicted patterns of vulnerability in the area

People and Wildlife: Conflict or Coexistence? eds. Rosie Woodroffe, Simon Thirgood and Alan Rabinowitz. Published by Cambridge University Press.

around Kibale National Park, Uganda, where farmers risk crop loss to a variety of wildlife, including primates, bush pigs (*Potamochoerus* spp.) and elephants. Our case study and review indicate that elephants and other large mammals generally cause far less damage to regional agricultural production than do rodents and invertebrate pests. However, aggregate measures of damage may be misleading. People's perception of risk is as important as actually losses, and their perceptions more often focus on rare, extreme damage events (e.g. a catastrophic raid by elephants) than persistent, small losses that cumulatively may be greater. Moreover, large ungulates and large carnivores are often viewed as highly charged symbols of state intervention and coercion; thus the damage they cause is especially resented (Newmark *et al*. 1994; Naughton-Treves 1997; De Boer and Baquete 1998; Nchanji and Lawson 1998; Gillingham and Lee 1999). The Kibale case study also reveals that when risk is absorbed at the individual household level, material wealth, and in particularly landholding size, determine who is able to cope with major losses to wildlife.

COPING WITH WILDLIFE 'PESTS' IN RURAL AFRICA

Contemporary factors intensifying human–wildlife conflict in Africa

Human–wildlife conflict is not a new problem. During the pre-colonial period, in some areas of Africa, crop-raiding by elephants and other large animals caused food shortages, displaced settlements or prevented agriculture altogether (Game Department of Uganda 1924; Osmaston 1959; Naughton-Treves 1999). By contrast, relatively few African farmers today regularly confront large wildlife on their land unless they live near protected areas or in remote regions. Ultimately, habitat loss and the extirpation of large species have reduced the overall area of conflict. (There are important local exceptions to this general trend. In areas where wildlife conservation rules are enforced, the zone of conflict may expand as wildlife populations recover. Such is the case in several southern African regions where elephant numbers have grown significantly over the past decade (see Osborn and Hill, Chapter 5).). Why, then, do leading conservationists now identify human–wildlife conflict as a primary threat to conservation in Africa (Hoare 1995; Kangwana 1995; Tchamba 1995; Barnes 1996; Western 1997)? Because where conflict persists today, its consequences are amplified for both wildlife and people. For example, laws designed to protect rare or endangered species (e.g. hunting prohibitions) often compromise people's ability to defend their crops or livestock. Meanwhile, wildlife survival may be threatened by lethal control or fencing campaigns (Woodroffe and Ginsberg 1998). In some cases local citizens' protests over wildlife damage can undermine regional or national conservation programmes (Anonymous 1994; Tchamba 1995).

Research on the underlying causes of human–wildlife conflict in Africa reveals the variable and complex interactions between rural populations and wildlife (Table 16.1). No single factor or condition explains conflict across the continent. Moreover, despite growing attention to human–wildlife conflict, uncertainty persists about the actual magnitude of the problem. Some experts claim that farmers consistently exaggerate crop damage to wildlife (Wakeley and Mitchell 1981; Bell 1984a; Roper *et al.* 1995; Siex and Struhsaker 1999). Others suggest that elephants and other large ungulates are unjustly blamed for damage, and that smaller animals, such as rodents or primates, cause greater losses over time (Mascarenhas 1971; Gesicho 1991; Hawkes 1991; Gillingham and Lee 1999). Unfortunately, the database on crop damage amounts and patterns is poor and burdened by ill-defined methods that limit comparisons between species and between sites. Too often, researchers exaggerate impacts by extrapolating results from crop-raiding 'hotspots' to entire regions, and rarely do they compare farmers' reports with systematic field measurements. To understand rural citizens' complaints, we must examine the spatial distribution and extent of crop loss, as well as the socio-ecological factors that shape local coping strategies and perceptions of risk.

Crop loss to wildlife versus other pests in the tropics

The term 'pest' is typically defined as any animal that consumes crops during any stage of the agricultural cycle, from planting to post-harvest storage (Porter and Sheppard 1998). Definitive comparisons of the economic impact of wildlife in comparison with other pests in tropical bush-fallow or shifting agricultural systems are difficult due to scarce data and extreme variability in crop yields and losses across farms, communities and regions. However, the literature on 'pests' provides rough estimates for the magnitude of non-wildlife losses, and reveals important factors shaping local coping capacity and tolerance of pests.

Farmers in tropical environments are exposed to a greater variety of pests than are temperate farmers, although the density of any given pest species is usually lower (Porter and Sheppard 1998). Tropical farmers also tend to be exposed to elevated and chronic levels of loss, in contrast with the periodic outbreaks of single pests in temperate agro-ecosystems (Oerke *et al.* 1995; Yudelman *et al.* 1998). For example, 60% of Tanzanian farmers ($n = 916$) rated pests as their primary economic problem, above low crop prices, lack of transport, failed rains and poor soils (Porter 1976). In Zimbabwe, local farmers ranked pests (including wildlife) first among

Table 16.1. *Explanations for intensifying human–wildlife conflict in Africa*

Changes in land use	Changes in wildlife behaviour and ecology	Changes in human socio-political systems
Agriculture expands into wildlife habitat, driven by population growth, voluntary or state-sponsored settlements, or shift to farming by pastoralists (Barnes 1990; Campbell *et al.* 1999; Gachago *et al.* 1995; Graham 1973; Hill 1997; Kiiru 1995; Tchamba 1996; Thouless 1994; Western 1997)	Wildlife populations 'packed' into parks and reserves by heavy hunting outside boundaries face food shortages (Gachago *et al.* 1995; Barnes *et al.* 1995; Mwathe 1992; Chiyo *et al.* (unpubl. data); Naughton-Treves *et al.* 1998)	Centralized, state ownership of wildlife lowers local tolerance of wildlife (Western 1997; Naughton-Treves 1997)
Agriculture intensification reduces availability of wild foods (Campbell *et al.* 1999; Naughton-Treves 1998)	Wildlife subject to intense hunting or culling form large groups and cause greater damage to local crops and vegetation (Southwood 1977)	Privatized land ownership erodes traditional collective coping strategies for wildlife pests (Agrawal 1997; Bell 1984b; Lahm 1996; Mubalama 1996)
Agricultural decline yields extensive second growth favourable to crop-raiding wildlife; remaining farms are isolated amidst 'bush', and more vulnerable to raiding (Lahm 1996; Mascarenhas 1971)	Protected wildlife species lose fear of humans and forage among settlements and farms (Gachago *et al.* 1995; Tchamba 1996; Naughton-Treves 1998; Kangwana 1995)	Urban employment opportunities draw men away from guarding fields (Lahm 1996)
Logging yields abundant second growth favourable to crop-raiding wildlife (Lahm 1996; Barnes *et al.* 1991)	–	Better access to schools releases children from their traditional role as guards and sentinels against raiding wildlife (Goldman 1996)
Artificially maintained water sources attract wildlife to human settlements during droughts(Thouless 1994)	–	Politicians now pay closer attention to local citizens who complain loudly against elephants, and this raises public awareness of the conflict (Kangwana 1995; Anonymous 1994; Hoare 1995; Barnes 1996)
Construction of canals, power installations and cattle fences cuts off migration routes and leads to 'aggressive' wildlife behaviour (Kangwana 1995; Kothari 1996; Lahm 1994)	–	War may displace wildlife from forests into agricultural areas (Tchamba 1995)

30 obstacles to improved quality of life (Wunder 1997). While there is general consensus that pests reduce agricultural productivity significantly in the tropics, losses are rarely measured precisely, particularly in peasant agricultural systems. Estimates range from 10% to 50% of total crop production, with an average estimate of 30% loss (Porter and Sheppard 1998; Yudelman *et al.* 1998). Another comprehensive survey estimated even higher losses for African farmers; roughly 51% of production was lost due to insects (15%), pathogens (13%), weeds (13%) and other pests, including rodents (10%) (Oerke *et al.* 1995). These data lack precision, but they suggest the general order of magnitude of losses.

Crop yields and losses in peasant agriculture are difficult to measure and compare because farmers typically plant complex polycultures in fields of ill-defined area. Planting densities vary greatly within and between fields. Pest infestations happen sporadically and often coincide with changes in climatic conditions. Given the spatial and temporal complexity of peasant agricultural systems, calculating average pest losses is not only difficult, it may be misleading. One farmer may easily tolerate a 15% loss in maize, while her neighbour cannot (Goldman 1996). A 28% loss during a drought may cause hunger, but not during a good planting season (Scott 1976). In sum, explaining local tolerance to wildlife via average percentage crop losses is inadequate because it masks the vulnerability of certain individuals and the more fundamental factors shaping public perception of risk. One must also address the socio-economic factors that influence local capacity and willingness to cope with crop damage to elephants or other animals.

Collective versus individual strategies for coping with risk

The social significance of crop loss to wildlife may best be understood in terms of *vulnerability*, a concept used in environmental hazards research to encompass risk of exposure and capacity to cope. Cutter (1996: 532) defines vulnerability as 'the interaction of the hazards of place . . . with the social profile of communities'. In other words, vulnerability is shaped by both biophysical and social conditions (Liverman 1990; Carter 1997). For example, a farmer might face high levels of risk because he plants crops in an area frequented by hippopotami (*Hippopotamus amphibius*), but he is not necessarily vulnerable if he has other substantive sources of income or food. A highly vulnerable farmer is someone who plants crops in risky places and has limited capacity to cope. Carter (1997) goes on to describe risk as a 'mechanism of differentiation', meaning that communities are internally differentiated by individual exposure to risk and individual capacity to cope with risk, *and* that risk in turn can further differentiate members of communities. Results of research on drought hazards in Africa highlight two key factors determining individual vulnerability: *insurance* and *wealth*. These factors are directly relevant to human–wildlife conflict.

The vulnerability of smallholder farmers to elephant crop raiding can be mitigated by two insurance strategies: (1) *individualist self-insurance* (e.g. field scattering, crop diversification, employment of guards on individual property), and (2) *social reciprocity between households* (e.g. voluntarily sharing public spaces and labour, and aiding less fortunate neighbours) (Scott 1976; Carter 1997). Individualist self-insurance strategies depend heavily on individual access to land, labour, capital, etc. By contrast, social reciprocity insurance depends on traditions of sharing, close community relations and communal land management. Of course there is overlap between individual and social insurance strategies, and farmers may participate in both. However, given the shift toward private landholding and markets, and the decline of sharing and communal property regimes, the tendency in rural Africa today is toward greater reliance on individualist self-insurance (Carter 1997). This suggests a trend toward individualization of risk. In Malawi, Bell (1984) observed that large extended families on traditional farms neighbouring a park suffered 80% less crop damage to wildlife than did families on individual plots in neighbouring government settlements. Thus a group of farmers may be able to collectively cope with crop losses to elephants, while individual households cannot.

The capacity of individuals or households to absorb risk depends largely on wealth (social and physical endowments) and political influence. In peasant agriculture, farm size is an index of wealth and may be the most important endowment for coping with risk. A case study from southern Africa showed that only 10% of individuals in the upper quartile of landholding size suffered food scarcity during drought, while 85% of the bottom quartile suffered food scarcity (Carter 1997). Land availability is also an important predictor of farmers' capacity to cope with crop losses in Kenya (Goldman 1996). As long as farmers had sufficient access to land, they continued to tolerate 15% losses of their maize yields to invertebrate pests. As land became scarce, individuals bought pesticides or changed to another crop (Goldman 1996). Wealth can also be measured in access to capital or labour. Capital permits smallholder farmers to hire guards or build barriers. In contrast, the poorest households face *compounding vulnerability* (Carter 1997; Naughton-Treves 1997). Without large landholdings they cannot buffer themselves from wildlife conflict, nor can they hire additional labour. For example, widows and invalids often suffer the greatest damage within communities and are least able to cope (Bell 1984a); L. Naughton-Treves unpubl. data). In short, subsistence farmers with minimal endowments (i.e. access to kinship or community labour and resources, or alternative incomes) are the most vulnerable (Scott 1976; Porter 1979).

Ranking wildlife pests

Another way to understand local tolerance to wildlife is to compare 'worst pest' rankings. In Table 16.2 we tabulate the results of 25 studies of wildlife pests in Africa. We selected only studies that explicitly ranked problem animals by species or group, and those from sites or regions where elephants are present. These 25 studies come from 13 countries and include both savanna and forest sites. They also include examples of each major type of human–wildlife interface (Hoare 1995): 'hard' edges of parks or reserves (e.g. Kenya and Ghana cases), mosaics of agriculture and natural habitat (e.g. Cameroon) and isolated agricultural settlements embedded in forest (e.g. Congo). Out of 38 types of animals ranked as problem animals, the five most frequently mentioned were: elephants (32 cases), monkeys (including baboons, *Papio* spp.) (30), rodents (19), bush pigs (18) and antelopes (11). The animals most frequently described as 'worst animal' were elephants (8), monkeys (including baboon) (8), bush pigs (5), cane rats (*Thryonomys swinderianus*) (2) and buffalo (*Syncerus caffer*) (2). Elephants' mean rank was 2.5 $\pm$ 1.5 ($n = 33$), and there was no significant difference between rankings at savanna versus forest sites ($n = 14$ savanna and 14 forest sites). There was also no significant difference in farmers' versus researchers' ranking of problem animals. The only apparent discrepancy was between the ranking of elephants at different scales of analysis. Elephants were not ranked 'worst pest' in any of the six nation-level assessments and in only two of the 15 provincial or district-level rankings. Bush pigs were the only large mammal to emerge in national-level rankings. By contrast, six of 16 studies at park borders ranked elephants worst. This suggests that elephants tend to be a significant pest at the local or possibly provincial level, but not at the national level.

Comparing 'worst pest' rankings between studies is problematic. For one, some studies focussed specifically on elephants, and may have biased results accordingly. Also, the scale of analysis varied from single villages to nations. Methods were often poorly defined. Many studies ranked animals only by interviewing local farmers. This is a valuable approach for learning about local attitudes, but respondents in such studies often hope for compensation and thus may inflate damage reports, particularly for large or highly symbolic species (Mascarenhas 1971; Gesicho 1991; De Boer and Baquete 1998). Other studies ranked animals by the relative amount or frequency of their damage. This approach may avoid the problems of inflated complaints, but it introduces other problems. For example, given the unpredictable pattern of raiding by wildlife, results from a single season or single year may not be representative. Thus the data in Table 16.2 are preliminary, and should be interpreted with caution.

Table 16.2. *Ranking problem wildlife in Africa*

Country	Site (habitat)[a]	Method[b]	Problem wildlife ranking (1=worst problem): 1	2	3	4	5	Elephant ranking	Sample size and unit	Reference
Cameroon	Banyang-Mbo Forest Reserve (f)	R	Cane rat	Buffalo	Porcupine	Bush pig	Bird	–	19 farms monitored, animals ranked by amount of damage	Naughton-Treves *et al.* 2000
	Banyang-Mbo Forest Reserve (f)	F	Elephant					1	Interviews and public meetings with 430 villagers around reserve	Nchanji and Lawson 1998
Congo	Parc National Nouabale-Ndoki (f)	R	Elephant					1	29 fields, elephants ranked first by damage amount	Madzou 1999
Democratic Republic of Congo	Okapi Faunal Reserve (f)	R	Primate	Elephant	Bush pig	Buffalo		2	40 farmers in 29 villages	Mubalama and Hart 1995
	Okapi Faunal Reserve (f)	R	Monkey	Bush pig	Elephant			3	40 farmers in 29 villages	Mubalama 1996

Table 16.2. *(cont.)*

Country	Site (habitat)[a]	Method[b]	Problem wildlife ranking (1=worst problem): 1	2	3	4	5	Elephant ranking	Sample size and unit	Reference
	Garamba National Park (s)	F	Elephant	Hippopotamus				1	48 interviews with field verification near park boundary	Hillman Smith *et al.* 1995
Gabon	Haut-Ogooué Province (s+f)	F	Cane rat	Porcupine	Elephant	Bay duiker	Bush pig	3	239 families in 15 villages	Lahm 1994
	Ngounie Province (s+f)	F	Cane rat	Elephant	Porcupine	Sitatunga	Chimpanzee	2	364 families in 20 villages	Lahm 1994
	Nyanga Province (s+f)	F	Cane rat	Elephant	Porcupine	Mandrill	Gorilla	2	333 families in 20 villages	Lahm 1994
	Estuaire Province (f)	F	Cane rat	Elephant	Porcupine	Sitatunga	Emin's rat	2	286 families in 19 villages	Lahm 1994
	Moyen Ogooué Province (f)	F	Cane rat	Elephant	Porcupine	Mangabey	Sitatunga	2	231 families in 19 villages	Lahm 1994
	Ogooué-Ivindo Province (f)	F	Cane rat	Elephant	Porcupine	Gorilla	Bay duiker	2	669 families in 38 villages	Lahm 1994
	Ogooué-Lolo Province (f)	F	Cane rat	Elephant	Porcupine	Gorilla	Suntailed monkey	2	298 families in 20 villages	Lahm 1994

	Ogooué-Maritime Province (f)	F	Elephant	Hippopotamus	Cane rat	Buffalo	Mangabey	1	210 families in 30 villages	Lahm 1994
	Woleu-Ntem Province (f)	F	Cane rat	Elephant	Gorilla	Chimpanzee	Squirrel	2	296 families in 37 villages	Lahm 1994
	nationwide (s+f)	F	Cane rat	Elephant	Porcupine			2	2926 families in 218 villages (sum of previous nine entries)	Lahm 1994
Ghana	Kakum/Assin Forest Reserve (f)	?	Bird	Monkey	Bush pig	Elephant		4	Regional appraisal (methods not specified)	Dudley *et al.* 1992
Kenya	Shimba Hills National Reserve (s)	F	Bush pig	Baboon	Elephant	Monkey	Buffalo	3	138 households on park boundary	Kiiru 1995
	SE Kajiado District (s)	F	Buffalo	Antelope	Elephant	Monkey	Wildebeest	3	137 households in 1977, frequency for those reporting conflict	Campbell *et al.* 1999
	SE Kajiado District (s)	F	Antelope	Elephant	Monkey	Zebra	Hyena	2	223 households in 1996, frequency for those reporting conflict	Campbell *et al.* 1999

Table 16.2. *(cont.)*

Country	Site (habitat)[a]	Method[b]	Problem wildlife ranking (1=worst problem) 1	2	3	4	5	Elephant ranking	Sample size and unit	Reference
	Laikipia/ Samburu region (s)	F	Elephant					1	Methods unspecified	Thouless 1994
	nationwide (s+f)	F	Baboon	Monkey	Elephant			3	Interviews (sample size not specified)	KWS in Feral 1995
Malawi	Kasungu (s)	R	Elephant	Bush pig	Baboon	Vervet monkey	Eland	1	Damage amount in 80 farms adjacent to or within 1 farm of park	Bell 1984b
Mozambique	Maputo Elephant Reserve (s)	F	Bush pig	Hippopotamus	Elephant	Bushbuck		3	200 households in 4 settlements, ranked by frequency of complaint	DeBoer and Baquete 1998
Rwanda	Volcans National Park (f)	F	Buffalo	Cane rat	Jackal	Porcupine		–	181 farmers < 2250 m of park boundary	Plumptre and Bizumuremyi 1996

Tanzania	Kilimanjaro National Park (f)	F	Monkey	Bush pig	Rodent	Bird	Baboon	–	1396 farmers residing < 12 km of reserve boundaries	Newmark *et al.* 1994
	Manyara National Park (s)	F	Elephant	Baboon	Buffalo	Warthog	Hippopotamus	1		Newmark *et al.* 1994
	Mikumi National Park (s)	F	Bush pig	Baboon	Monkey	Elephant	Hippopotamus	4		Newmark *et al.* 1994
	Selous Game Reserve (s)	F	Elephant	Hippopotamus	Buffalo	Bush pig	Monkey	1		Newmark *et al.* 1994
	Selous Game Reserve (s)	R	Vervet monkey	Bush pig	Bird	Rodent		–	Methods unspecified	Gillingham and Lee 1999
	nationwide (s+f)	F	Bush pig	Bird	Monkey	Insect	Rodent	8	916 enumeration areas, animals ranked worst in each	Agroclimatological Survey of Tanzania 1972 in Porter 1998
Uganda	Kibale National Park (f)	R	Baboon	Bush pig	Red-tailed monkey	Elephant	Chimpanzee	4	93 farms within 500 m of park boundary	Naughton-Treves 1997
	Bwindi National Park (f)	F	Monkey	Baboon	Bird	Rodent	Elephant	5	316 farmers in 10 enumeration areas along park boundary	Bearsted-Smith *et al.* 1995

Table 16.2. *(cont.)*

Country	Site (habitat)[a]	Method[b]	Problem wildlife ranking (1=worst problem) 1	2	3	4	5	Elephant ranking	Sample size and unit	Reference
	Budongo Reserve (f)	F	Baboon	Bush pig	Vervet monkey	Bird	Bushbuck	–	245 farmers in villages adjacent to forest, forest fragments and plantations	Hill 1997
Zambia	Upper Lupande (s)	F	Bush pig	Monkey	Hippopotamus	Chimpanzee	Elephant	5	135 farmers within Upper Lupande Game Management Area	Balikrishan and Ndhlovu 1992
Zimbabwe	BuliliMamangwe (s)	F	Bird	Springhare	Elephant	Jackal	Warthog	3	966 farmers residing in up to the fourth village from	Hawkes 1991

							unsettled wildlife area	
Sebungwe, Zambezi Valley (s)	F	Insect	Bird	Elephant	Hippopotamus	3	2 villages	Wunder 1997
Nyami Nyami district (s)	F	Elephant	Buffalo			1	Frequency of formal animal complaints	Hoare 1995

[a] Official name of area (s, savanna + woodland; f, moist forest; s + f=mixture of both types).
[b] Method: how was the ranking generated? R, researcher measurements; F, farmer reports.

Table 16.3. *Factors shaping tolerance of pests*

	Higher tolerance	Lower tolerance
Socioeconomic factors		
Land availability	Abundant land	Scarce land
Ownership of wildlife	God, self, community	Government or elite
Coping strategies	Varied, unregulated	Narrow, highly regulated
Social unit absorbing loss	Communal, group	Individual or household
Labour availability	Abundant, inexpensive	Rare, expensive
Value of wildlife	High (game, tourism, etc.)	Low (pest, vermin)
Capital and labour investment in crop	Low	High
Type of crop damaged	Subsistence	Cash or famine crop
Alternate income	Various	None
Ecological factors		
Wildlife body size	Small, non-threatening	Large, dangerous
Timing of raid relative to harvest	Early	Late
Wildlife group size	Solitary	Large
Damage pattern	Cryptic	Obvious
Crop preference of pest	Narrow, one crop	Any crop
Crop part damaged	Leaves only	Fruit, tuber, pith, grain
Circadian timing of raid	Diurnal	Nocturnal
Crop damage in each raid	Self-limited	Unlimited
Frequency of raiding	Rare	Chronic

Factors shaping local attitudes towards and capacity to cope with wildlife

To better understand farmers' attitudes to various wildlife species, and to explain their apparent intolerance of elephants, we reviewed studies that identified factors shaping tolerance of pests (Table 16.3). Some of these factors are obvious. For example, no animal taking human lives is tolerated. Livestock losses to wildlife are considered worse than crop losses. Tolerance is apparently shaped more by amounts of crop loss than by frequency of raids. Animals highly prized as game by the local population may be tolerated despite significant costs. For example, each year, white-tailed deer (*Odocoileus virginianus*) in Wisconsin cause > US$34 million in crop damage and US$92 million in damage to vehicles (38000 deer–car collisions each year: WDNR 1994). Yet there is widespread support for maintaining a population of > 1.2 million deer due to the profitable and popular annual hunt (670000 hunters participate and generate US$255m in sales). Other influential factors are less straightforward. For example, some studies conclude that farmers tolerate damage to high-value cash crops least (Blair 1979), while others suggest that raids on 'famine' crops like cassava cause greater resentment (Mascarenhas 1971).

Local intolerance for wildlife may also be amplified by institutional constraints on coping strategies. People are less tolerant of imposed risk than they are of risk they take on voluntarily. For example, Starr (1969) showed the public to be 1000 times more willing, on average, to accept voluntary risks (e.g. driving) than those imposed upon them (e.g. pollution). Farmers feel especially vulnerable to large, highly symbolic animals that are perceived to – and often do – belong to the government. For example, elephants are highly prized by tourists and wildlife agencies, but they inflict potentially catastrophic damage. The perceptions of farmers often reflect rare, extreme-damage events rather than persistent, small losses that cumulatively may be greater (Naughton-Treves 1997). The complex interplay of actual risk and the effectiveness of each farmer's coping strategies is filtered through a cultural and socio-economic perspective. When asked 'Which animal is worst?' or 'How severe are your losses to wildlife?', a farmer's answer is shaped not only by her previous experiences with wildlife pests, but also by her perceived status with respect to the park, conservation authorities and the researcher. The following case study from Kibale National Park explores the spatial and social distribution of crop damage to wildlife, and compares local risk perceptions and coping strategies. This case study illustrates many of the points identified in the broader literature regarding the distribution of damage and differentiated capacity of individual households to cope with risk.

LOCAL RESPONSE TO CROP DAMAGE BY WILDLIFE AROUND KIBALE NATIONAL PARK, UGANDA

Kibale National Park is a 760-km^2 forest remnant located in the Toro region of western Uganda (Fig. 16.1). Kibale is rich in primates and other species (Struhsaker 1997), including those notorious for crop-raiding, such as olive baboons (*Papio cynocephalus*), red-tailed monkeys (*Cercopithecus ascanius*), elephants and bush pig. Currently, 54% of the land <1 km of Kibale's boundary is used for smallholder agriculture (Mugisha 1994). Farmers in the area belong to two predominant ethnic groups, the long-present Batoro, and the immigrant Bakiga, who came to Kibale by the tens of thousands from southwestern Uganda during the 1950s and 1960s (Turyahikayo-Rugyema 1974). Toro chiefs (of the Batoro people) traditionally allocated land to immigrants on the outskirts of their settlements, in part to buffer Toro farmers from crop damage by wildlife (Aluma *et al.* 1989). Today, both groups plant more than 30 species of subsistence and cash crops: bananas, maize, beans, yams and cassava cover the greatest area. In both groups, women generally assume responsibility for food crops, whereas men tend cash crops, such as brewing bananas. Farm sizes are small – averaging

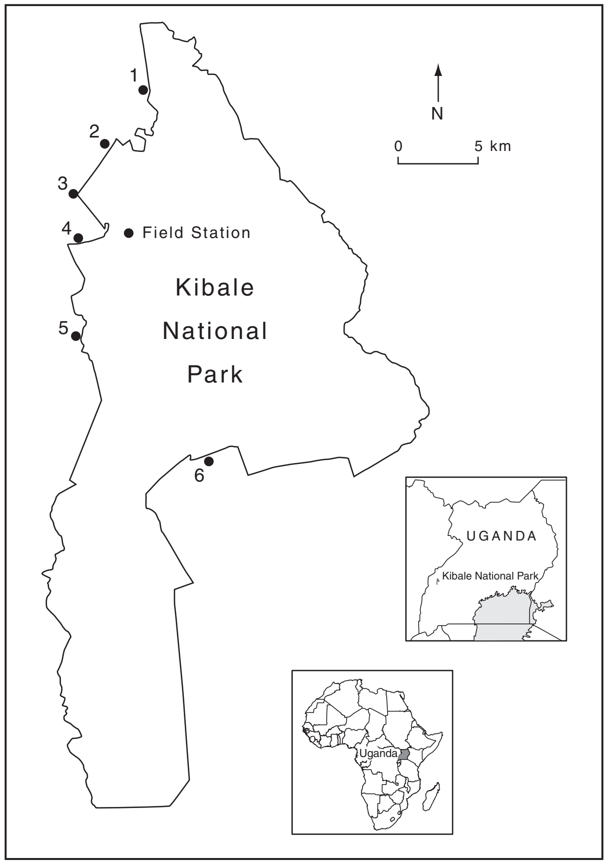

Figure 16.1. Map showing Kibale National Park and study sites.

1.4 ha – and population density is high: 94–272 individuals per km^2 around Kibale National Park (Mugisha 1994).

The social and physical landscape of Toro has profoundly changed this century (Naughton-Treves 1999). Where there were once isolated agricultural settlements amidst forest, today there are islands of forest embedded in agriculture. Natural habitat continues to shrink outside Kibale National Park. Edge species persist in agro-ecosystems (e.g. bush pigs, baboons and cane rats), but large or interior forest species are mainly confined to the park (Chapman and Onderdonk 1998). Despite regional declines in wildlife populations, farmers living within 1 km of Kibale complain bitterly about crop loss to animals. Anger about crop loss to wildlife is expressed most intensely during group discussions. People ask, 'Why should we starve so that baboons may eat?'

Research design and methods

This case study offers a synthesis of data collected during field research in 1992–4 and 1999 (Naughton-Treves 1997, 1998; Naughton-Treves *et al.* 2000). The basic aim of the research was to document systematically the amount and distribution of crop damage by wildlife in the communities neighbouring Kibale, and to then use multivariate analysis to predict vulnerability of loss at various scales (field, farm, village). We were equally concerned with understanding people's perception of risk and their varying capacity to cope with losses. The long-term nature of the study offered us an opportunity to assess response to damage over several years, and to test the hypothesis that a household's wealth powerfully shapes its coping capacity when risk is individualized (as per Carter 1997).

During 1992–4, crop damage to animals was monitored on 93 farms in six villages (Naughton-Treves 1998). Crop damage was measured each week by two assistants who walked transects through fields perpendicular to the boundary of Kibale (30 m wide extending 500 m from boundary). Along the transect, crop type and maturity were recorded. Every trace of crop damage by vertebrates ($>$ 2 kg) was noted and its extent measured by pacing area or counting stalks. Raiding animals were rarely seen, so evidence from dung, tracks, bite marks and patterns of damage were used to infer the identity of the responsible species. Inter-observer reliability and damage measurement techniques are detailed in Naughton-Treves (1998). Also detailed there are techniques for identifying independent forays by animals. In brief, when adjacent transects crossed the same, large damaged area, only one event was noted (if the raiding species was the same). Similarly, if the same animal inflicted damage at multiple points along a monthly transect, a single foray was recorded. These methods of determining independence do not inflate frequency estimates, particularly for animals that damage wide swathes of crops (e.g. elephants). We also conducted several public meetings and 145 interviews to appraise local attitudes to wildlife and coping strategies (Naughton-Treves 1997).

During 1999, the same team of field researchers resumed monitoring crop damage in three of the six original study villages (Fig. 16.1), this time on a monthly basis. In 1999 we also explored local farmers' long-term response to crop loss vs. Other hardships by returning to all the original six villages to survey changes in land use and ownership. In essence, we traced the fate of 85 farms in relation to their history of crop-raiding. We assumed that farm abandonment was the most drastic response to crop-raiding, while field fallowing was a more moderate response. Note that in the local context, 'abandoning' a field means to leave it without crops for more than five years. 'Fallowing' a field refers to letting it rest for one to two years (short fallow), or three to five years (long fallow).

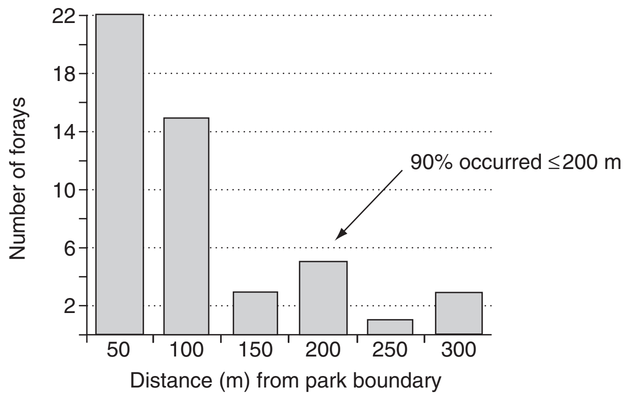

Figure 16.2. Frequency of elephant raids versus distance from the park.

Results

Amount and distribution of damage by wildlife

Across the two study periods, the strongest predictor of damage was proximity to the forest boundary. During 1992–4, 90% of damage events occurred $<$ 160 m of the forest boundary, vs. 90% $<$ 200 m during 1999. This pattern held true for elephants as well (Fig. 16.2). Households located within this 'high risk' zone lost 4–7% of crops per season on average in 1992–4, and 6–9.4% in 1999 (the average loss varies by crop type). In both sampling periods the distribution of damage was highly skewed such that some fields were on occasion completely destroyed, while many others were untouched.

The frequency and extent of crop damage varied markedly within and between villages, between species and between years. We recorded damage by 12 species, including livestock. Table 16.4 presents the results for the nine types of animals that caused damage more than once in 1999 (rodents are pooled). Goats damaged crops most frequently, but elephants did the most damage per foray (mean and maximum). Livestock caused almost two-thirds of the damage, while wildlife caused one-third. Among the wildlife, elephants accounted for the vast majority of area damaged (78%), but this was confined entirely to six farms at one village. Baboons were the most frequent raiders across villages. Figure 16.3 illustrates the variability between the two study periods.

Residents' coping strategies

Farmer households around Kibale generally manage their land individually. Collective planting, weeding or guarding is uncommon, although the immigrant social group (Bakiga) employ some collective land management strategies during certain seasons. Our previous analysis of individual

Table 16.4. *Crop damage by animals in farms neighbouring Kibale National Park, February to August 1999*

Animal	Frequency of crop damage			Area damaged m^2			Percentage of field lost per foray	
	Most frequently damaged crop	Percentage of farms damaged ($n = 51$)	Percentage of total forays ($n = 273$)	Total	Mean ± Se per foray	Largest single foray	Mean	Maximum
Goat	Banana, cassava	68.6%	62.3%	10 400	61 ± 7	668	6.0%	100.0%
Baboon	Sweet potato, maize	27.5%	7.7%	395	19 ± 10	211	5.2%	70.3%
Cane rat	Sweet potato, cassava	19.6%	4.4%	721	56 ± 20	200	16.0%	69.0%
Chicken	Bean, maize	15.7%	3.3%	298	33 ± 15	143	11.8%	16.2%
Red-tailed monkey	Banana, maize	13.7%	8.1%	212	10 ± 1	20	0.2%	0.6%
Wild birds	Groundnut, bean	11.8%	2.6%	112	16 ± 8	58	5.7%	15.1%
Elephant	Banana, cassava	11.8%	6.6%	5 207	289 ± 89	1475	5.7%	21.1%
Chimpanzee	Banana, maize	5.9%	1.5%	34	8 ± 3	13	0.6%	0.6%
Cattle	Banana, cassava	5.9%	3.7%	2 140	214 ± 79	790	33.0%	100.0%
Totals								
Amount of damage (m^2):				19 519				
Summed for all animals								
Summed for livestock (% of total)				12 838 (65.7%), of which 51% was caused by goats[a]				
Summed for wildlife (% of total)				6 681 (34.3%), of which 77.9% was caused by elephants				

[a] In 34 cases, we knew whose livestock did the damage and 19 (56%) were caused by neighbours' livestock.

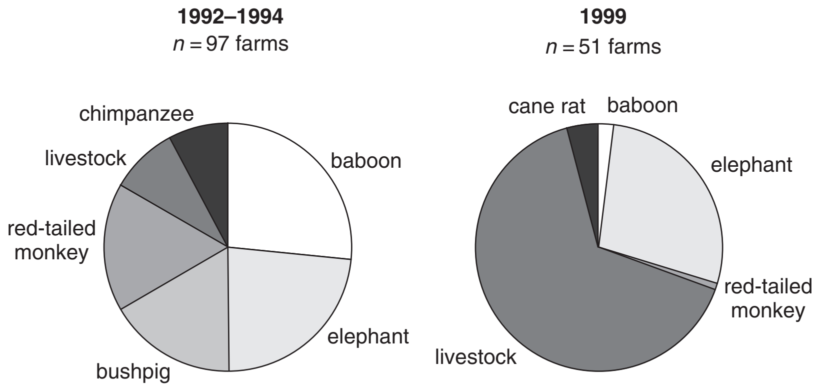

Figure 16.3. Pie charts comparing area damaged by different species. The 51 farms in the 1999 study were all part of the larger 1992–4 sample.

households' defensive strategies (e.g. hunting, strategic crop placement) showed that they could reduce damage by some species (e.g. bush pigs), but not others (e.g. elephants). In analysing people's actual and perceived risk of crop loss we learned that elephants inflict catastrophic damage to farms, but their forays are rare and highly localized. People's ranking of wildlife pests gave disproportionate weight to rare, calamitous raids by elephants (Naughton-Treves 1997). Another indication of the potential severity of elephant raids was that such events shaped people's attitude toward Kibale National Park. While the majority of farmers (83%, $n = 145$) believed that local people benefit from the park, those who suffered elephant damage were significantly less likely to identify benefits.

Differences between villages

Each village differed in the type and amount of pests they faced (Fig. 16.4). These data were analysed with a factorial design analysis of variance (ANOVA) incorporating village and proximity to forest as factors to predict the amount of damage in m^2. For all animals (wildlife + livestock), the villages differed significantly ($F_{2,982} = 12.4$, $p = 0.0001$). Villages still differed in the amount of crop damage when damage by wildlife and livestock were analysed separately (wildlife: $F_{2,971} = 7.4$, $p = 0.0007$; livestock: $F_{2,971} = 8.2$, $p = 0.0003$).

Direct and indirect costs of crop raiding

The direct, financial cost of crop-raiding can be estimated from the value of the crops per square metre multiplied by the area damaged (Fig. 16.5). Considering single forays, elephants inflicted the highest mean and maximum cost per farmer, but the overall cost of goat damage exceeded that of elephants and all other animals combined. Indeed, two-thirds of the

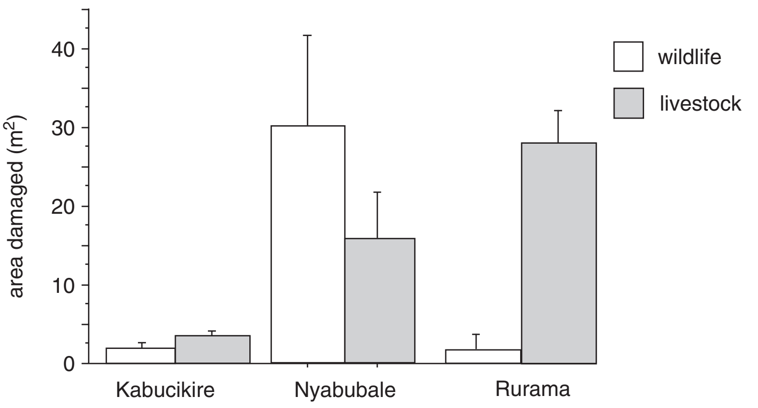

Figure 16.4. Area of crops destroyed by wildlife and livestock vs. village.

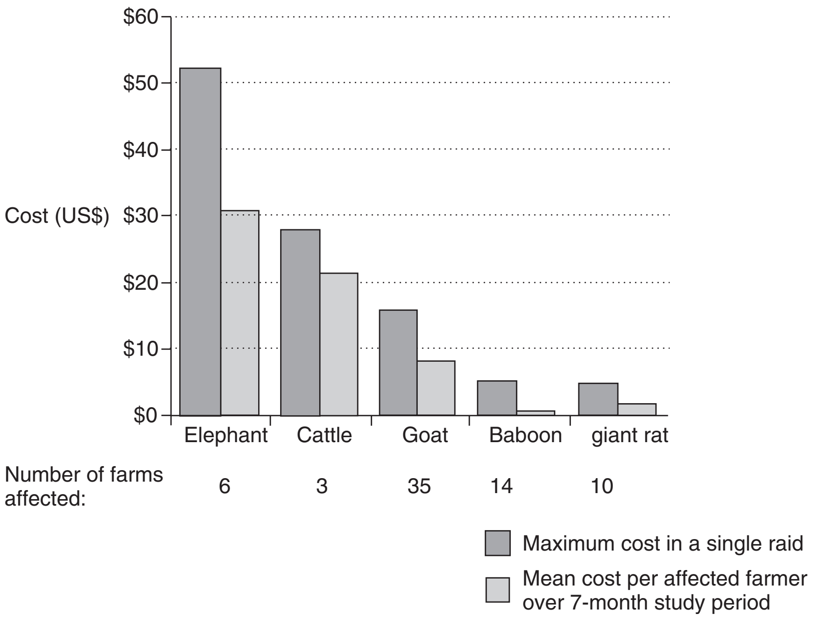

Figure 16.5. Direct costs (value per square metre multiplied by area damaged) of crop-raiding by various animals.

financial costs of crop damage were caused by livestock (goat, cattle, chicken and domestic pig combined).

In our assessment of general trends in land use in the six villages, we found that during the period 1994–9, farmers abandoned 32 fields ($n = 58$ farms, average $= 0.6 \pm 0.9$ fields per farm) and left 30 fallow ($n = 59$ farms, average$= 0.5 \pm 0.8$ fields). By comparison, clearing of land led to the creation of 60 new fields or an average of 1.8 ± 0.8 fields per farm ($n = 84$, range 0–4). Hence, the clearing of new fields roughly equalled the combined abandonment and fallowing of old ones. There was a correlation between the number of fields cleared and the number fallowed (Spearman $r_s = 0.35$, $Z = 2.65$, $p = 0.008$), i.e. the same farmers who cleared new fields were the ones that fallowed older ones. However, there was no correlation between the number of fields cleared and the number abandoned ($r_s = 0.19$, $Z = 1.44$, $p = 0.15$).

There was good evidence that farmers abandoned fields because of wildlife crop-raiding. Farmers ($n = 67$ interviewed) stated that they abandoned fields because of baboons (36%), bush pigs (24%), banana weevils (15%), elephants (12%), poor soil (5%) or several rarer reasons: death, illness, chimpanzees (*Pan troglodytes*) and red-tailed monkeys (1.5% each). Abandoned fields averaged 52 m from the park boundary (SE = 10.1, $n = 43$).

Our measurements of damage support the idea that field abandonment followed crop-raiding. The three villages of the 1999 study differed significantly from one another in the number of abandoned fields (Kruskal-Wallis $H = 10.82$, $p = 0.0045$), and this corresponded to measured crop damage by wildlife (see ANOVA result above). Nyabubale suffered the most wildlife crop-raiding and had the most abandoned fields (mean of 2.7 abandoned fields, pair-wise comparisons $p < 0.003$ for each). The other two villages, Rurama and Kabucikire, did not differ significantly with means of 0.6 and 0.3 abandoned fields per farm respectively ($p = 0.31$). In 21 cases, entire farms were abandoned. The three villages differed significantly in the proportion of farms abandoned (5%–57%, df = 2, $\chi^2 = 16.5$, $p = 0.0024$). Again, Nyabubale contained more abandoned farms (45.5%) than either Rurama or Kabucikire (12% and 5% respectively). Forest regrowth on these abandoned farms is visible in Landsat images. Here the park edge appears to be expanding. Only 11 farmers could be interviewed about their reasons for abandoning their farms. Of these, six farmers blamed elephants and baboons together, one blamed elephants alone, three blamed a death in the family, and one simply blamed poverty.

We sought physical and social factors that might predict which farmers would abandon their farms (farm size, proximity to the park, ethnicity, and non-farm employment). Only the size of the farm predicted abandonment using univariate non-parametric tests. We had data on the size of 75 farms. Overall, abandoned farms were the same size as farms that were active (Mann-Whitney $U, Z = -0.52$, $p = 0.60$); however, this result is strongly biased by the significant differences in farm size between villages. To counter this bias, we compared the field size of abandoned and active farms within villages. The size of active farms was larger than the size of abandoned farms in every case (Wilcoxon signed-ranks test df=2, $Z = 2.02$, $p = 0.043$). The larger farms were significantly less likely to be abandoned, and this effect emerged most clearly beyond a size of 1.8 ha.

It appeared that farmers with large landholdings were less likely to abandon their land when faced by wildlife crop damage. This seems to reflect different land-use practices and flexibility in field management. Larger farms contained more abandoned fields ($r_s = 0.41$, $Z = 2.85$, $p = 0.0043$), slightly more fallowed fields ($r_s = 0.29$, $Z = 2.04$, $p = 0.041$) and many more newly cleared fields ($r_s = 0.50$, $Z = 4.22$, $p < 0.0001$). In effect, large farms were being maintained as small-scale systems of shifting agriculture.

DISCUSSION AND CONCLUSIONS

The Kibale case study highlights lessons from the literature. As around other African parks, the highly variable and localized nature of crop damage by wildlife around Kibale makes it difficult to quantify the economic impact of crop raiding for Kibale's neighbours. However, our field data from 1992–4 and 1999 and from Chiyo (2000) do clearly indicate that damage by elephants and other large species is tightly confined to < 200 m of the park boundary. This pattern concurs with observations at other 'hard edges' that having an active farm between you and the park is the best defence against crop raiding (Newmark 1996; Hill 1997). At Kibale, even within this high-risk zone, only a few farms (on the order of 10%) suffered elephant damage. At a regional level, Kibale's elephants have a negligible economic impact on agriculture relative to rodent and invertebrate pests.

From an international perspective, an annual loss of 4–9% of planted fields immediately along Kibale's boundary (equivalent to roughly US$6 per farmer, or US$100 per kilometre of border) appears a trivial price for maintaining elephants and other threatened wildlife. Moreover, most of Kibale's neighbours extract fuelwood and water from the park worth far more than US$6 per year (L. Naughton-Treves unpubl. data). But the farmers who live on Kibale's border poorly tolerate crop loss to wildlife, particularly because they cannot legally use the full range of traditional defensive strategies. They particularly resent damage from elephants who raid nocturnally and are potentially dangerous. Moreover, estimates of average losses mask the great variation in amounts lost by different farmers and villages. The farmers suffering crop loss to elephants absorbed an average cost of US$60 per year, a significant amount in an area where annual incomes average US$300 (National Environment Action Plan Secretariat 1995). A few individuals lost much more. To the farmer who has lost an entire year's production in a single night, average losses are meaningless. In some cases elephant damage caused families to abandon their land, particularly those who owned < 1.8 ha. Although elephant raids are relatively rare, their severe potential impact shapes attitudes among Kibale's neighbours. In Kenya, patterns of crop damage roughly similar to those observed around Kibale (localized but severe for certain communities) have led to a public outcry and the demand to build fences and/or reduce the size of national parks (Okwemba 2004). Such cases demonstrate that human–wildlife conflict can be a major obstacle to community support for conservation, and the hostility of a vocal minority can undermine regional conservation initiatives (Newmark *et al.* 1994; Naughton-Treves 1997; De Boer and Baquete 1998; Nchanji and Lawson 1998; Gillingham and Lee 1999).

In most of the communities neighbouring Kibale, people contend with wildlife damage on an individual household basis. As the literature on drought and vulnerability shows, when risk is individualized, an individual's landholding size becomes especially important. At Kibale, we found empirical evidence that larger landholders cope better with elephant crop damage (i.e. they are less likely to abandon their land after repeated elephant raids). This does not, however, mean that the larger landholders willingly tolerate elephants. Indeed, around Kibale, the wealthier, more powerful farmers were often the most vehement in their demands for compensation from the government. Hostility to elephants was intensified by general resentment of conservation authorities and the status of elephants as 'property' of the state. We also observed that the larger the assembled group of farmers, the louder the complaints and greater the estimates of elephant crop damages. This provides proof, once again, that measuring risk perceptions and tolerance of wildlife is a challenging endeavour.

Beyond building better fences at park boundaries or planting appropriate buffer crops, one of the most important strategies to ameliorating human–wildlife conflict is building local management institutions capable of balancing conservation objectives with the demands of local agriculturalists. Mitigating wildlife crop-raiding is inherently a communal endeavour, particularly for species like elephants. To minimize the incidence and impact of raids, farmers ideally would make collective land-use decisions (e.g. plant crops together in large blocks, and/or plant large buffer strips), or draw on traditional insurance systems based on social reciprocity (e.g. share not just the benefits of wildlife but the costs as well). More applied research is needed to test the viability of collective management of risk, and to identify political and institutional arrangements that foster community-level tolerance to elephant crop damage. Applied research is also needed to better predict the spatial pattern of elephant raids so that the costs and benefits of wildlife conservation are more equitably distributed. Unfortunately, the trend in much of rural Africa is toward individualized and private land management, making collective management difficult (Agrawal 1997). No doubt in situations where risk in entirely individualized among smallholder farmers, and wildlife is highly endangered, state agencies or conservation non-governmental organizations must compensate farmers for crop damage (see Nyhus *et al.*, Chapter 7). To avoid these situations, conservationists must lobby against land-use policies that create high-conflict situations, e.g., smallholder settlements placed on park boundaries. And whenever possible, they should promote community-level management of elephants for tourism or hunting, building on promising examples from eastern and southern Africa.

ACKNOWLEDGEMENTS

This study received formal clearance from the Uganda Council for Science and Research, as well as nine Local Councils bordering Kibale National Park. P. Baguma provided first-rate field assistance. The Wildlife Conservation Society, IUCN Elephant Specialist Group, Fulbright-Hayes Foundation, and the National Science Foundation (SBR #XXXX) provided financial support. Some of the text in this chapter is adopted from a report commissioned by the IUCN special task force on human–elephant conflict (Naughton-Treves *et al.* 2000). Comments from M. Walpole, S. Thirgood and R. Hoare greatly improved this chapter.