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HUMANS AND FOREST ELEPHANTS IN CENTRAL AFRICA: CONFLICT AND CO-EXISTENCE IN AND AROUND PROTECTED AREAS

Thomas BREUER, Steeve NGAMA

Human-wildlife conflicts are ancient, but they are posing an increasing challenge for conservation managers across Africa (Lamarque *et al.*, 2009; Nyhus, 2016; Shaffer *et al.*, 2019). Human-wildlife conflicts can lead to a loss of biodiversity and a substantial decline in human well-being, most often for people living near protected areas (Thirgood *et al.*, 2005). Avoiding or solving these conflicts are key issues for both protected area and wildlife managers.

> Conservation conflicts can be defined as "situations that occur when two or more parties with strongly held opinions clash over conservation objectives and when one party is perceived to assert its interests at the expense of another" (Redpath *et al.*, 2013).

Conflicts and human-wildlife interactions include three frames. The first consists of (illegal) human activities involving wildlife (resource use) that lead to wildlife population disturbance and decline, and in the worst case, to species extinction. This is driven by an overall increase in the human population, particularly in sub-Saharan Africa, and an increasing need for land. These issues are addressed by conservation managers in their daily work, as well as by anti-poaching measures, law enforcement efforts, and work with stakeholders to mitigate habitat loss and fragmentation, and to eliminate retaliatory killing of wildlife.

The second frame consists of conflict arising from wildlife behavior directed at people and their belongings with negative outcomes for people, their health and their livelihoods. This type of conflict usually involves crop raiding and livestock predation. The third frame consists of conflicts between people over conservation, an often ignored but particularly important component of human-wildlife conflict. This includes conflicts of interest, conflicts over beliefs and values, interpersonal conflicts, and conflicts over information. Thorough knowledge of all three frames and their underlying drivers is crucial to identify intervention priorities (Redpath *et al.*, 2013, 2015; Baynham-Herd *et al.*, 2018, 2020).

Our current knowledge of human-wildlife conflict in Central Africa remains limited. Most studies have focused on the savanna region of Southern and East Africa (particularly related to savanna elephants, *Loxodonta africana*, and large carnivores) from which lessons can be learned (Hoare, 2015; Pooley *et al.*, 2017; Fraser-Celin *et al.*, 2018; Shaffer *et al.*, 2019). Nonetheless, human-wildlife conflict in Central Africa has occurred in both savanna and forest ecosystems for centuries.

Many species are involved in human-wildlife conflict in Central African savanna and forest ecosystems. Conflicts involving elephants (Tchamba, 1995, 1996; Granados & Weladji, 2012; Tchamba & Foguekem, 2012), buffaloes (*Syncerus caffer*) and baboons (*Papio anubis*) raiding crops, and predation on livestock by lions (*Panthera leo*) and other large carnivores (Van Bommel *et al.*, 2007; Bauer *et al.*, 2010) have been documented in the Sudanian and other savanna ecosystems (Bauer, 2003; Weladji & Tchamba, 2003; Bobo & Weladji, 2011).

For example, after the 1994 genocide in Rwanda, a large portion of Akagera National Park was given to Rwandans upon repatriation as they needed land on which to cultivate crops for their livelihoods and pasture their cows. Buffaloes and lions posed a serious threat to humans and their cattle. The loss of just one cow could mean severe economic pain in the surrounding communities, and many responded by hunting or poisoning the park's wildlife until some species were eradicated altogether. Lions, which numbered more than 300 before the 1990s, disappeared (Moran, 2019). Likewise, the decrease in the number of lions in the national parks of the northern area of the Central African Republic (CAR) is largely due to their systematic slaughter by nomadic herders who enter the parks with their herds during the dry season (Chardonnet, 2002). Even today, illegal persecution, including through poisoning, shooting and trapping, is the greatest threat to the survival of predators (Muruthi, 2005).

Primates also cause widespread damage in wood plantations by debarking and uprooting seedlings. Baboons are expert in raiding crops such as potatoes, sorghum and bananas. They can even chew sorghum stalks to extract the juice. Baboons also venture into

gardens, steal food from lodges and campsites, and can be a major nuisance in small towns if left unchecked. In Cameroon, the civet (*Civettictis civetta*) is a major predator, causing a decrease in livestock income of about 18% (Weladji & Tchamba, 2003). Smaller wildlife, particularly rodents, birds and insects, are often not the subject of intensive studies, but their crop raiding impact can be substantial (Arlet & Molleman, 2007). Although less common than crop damage, human death and/or injury is the most serious form of conflict between humans and wildlife. The hippopotamus (*Hippopotamus amphibius*) is widely believed to be responsible for more deaths than any of the large African wildlife. Yet despite the threat posed by human-wildlife conflict to the success of conservation projects and protected areas, conflict management is an understudied topic in Central Africa.

Protected area managers are experiencing increasing hostility from riverine communities, particularly farmers, who consider crop raiding as a major reason to dislike protected areas and wildlife conservation. These perceptions, coupled with negative impacts on livelihoods, could undermine current conservation efforts through a lack of support for, and a failure to apply, existing wildlife and protected area laws. This brings wildlife into direct conflict with human populations. In the extreme situation, human-wildlife conflict can act as a pretext for elephant poaching (Compaore *et al.*, 2020).

In this chapter, we discuss human-wildlife conflict issues around protected areas in Central Africa, with a particular emphasis on forest elephants (*Loxodonta cyclotis*). We describe conflicts that arise due to the presence of crop-raiding elephants within and around protected areas. Some other wildlife species, such as baboons, buffaloes, gorillas (*Gorilla gorilla*), and hippopotamus may pose similar problems. Other species also are likely to pose different types of conflicts, for example livestock predation by large carnivores such as lions and leopards (*Panthera pardus*), civet, etc. (Weladji & Tchamba, 2003), or spotted hyenas (*Crocuta crocuta*) around tourism camps and settlements. In this context, it is important to note that activities addressing various human-wildlife conflicts might involve completely different mitigation techniques (e.g., guarding and fencing related to livestock).

Since forest elephants are often mentioned as the number one conflict species in Central Africa, we believe that it is crucial to address this conflict, wherever it occurs. Measures to protect elephants increasingly have been applied in recent years to combat wildlife crime. While the impact of people on forest elephants (poaching, retaliatory killing, etc.) has dramatic impacts on elephant populations and the ecosystem (Breuer *et al.*, 2016; Poulsen *et al.*, 2018; Berzaghi *et al.*, 2019), we do not cover this wildlife crime aspect as it concerns a completely different set of law enforcement actors and activities. Instead, we address the implications of elephant conservation for people living with forest elephants and discuss how addressing human-elephant conflict should lead to co-existence of humans and elephants in Central Africa.

While our current knowledge of human-elephant conflict and its mitigation in Central Africa remains astonishingly limited (Naughton *et al.*, 1999; Nguinguiri *et al.*, 2017), many lessons can be learned from studies conducted on elephants in isolated protected areas with hard edges in West Africa (Barnes, 1999; Boafo *et al.*, 2004; Barnes *et al.*, 2005, 2015; Gunn *et al.*, 2014), as well as from general guidelines related to human-elephant conflict in Southern and East Africa as well as Asia (Hoare, 2000a, 2012, 2015; Nelson *et al.*, 2003; Dublin & Hoare, 2004; Lee & Graham, 2006; Parker *et al.*, 2007; Osei-Owusu, 2018; Gross, 2019; Shaffer *et al.*, 2019).

The conflict situation and potential mitigation measures differ according to the intactness of the landscape, which can be put into three broad categories:

1. **Isolated protected areas:** elephants primarily range inside protected areas and from time to time move out of them, for example to raid crops on land surrounding the protected area. There is often a hard edge between the protected area border and the surrounding land which is largely due to the fact of encroachment by people resulting in the isolation of "island" protected areas. This situation is particularly found in many protected areas in West Africa, but can also be remarkably similar for human settlements that are located within protected areas;
2. **Large relatively intact forest landscape and protected area networks:** forest elephants move freely within these relatively intact landscapes and

occur both inside and outside protected areas. In this context, protected areas are often falsely blamed for being responsible for conflict, whereas stakeholders (e.g., logging companies) responsible for wildlife management in the land outside of protected areas are not doing enough to address the conflict. This category is applicable to the largest intact landscapes in Western Equatorial Africa and is largely relevant to wide-ranging species, such as elephants, migratory herbivores, and large carnivores;

3. **Human dominated multi-use landscapes, dominated by agricultural land and large commercial plantations:** such situations are increasingly occurring in Central Africa (Asaha & Deakin, 2016). Here, elephants are rare, and there is a conflict of interest between farmers and those who wish to protect the remaining elephant populations.

Furthermore, it should be noted that many human-wildlife conflict studies and manuals mainly concentrate on mitigation measures. However, these technical activities only treat the symptoms of the problem (Barnes, 2002; Dublin & Hoare, 2004; Hoare, 2015; Gross, 2019). The conflict lies at various levels, and different activities going beyond mitigation are needed to address conflict issues among stakeholders and the underlying and deep-rooted causes of conflict in order to transform conflict into co-existence (Madden & McQuinn, 2014, 2017; Nyhus, 2016; Frank *et al.*, 2019).

In the following, we cover three objectives and provide various recent case studies related to human-forest elephant conflict. First, we briefly summarize the history and current situation of human-elephant conflict in Central Africa. We next describe the types of human-elephant conflict and discuss the impacts on human livelihoods. Finally, we propose a holistic approach to addressing human-elephant conflict that integrates both biological and social science methods to the complex issues of human-elephant conflict. We briefly describe several components of such a holistic approach to human-wildlife conflict which will help to prevent future conflicts and mitigate existing conflicts using cost-effective techniques. Such an integrated approach allows the inclusion of qualitative data using sociological methods such as participant observation, which has been proven to provide more insights into the various dimensions of the conflict. We advocate for increased elephant tolerance and human-elephant co-existence within conservation landscapes, as well as for more mitigation methods where elephants are compressed into small protected areas.

1. Historical and current patterns of human-forest elephant conflict in Central Africa

Relatively little is documented about the history of human-elephant conflict in Central Africa despite its occurrence since pre-colonial times (Barnes, 1996; Lahm, 1996). Elephants have been hunted for tusks, meat, fat, and bones throughout their range. The killing of elephants by the Baka and Aka tribes was a widespread cultural tradition (Agam & Barkai, 2018) and is still an important part of their cultural heritage (Tsuru, 1998). However, the colonial ivory trade resulted in the removal of millions of forest elephants and many of the large tuskers (Poulsen *et al.*, 2018).

In the past, human-elephant conflict may have existed, but it was likely to be of little concern – even in the largest palm oil (*Elaeis guineensis*) or rubber (*Hevea brasiliensis*) plantations – as elephants were simply shot when they approached fields. Elephants likely avoided human settlements, resulting in little human-elephant conflict. Furthermore, local people were regularly resettled along roads and to urban centers both before and after the colonial period. This resulted in huge remote forests (with large tracks of secondary forest that are preferred by forest elephants) with very few people and very limited access (large areas of Southern Cameroon, Gabon and Northern Congo) that contained large elephant populations residing at high densities (e.g., Minkébé forest in Northeast Gabon).

Poaching for ivory was common but occasional. Sport hunting was performed by expatriate employees of logging companies and other industries. Forest elephants were often killed when they approached villages, and therefore they largely ranged far away from villages in remote and inaccessible forests. In contrast, people in today's Democratic Republic of Congo (DRC) have been forced to exploit the forest for natural products, particularly wild rubber and palm oil; this likely has had a negative impact on the abundance and distribution of forest elephants and consequently human-elephant conflict.

With the creation of many protected areas in the 1990s and increasing measures of conservation, forest elephants eventually returned close to human settlements and started raiding crops in the villages where they were well protected. Around these villages, protection measures were relatively well implemented due to the presence of conservation actors. Consequently, forest elephants started to range even closer to human settlements, where they felt safe and where crops were easily accessible. Complaints of human-elephant conflict have been increasing ever since. Today, forest elephants still occur in relatively moderate numbers in the dense rain forests of Gabon, Congo, and Southeast Cameroon, as well as in and around Salonga National Park in the DRC (Maisels *et al.*, 2013). Most other populations are fragmented and have undergone dramatic declines due to commercial poaching for ivory, which has caused a population decline of over 60% (and in some sites even over 80%) over the last decade (Maisels *et al.*, 2013; N'Goran *et al.*, 2016; Poulsen *et al.*, 2017).

Historically, the largest landscapes had exceptionally low human population densities with relatively intact forests where forest elephants could roam freely. However, this has changed rapidly over recent decades due to the expansion of commercial logging, mining activities and development corridors (Edwards *et al.*, 2014; Laurance *et al.*, 2015; Kleinschroth *et al.*, 2019). The development of infrastructure and roads, and encroachment from people coming from outside these landscapes, has led to a mixture of people of varying origins and socio-economic backgrounds, and an intensification of farming, more sedentary settlements, and shorter fallow periods. This has further resulted in the expansion of farming activities around traditional settlements, and along new roads, particularly in the DRC (Laporte *et al.*, 2007; Kleinschroth *et al.*, 2015, 2019; Tyukavina *et al.*, 2018). This increased cultivation combined with forest conversion is causing an expansion of agricultural areas into forest elephant habitats (Kleinschroth & Healey, 2017; Tyukavina *et al.*, 2018), and consequently an increased potential for human-elephant conflicts (Breuer *et al.*, 2016).

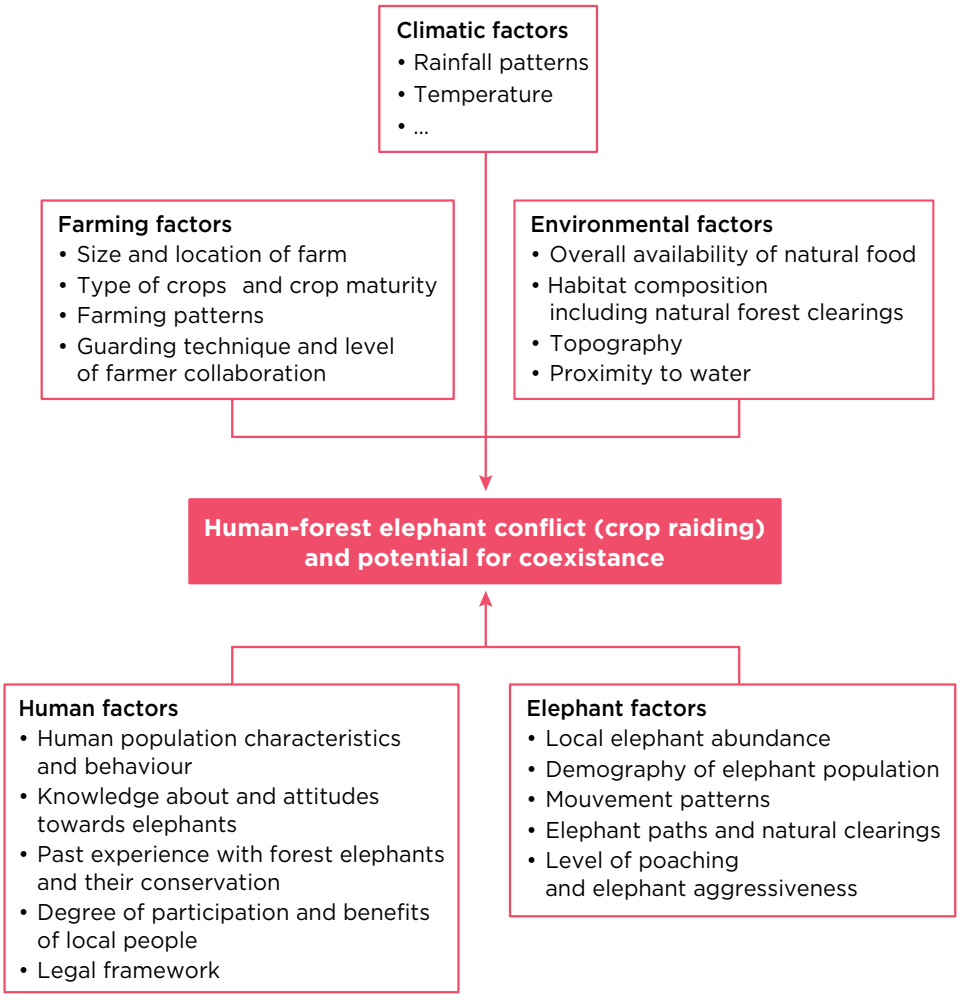
In addition to a dramatic reduction in the number of forest elephants, there are other far-reaching consequences of anthropogenic impacts. Forest elephants avoid areas of high poaching intensity and take refuge in areas where they feel safe (with no poaching), leading to locally high forest elephant

abundance (which is rather a compression), and potentially high crop raiding impacts. Furthermore, elephants that have witnessed the killing of their conspecifics and have grown up without larger tuskers might lose fear and show increased aggression. Similarly, poaching has led to more demographic and behavioral changes of forest elephants that are likely to increase human-elephant conflict throughout the region (Breuer *et al.*, 2016).

We realize that much progress has been made in recent years to combat elephant poaching, including the prevention of poaching events, the arrests of organized poaching gangs and the punishment of traffickers and middlemen. However, it is important to understand that forest elephants have extremely slow population growth rates (Turkalo *et al.*, 2017), and the apparent increase in conflict is thus not due to a sudden increase in the local forest elephant populations. Rather, the continuous immigration and expansion of people into forest lands, the increase of the density of the last elephant populations repelled in these forest tracks, the lack of effective mitigation methods, and potentially an increase in so-called problem elephants, are among the main reasons behind the increasing conflict.

In summary, a diversity of factors must be considered when dealing with human-elephant conflicts, including elephant and human populations' dynamics and behavior, as well as environmental factors (Figure 1). Climate change has been particularly overlooked, as it seems that the fruiting of natural forest trees seems to have fallen dramatically during the past 30 years, which may have pushed elephants "out of the wood" (Bush *et al.*, 2020).

Figure 1 - Factors contributing to human-forest elephant conflict (crop raiding) and potential for co-existence in Central Africa



2. Types of human-elephant conflict and impact on livelihoods

Elephants and people compete for space, water and food. Rural human population growth results in an expansion of agricultural land and a reduction of forest elephant habitat. Due to their large body size, enormous nutritional needs (up to 450 kg of food per day), and wide-ranging behavior, forest elephants regularly come into conflict with humans (Fritz, 2017). Elephants are particularly notorious crop raiders, and their ability to destroy an entire year's worth of crops in a single visit can threaten a farmer's livelihood. Elephants are messy eaters and can easily destroy around one hectare of crops in a few raids. When we address conflict due to forest elephants, it is therefore important to know that a single elephant can cause huge damage. Thus, it is not surprising that forest elephants are considered among the top-ranking crop-raiding species, which likely leads to declining tolerance for elephants in rural communities (Naughton-Treves & Treves, 2005).

In addition to damaging crops, they destroy food stores and water sources, and sometimes threaten human life. Impacts can be either direct (crop loss, property destruction, injury, etc.) or more hidden, such as the opportunity costs of added expenditures and workload (Hoare, 2000a; Hill, 2004; Jadhav & Barua, 2012; Walker, 2012; Barua *et al.*, 2013; Gladman *et al.*, 2020; Salerno *et al.*, 2020).

Another way to categorize these costs is to split them into tangible and intangible categories (Kansky & Knight, 2014). Tangible costs are financial losses such as infrastructure and harvests damages, whereas intangible costs are non-monetary, temporally delayed, and often psychological in nature (fear, stress, sleep-deprivation or in the extreme case grief over a death). To be successful, a human-elephant conflict program must consider both monetary and intangible costs as they are likely to have different types of influence on peoples' perceptions and levels of tolerance for co-existence. Here we briefly describe some of the major impacts that forest elephants can have on people and their livelihoods.

2.1 Crop raiding

Crop raiding is often mentioned as being responsible for the largest (monetary) impact of human-wildlife conflict on human livelihoods (Naughton *et al.*, 1999; Mackenzie & Ahabyona, 2012; Hill, 2018). In Central Africa, it predominantly impacts individually managed smallholder farms using slash-and-burn practices (Lahm, 1996; Madzou, 1999; Naughton *et al.*, 1999; Boukoulou *et al.*, 2012a; Eyebe *et al.*, 2012; Fairet, 2012; Walker, 2012; Inogwabini *et al.*, 2014; Nsonsi *et al.*, 2017). Crop raiding is likely to have occurred ever since the existence of agriculture in Africa. Most people

in Central Africa practice smallholder agriculture and shifting cultivation (land is cultivated for around two years and then allowed to lie fallow for 5-20 years), primarily of root crops such as cassava, yams and cocoyam, banana/plantain trees, and occasional ground nuts. Farming is typically practiced using slash-and-burn practices on private family plots managed by native smallholders. Cultivation in re-growing secondary forests of umbrella trees (*Musanga cecropiodes)* is often preferred because these are easier to clear than old and mature forest.

Crop raiding decreases agricultural productivity, can lead to the abandonment of fields, and hinders efforts to reduce poverty as rural incomes often depend on small-scale farming and are rarely compensated (Mackenzie & Ahabyona, 2012; Walker, 2012; Hill, 2018). Farmers whose entire livelihoods depend on agriculture are often the most vulnerable. Causing on average a crop loss of over 25%, crop raiding can have severe consequences on both family food supplies and household income (Fairet, 2012; Walker, 2010, 2012). Few people have the financial means to ensure field protection. The need to protect fields overnight exposes guards to mosquito-borne disease, stress, and lack of sleep. Thus, crop raiding can have many negative side-effects and increase vulnerability (e.g., lack of funds for mitigation measures). The extent of the crop loss is therefore likely to influence people's perception of forest elephants.

2.2 Infrastructure destruction

Elephants also occasionally destroy infrastructure. Destruction of property occurs when elephants break into houses while looking for salt, soap, bread or even toilet paper. Forest elephants even destroy small-scale alcohol breweries or accidentally fishing nets and dugout canoes (Nsonsi *et al.*, 2018).

Forest elephants destroy not only the property of local communities but also tourism and research camp infrastructure. At Mbeli Bai, in the Nouabale-Ndoki National Park, one single large musth bull terrorized researchers and regularly destroyed boardwalks over the swamp and the tourism facilities. The same bull destroyed the tourism dining room multiple times, and even removed mattresses from tourism bungalows which did stand on four high concrete posts. Years later, another younger bull regularly entered the same camp and due to his aggressive behavior, the tourism activities had to be closed. Similar problems occur at other research and tourism camps.

2.3 Competition for natural resources, access restriction, injury and killing of people

Forest elephants compete for wild foods such as wild mangos (*Irvingia spp.*), and many other fleshy fruits such as *bambu* (*Chrysophyllum lacourtianum*)

and moabi (*Baillonella toxisperma*) that have an important value for local livelihoods and on local and regional markets. Most of these larger trees are connected via elephant paths. Elephants harvest these fruits from the ground or bump their heads against the tree trunks with force (Maisels *et al.*, 2002). Forest elephants therefore directly compete with local gatherers for these fruits and also come into contact with people when looking for trees growing naturally in the vicinity of settlements, such as palm trees.

Forest elephants are dangerous to people. Aggressive encounters with elephants in the dense rain forest are common. Physical aggression and charges are not uncommon. Biomonitoring and ranger teams are regularly charged by forest elephants, and several people have been wounded or killed. Thus, walking in a forest elephant habitat is becoming more and more dangerous, making it necessary to be prepared for potential aggressive encounters. Heightened aggression both in the short and long term is likely to be a consequence of poaching (Breuer *et al.*, 2016). For example, we witnessed an elephant bull that had been extremely peaceful and regularly frequented the park headquarters become very aggressive after a poaching event in a nearby forest clearing. Researchers and tourists have been killed by hyper aggressive male elephants and elephant mothers protecting their young offspring.

Forest elephants can also be dangerous to people when approaching settlements. When elephants lose fear, they come near people and become destructive (see above). Elephants can prevent people from passing and might actively charge people. This can substantially compromise conservation efforts. In order to anticipate any aggressive behavior, it is strongly recommended that people be aware of the risks of charging elephants and understand their body language.

2.4 Opportunity costs

Human-elephant conflict also generates opportunity costs, poor health and poor nutritional status (Fairet, 2012; Walker, 2012; Barua *et al.*, 2013; Gladman *et al.*, 2020). Staying up overnight to protect crops leads to an increased workload, lack of sleep and more stress, lower health and a rising fear of elephant. Children might not be able to attend school if they must work overnight to protect the farms or if an elephant blocks the roads and prevents them from passing. Conflict events may thus affect people for years after they occur. We will see below that such intangible costs strongly influence tolerance for co-existing with wildlife.

2.5 Price increase and standard of living

Crop raiding can also have secondary impacts on people not involved in the farming sector as prices of cash crops can be higher in remote villages where local production cannot meet demand for staple foods (Fairet, 2012; Walker, 2012). For example in Northern Congo, cassava had to be imported (despite being subsidized by a nearby conservation project), and the price was up to 25% higher in villages where elephants had destroyed almost all crops (Nsonsi, n.d.).

3. Finding solutions to human-elephant conflict

Measures to address human-wildlife conflict are diverse and address different elements of the conflict. They include practical solutions dealing with the symptoms of the conflict (e.g., impact mitigation measures to reduce crop loss and ensure income safety) or addressing previously unresolved social issues underlying the conflict (e.g., issues in relationships between stakeholders) or even deep-rooted values and social beliefs (including addressing past traumata). They range from activities that aim to prevent human-wildlife conflict before it occurs to mitigation measures that aim to reduce the impacts of human-wildlife conflict after it occurs (Nelson *et al.*, 2003; Redpath *et al.*, 2013; Nyhus, 2016; Young *et al.*, 2016a; König *et al.*, 2020). Thus, in the case of elephants, it is not only crucial that we fully understand the ecology of forest elephant behavior to modify their behavior (Mumby & Plotnik, 2018), we also need to acquire a clear understanding of the human dimension of the conflict (Dickman, 2010; Bennett *et al.*, 2017a; Hill, 2017; Wallace & Hill, 2017; Gross, 2019; Shaffer *et al.*, 2019).

Unfortunately, human-wildlife approaches are rarely systematically included in conservation and protected area management projects in Central Africa

(Naughton *et al.*, 1999; Hoare, 2012, 2015; Nguinguiri *et al.*, 2017; Gross, 2019; Shaffer *et al.*, 2019). Most measures addressing human-elephant conflict have been applied in isolation, and holistic approaches are rare because they are not often included in the design of programs and/or there is a lack of funding. To our knowledge, the specific problem of crop raiding has never been addressed in full, even where conservation projects in the Central Africa have been running for several decades. Where human-elephant activities occur, conservationists often only aim to mitigate the visible impact of wildlife without considering the human dimension of the conflict. It is important to understand that a combination (and ideally the full range) of interventions needs to be deployed – there is no one-size-fits-all solution.

Implementing technical solutions that focus on physical and spatial measures (e.g., beehive fencing) in isolation and economic fixes (e.g., compensations) only address parts of the overall problem (see Figure 1). More importantly, the deeper-rooted reason for the conflict is not solved. Holistic landscape-based approaches aim to increase the willingness of local communities to tolerate and co-exist with wildlife conflict. They apply land-use planning, community conservation and participation using scenarios of climate change as well as increased population growth, immigration and agricultural expansion, more extractive industries, agroforestry, and increased fragmentation (Osborn & Parker, 2003; Dublin & Hoare, 2004; Walker, 2010; König *et al.*, 2020).

Conservationists and protected areas' managers in Central Africa must start to work on more long-term approaches applying land-use planning, understanding of stakeholders, increasing community participation and implementing co-existence activities that raise the level of tolerance of living with wildlife and try to accommodate forest elephants as a species within a shared landscape. Human-wildlife conflict must be addressed at various administrative levels (vertical integration) to elaborate the relevant intervention policy and the institutional links between local, regional and national entities (Hoare, 2015). A focus on shorter-term measures in the conflict zone will not lead to success.

Furthermore, any human-wildlife conflict program must build on local knowledge and a willingness to respect local realities (Treves *et al.*, 2006; Treves *et al.*, 2009; Young *et al.*, 2016a; Wallace & Hill, 2017; Branco *et al.*, 2019). An electric fence is no solution when financial means are lacking, and bee-fencing cannot be applied when local resistance against bees exists. Finally, any co-existence approach needs to respect the existing cultural relationships of people and elephants. We must include knowledge about the ethnobiology of a site to increase tolerance towards conflict species (Setchell *et al.*, 2017; Parathian *et al.*, 2018).

Conservation organizations jointly working with governmental offices in Central Africa can play a crucial role in the implementation of human-wildlife conflict projects. They often have the knowledge and staff capacity needed, and can raise funds to cover salaries of full-time employment for experts and the relevant operational budget and logistics. Given the wide-ranging nature of elephants, it will be important to collaborate with other stakeholders (logging and safari companies, and mining extractives) in the buffer zones of protected areas. WWF (World Wide Fund for nature) has developed a long-term and holistic human-wildlife conflict "SAFE" system (Brooks, 2015) that integrates a variety of measures to ensure that wildlife and people co-exist in harmony while protecting both wildlife habitats and people's assets (Appendix 1).

3.1 Understanding the conflict

A thorough understanding of all dimensions of the conflict is crucial for any human-wildlife conflict program to be successful (Hill, 2004, 2017; Dickman, 2010; Guerbois *et al.*, 2012; Redpath *et al.*, 2013; Kansky & Knight, 2014; Young *et al.*, 2016a; Wallace & Hill, 2017; Gross, 2019; König *et al.*, 2020). Only a few studies in Central Africa have systematically aimed to fully understand the diverse components of human-wildlife or elephant conflict and its underlying drivers (Nsonsi, n.d.; Walker, 2010; Crawford, 2012; Fairet, 2012). These include the biology of the conflict species and the ecological variables that might impact the conflict as well as the human techniques (e.g., crops planted, farming cycle, location of fields) that increase vulnerability to conflict animals. Rarely do human-wildlife conflict projects

investigate conflicts between people, even though the conflict with wildlife might often be a surrogate for a deeper-rooted social conflict.

Problems can be very site specific and depend on the socio-cultural context of the stakeholders as well as the ecological setting in the landscapes or around the concerned protected area. Furthermore, it is important to understand whether the human-elephant conflict concerns a larger portion of the human and elephant populations or just a few problem elephants or concerned farmers. Thus, understanding susceptibility to and determinants of human-elephant conflict requires a deeper knowledge of site-specific conflict patterns, especially crop raiding, which is likely to change over time as elephants quickly adapt to new situations. There are various dimensions of vulnerability, including biophysical, social and institutional components, and investigating these components together is likely to reveal a much better understanding than investigating a single factor on its own.

It is important to know that forest elephants have always been present in these landscapes. They have not been re-introduced, nor have they been forced out of protected areas due to growth in the elephant population. It is a misconception that more signs of human-elephant conflict are due to an increasing forest elephant population resulting from successful law enforcement activities as forest elephants show slow population recovery (Turkalo *et al.*, 2017). Conflict between elephants and people arises due to the expansion of human settlements and slash-and-burn agriculturel, which are encroaching on elephant habitats, and to elephants moving to areas where they feel safe. Increasing habitat loss and fragmentation due to development of linear infrastructure, expansion of human settlements and people's need for land, agriculture and pastures are resulting in a serious increase in human-wildlife conflict zones throughout the continent (Kleinschroth *et al.*, 2019).

Poaching has worsened the situation on various levels. For example, conflicts are exacerbated due to the phenomenon of compression into protected areas and the loss of fear of humans due to local high levels of protection, and the attraction of elephants to secondary forest with its dense understory (Nchanji & Lawson, 1998; Naughton *et al.*, 1999; Naughton-Treves & Treves, 2005; Breuer *et al.*, 2016). Given the anthropogenic impacts on forest elephants, the killing of larger older tuskers with the resulting loss of ecological knowledge, heightened aggression and increased exploratory behavior of younger males combined with increased compression and fragmentation, it is very likely that human-elephant conflict is going to severely increase in the future, despite an overall decline in forest elephant numbers (Breuer *et al.*, 2016). This may be exaggerated by the deteriorating social context (e.g., increased poverty, civil and political instability, worsened governmental support, rapid population growth and land needs, but also rural exodus, etc.) in some Central African countries (e.g., social vulnerability). If local people feel that they are left alone to face these problems, a transformation from conflict to co-existence is unlikely to happen.

3.2 Perceptions and root causes affecting tolerance of co-existence with forest elephants

Conservation programs aiming to mitigate the impacts of human-wildlife conflict must understand the social dimensions of the conflict because human-wildlife conflict is often mainly about social conflicts between different human groups (Hill, 2004; Dickman, 2010; Hill, 2017; Wallace & Hill, 2017; Vucetich *et al.*, 2018). Negative impacts on livelihoods (and tangible costs) often are far less of a problem than the pervasive existence of negative perceptions among stakeholders (Hill, 2004; Webber *et al.*, 2007). Such data should take into account that the perception of conflict wildlife can differ between households and according to a variety of socio-economic factors such as gender, level of education, ethnicity, residency, dependency on farming and wealth (Naughton *et al.*, 1999; Hill, 2004; Naughton-Treves & Treves, 2005; Kansky & Knight, 2014; Nsonsi *et al.*, 2017, 2018).

3.2.1 Addressing lack of knowledge and considering local attitudes

First, it is important to understand that local people, and occasionally even members of wildlife authorities in Central Africa, have limited knowledge about the management of human-wildlife conflicts. Statements such as the "wildlife that come from the nearby protected area" often are incorrect because wildlife are not confined (in most cases) to protected areas and often have been living in the landscapes long before the establishment of human settlements and agriculture.

Next, the size and behavior of the crop-raiding species strongly influences perceptions; for example, attitudes towards elephants are often based on extreme damage events which contrast with the small persistent damage caused by smaller animals such as rodents or insects (Hill, 2004; Naughton-Treves & Treves, 2005; Oerke, 2006; Arlet & Molleman, 2007).

As a result, attitudes towards wildlife are controversial (Lee & Graham, 2006): on the one hand, wildlife such as elephants, gorillas and lions can be viewed as icons and flagship species for conservation. When conservationists and people in the Western world argue about the importance of forest elephants, they use terminology such as forest engineers, ecosystem services, and seed dispersers (Blake *et al.*, 2009; Poulsen *et al.*, 2018). They regard wildlife with affection and admiration and highlight their role as tourism magnets. Local people often do not understand the link between wildlife presence and ecological services as these concepts are complex. For example, it was recently demonstrated that elephants have a positive effect on soil fertility with important implications for local agricultural practices (Sitters *et al.*, 2020).

On the other hand, local people see wildlife quite differently and judge them as dangerous and pests that damage their property (Hill, 1998). For example, in Northern Congo, negative attitudes towards forest elephants were largely associated with farming activity, lack of benefits from the conservation project and past conflicts with wildlife law enforcement (Nsonsi *et al.*, 2017, 2018). Only occasionally do local stakeholders have positive attitudes towards wildlife, particularly among indigenous people (Köhler, 2005). Even

where positive benefits of wildlife exist, interactions with wildlife are framed negatively. Complaints expressed by local farmers can make human-elephant conflict a highly political issue between protected area managers and local communities. This is intensified due to a widespread lack of understanding about the role of each conservation actor.

Understanding perceptions of wildlife and the prevalent conservation conflict matters and needs to inform wildlife tolerance and co-existence strategies and the implementation of management responses (Nsonsi *et al.*, 2017, 2018; Vasudev *et al.*, 2020). When addressing human-wildlife conflict, it is therefore important to understand who the different stakeholders are, what their interests are, and what types of conflict exist between them.

3.2.2 Lack of participation and ownership of wildlife and protected areas

Perceptions might also reflect underlying issues of wildlife ownership, differences in benefit sharing and stakeholder involvement as well as power differentials between different human groups (institutional vulnerability). Overall, protected area management in Central Africa reflects a top-down conservation strategy in which locals are mostly excluded from decision making. However, authorities in charge of managing protected areas in Central Africa have limited technical skills and financial means. International Non Governmental Organizations (NGOs, including foreign staff) therefore often take over much of the daily work on the ground in collaboration with the government. Given this strong presence of NGOs, locals consider them as the owners of wildlife and the management body of protected areas. This is further exacerbated by so-called Public-Private Partnerships (PPP) in which NGOs take over the management body of a protected area (Hatchwell, 2014).

Conflicts between local people and protected area managers are common around national parks. This is due to a lack of local community participation in the management of protected areas, and occasionally poor relationships between local people and protected area managers (Lambini *et al.*, 2019). Correspondingly, local people often have hostile attitudes towards wildlife authorities and the concept of protected areas (West *et al.*, 2006). When local people feel that there is a lack of transparency in decision making, or think that there are unequal power dynamics, a lack of trust is often manifested (Peterson *et al.*, 2010; Stern & Coleman, 2015; Young *et al.*, 2016a).

For example, in Northern Congo and coastal Gabon, many stakeholders expressed confusion about the ownership of wildlife, some even stating that elephants belong to the "Western" people who only care about conservation and not about people's livelihoods (Fairet, 2012; Nsonsi *et al.*, 2017). Local resistance to conservation agendas might lead to increased complaints about human-wildlife conflict. Consequently, this can result in political maneuvering and the use of conflict language, such as "pests" or "problem animals", a lack of trust, and communication barriers. When farmers are unsatisfied with conservation narratives that are against their interests, they might express their anger, deception and lack of empowerment by complaining about elephants. Raising concerns about conflict can occasionally be an attempt by local people to receive financial support where compensation occurs.

3.2.3 Underlying conflict and past unresolved incidents of human-wildlife conflict

Aggressive wildlife behavior events remain in people's memories. Perceptions can reflect past conflictual events and not necessarily current conflict. Negative perceptions towards wildlife can result from past confrontations with wildlife laws (e.g., with rangers) and consequently some wildlife species, in particular forest elephants, are perceived as the main conflict species (Fairet, 2012; Nsonsi *et al.*, 2018).

Sometimes local people, including farmers, even threaten conservationists and park managers because wildlife destroyed their properties, including fields. For instance, if an elephant kills a farmer near a protected area, this may result in a massive protest against the protected area's administration, sometime resulting in the burning of staff offices and cars. Clearly, such deep-rooted attitudes and political manipulation have often been ignored in local conservation projects. Indeed, intangible costs have been identified as having a much larger impact on tolerance of living with wildlife like elephants and buffaloes than the perceived monetary costs or lack of benefits from their conservation.

3.2.4 Other social and cultural conflicts

There are also conflicts between farmers. For instance, some farmers accuse their neighbors of witchcraft and of transforming themselves into elephants to destroy their plantations because, by chance, an elephant feeds in one field and leaves the neighboring fields untouched (Nsonsi, n.d.). The owner of the destroyed field takes a negative view of the luckier ones.

Perceptions are likely to differ due to people's ethnic and residency background (Parathian *et al.*, 2018). Clearly pygmies, who have a strong spiritual link to elephants, have different attitudes than Bantus (Köhler, 2005). Many Bantu tribes believe that elephants are totems of the Aka/Baka pygmies who want to punish them by annihilating their efforts in the agricultural sector. And more importantly, immigrants are likely to show less tolerance compared to people that have grown up with elephants living nearby.

Thus, an understanding of the perceptions of those who are affected by the conflict is crucial as their beliefs are likely to influence their behavior (Nsonsi *et al.*, 2018). Such a knowledge gain will help to frame conflict mitigation strategies.

3.3 Susceptibility to wildlife crop raiding

Understanding factors influencing crop consumption by wildlife is important to design crop protection methods (Naughton-Treves, 1998; Sitati *et al.*, 2003; Jackson *et al.*, 2008; Graham *et al.*, 2010; Songhurst & Coulson, 2014). Crop raiding behavior is likely different due to differences in wildlife habitats (e.g., availability of water, location of fruiting patterns). For instance, there are differences between elephants species (e.g., savanna elephants move in large herds while forest elephants tend to form small groups; Fishlock *et al.*, 2008; Schuttler *et al.*, 2012; Schuttler *et al.*, 2014; Turkalo *et al.*, 2013; Fishlock & Turkalo, 2015; Mills *et al.*, 2018; Beirne *et al.*, 2020; Brand *et al.*, 2020), and differences in farming patterns (mainly small-scale farms in forest areas compared to larger fields in the savannas). In addition, it is important to realize that each location has its own set of factors affecting the spatial and temporal pattern and intensity of crop raiding, and hence the different options available to mitigate the conflict. While there is a deepened understanding of some of the factors affecting the vulnerability of farms to crop-raiding elephants in savanna ecosystems, little is known about forest elephants.

A variety of factors are likely to affect susceptibility to crop raiding (Sitati, Walpole & Leader-Williams, 2005; Graham *et al.*, 2010; Guerbois *et al.*, 2012; Goswami *et al.*, 2015; Wilson *et al.*, 2015; Gross *et al.*, 2018). They are related to the behavior of crop-raiding elephants (Osborn, 2004; Chiyo & Cochrane, 2005; Rode *et al.*, 2006; Chiyo *et al.*, 2011; Chiyo *et al.*, 2012; Gunn *et al.*, 2014), natural features (biophysical: e.g., density of elephants, proximity to natural habitat and feeding sites, rainfall, topography, availability of wild fruits, etc.) as well as intrinsic features of the farms (crop species, stage of ripening of crops, farm size and location, cultivation cycles of local farmers, effectiveness of farm protection measures, etc.) (Barnes *et al.*, 1995; Barnes *et al.*, 2005; Lahm, 1996; Nchanji & Lawson, 1998; Osborn, 2003; Boafo *et al.*, 2004; Chiyo *et al.*, 2005; Kofi Sam *et al.*, 2005; Gross *et al.*, 2018; Snyder *et al.*, 2020).

The biophysical vulnerability to crop raiding patterns in Central African forested areas is poorly understood and shows many site-specific patterns. Thus, to predict these patterns, we need to understand why and when forest elephants raid crops. Various hypotheses have been proposed that remain largely untested. There are many short-term studies aiming to understand crop raiding patterns within Central Africa (Nsonsi, n.d.; Lahm, 1996; Kamiss & Turkalo, 1999; Madzou, 1999; Ongognongo *et al.*, 2006; Walpole & Linkie, 2007; Boukoulou *et al.*, 2012b; Eyebe *et al.*, 2012; Fairet, 2012; Inogwabini *et al.*, 2014; Ngama *et al.*, 2019).

Certainly, as confirmed in many studies, the maturity of crops has a strong impact on the occurrence of raids. When crops are ripe, they attract animals due to their high nutritional value. Crop type is undoubtedly also an important factor impacting raids. Among the preferred crops are maize, bananas and cassava, but also sugarcane, sweet potatoes and rice. Crops may also provide additional benefits to wildlife, such as the provision of rare nutrients.

The location, size and vegetation around a field (see fruiting trees above) are also important predictors

of elephant crop raids. In Central Africa, it appears that the scattered pattern of planting due to low quality soil, far away from the village, also creates more opportunities for crop-raiding by wildlife. If farmers open their fields in a nearby elephant habitat, these fields will be more vulnerable.

It therefore is important to understand how elephants move through the forest and which factors influence their distribution and abundance in the absence of anthropogenic activities (e.g., habitat types, understory composition and canopy closure, proximity to natural forest clearings or other salt licks, seasonal concentration of fruiting trees; existence of elephant paths; Ngama *et al.*, 2019; Beirne *et al.*, 2020). In a recent study in Gabon, researchers found that the presence of wild fruiting trees near farms increased the occurrence of crop damage, particularly when those trees were bearing ripe fruits (Ngama *et al.*, 2019).

Fields are also more difficult to guard if they are far from a village. For instance, elephants largely raid crops during the night or when people are absent. Smaller fields are often more vulnerable than larger ones. The general lack of organized, team-based mitigation strategies exacerbates the situation.

Patterns found in savanna elephants (e.g., rainfall) are likely not to be the same for forest elephants because water is overall abundant with some notably seasonal exceptions (Blake, 2002). Nevertheless, peaks in crops raiding occur more often in the wet season at some sites when forage quality is low and when elephants appear to be ranging closer to cultivated areas, although other studies could not find any seasonal difference. However, traditional farming is determined by the rainfall season. Researchers also found higher susceptibility to crop raiding when fields were located near permanent water points at some sites, but not at other ones. Interestingly, elephants do not raid crops grown on steeply sloping fields, thus providing further conflict mitigation options (Ngama *et al.*, 2019).

Furthermore, there are likely to be large inter-individual, age and sex differences, and the reasons for crop raiding might additionally vary not only between sites but also between individuals of the same elephant population, as seen in savanna elephants (Chiyo *et al.*, 2011, 2012). The extent to which the different social system of forest elephants, with much smaller groups, influences conflict patterns is unknown. There is limited site-specific information on ranging patterns of forest elephants, particularly on the usage of elephant paths, natural forest clearing, or other high elephant value forests. Unfortunately, our baseline knowledge about elephant habitat use and movements is predominantly determined by individual movement patterns (Blake, 2002; Momont *et al.*, 2015; Mills *et al.*, 2018; Beirne *et al.,* 2020; Molina-Vacas *et al.*, 2020) or from large landscape surveys (Clark *et al.*, 2009; Stokes *et al.*, 2010).

Finally, human activities are likely to modify raiding patterns. Clearly, human activities (poaching, linear infrastructure, road traffic), strongly impact population-wide-elephant distribution (Laurance *et al.*, 2006; Stokes *et al.*, 2010; Yackulic *et al.*, 2011). Forest elephants avoid areas of high-poaching intensity and take refuge in secure areas, leading to locally high forest elephant abundance and intensified crop raiding near villages where elephants feel safe (Breuer *et al.*, 2016). However, the degree of impact remains to be studied. Additionally, forest elephants appear to be attracted to secondary forest and there might be a link between logging disturbance and increased levels of crop-raiding incidents. Therefore, natural and anthropogenic factors work in combination.

3.4 Monitoring the conflict, its impacts and the effectiveness of conflict management interventions

Despite the multitude of review articles on human-wildlife conflict, the existence of many different human-wildlife conflict manuals (Nelson *et al.*, 2003; Parker *et al.*, 2007; Walpole & Linkie, 2007; Fernando *et al.*, 2008; Osei-Owusu & Bakker, 2008; WWF, 2008; Lamarque *et al.*, 2009; Osei-Owusu, 2018), and the availability of online resource pages, there is a paucity of data on the effectiveness of conflict management measures in Central Africa. This contrasts with other regions in Africa and Asia, where mitigation measures have been studied in detail (Davies *et al.*, 2011; Gunaryadi *et al.*, 2017; Branco *et al.*, 2019; Scheijen *et al.*, 2019) and occasionally have succeeded in reducing the conflict to tolerable levels. However, mitigation measures in isolation will not be successful and must be integrated into larger

human-elephant co-existence programs (see below) as all negative impacts of the conflict can never be eliminated. We briefly present a few important monitoring questions and tools.

Monitoring must take place at different levels with baselines and follow-up monitoring of project success of prevention and mitigation strategies (Pozo *et al.*, 2017). Various questions about human-elephant conflict need to be answered, most notably: reports by farmers themselves have been shown to overestimate the real impact of damage by crop-raiding species; so what is the exact amount of crop-raiding by forest elephants and how does it compare to less visible species (such as rodents)? How effective are mitigation methods in reducing tangible costs? How can we measure and monitor intangible costs to better address them? How does crop-raiding and trampling damage impact the harvest in palm oil or agroforestry plantations (e.g., African oil palm, safou (*Dacryodes edulis*), kola nut (*Cola spp.*), etc.)?

Standardized data collection protocols have been developed for savanna elephants that have been used to quantify the impact of crop raiding (Hoare, 1999, 2000b; Parker *et al.*, 2007). However, it has been extremely challenging to confirm whether reported (or perceived) impacts reflect real impacts because of the time required for wildlife managers to confirm raids. Therefore, more participative and real-time documentation has been recommended. For example, community-based monitoring of crop raiding using mobile devices has been used in Southern Africa and is being tested in Central Africa (Angoran, 2016; Le Bel *et al.*, 2016; Nguinguiri *et al.*, 2017). To put such systems in place, local data collectors must be trained and supervised over several years.

More innovative methods, such as camera traps, can help to determine raiding patterns (timing and location) and age and sex patterns of crop-raiding elephants (Smit *et al.*, 2017; Ngama *et al.*, 2018). Combined with the mapping of forest elephant hot spots (e.g., fruiting trees, natural forest clearings and other licks along large elephant paths), such data can help to identify high conflict zones which can then be integrated into a larger human-elephant co-existence approach and land-use plan with the aim to increase the acceptance of elephants on community land (see below). The involvement of local communities is crucial for the development

of participative community action plans, which are currently being developed in several countries of Central Africa. Furthermore, data on human-wildlife conflict must be linked to detailed information on wildlife demography, distribution, movement patterns and human activities.

We need to integrate social sciences and methodologies (interview, community engagement, focus groups, etc.) into human-wildlife conflict programs to gather information on people's perceptions and drivers of negative attitudes to wildlife (Hill, 1998; Hartter, 2009; Nsonsi *et al.*, 2017, 2018; Vasudev *et al.*, 2020). This also includes qualitative data which can be exploratory and comparative in their approach, the use of different analytical methods, and the involvement of both natural and social scientists (Bennett *et al.*, 2017a and b; Setchell *et al.*, 2017). How do people value the proposed mitigation strategies and how are people's perceptions changing in relation to mitigation success or increased participation?

3.5 Legal framework for elephant conservation and human-elephant conflict in Central Africa

Central African countries do not share the same laws and have different engagements when it comes to activities related to elephant conservation and human-elephant conflict (Breuer *et al.*, 2015). Activities that fall under such legislation include, for example, reactive actions such as translocations, killing of problem animals, compensation and insurance, but also land-use planning. Within a country, there are often multiple laws from different sectors (environment, forest, wildlife, agriculture) that must be considered when dealing with human-wildlife conflict.

Few countries have detailed laws providing a legal framework of dealing with wildlife conflict animals and compensations. For instance, Rwanda enacted a law on the compensation of damage caused by wildlife (Law N°26/2011 of 27/07/2011) and established the Special Guarantee Fund for accidents and damage caused by vehicles and wildlife (Law N°52/2011 of 14/12/2011).

Elephants are totally protected in all Central African countries. But the killing of elephants, for example for trophy hunting, is allowed in some countries. Trophy hunting has unknown consequences on elephant populations, particularly when large tuskers are removed (as there is often a minimum size of tusks to be allowed to be hunted).

Most national and regional strategies and action plans to assist in the conservation of forest elephants are largely outdated and date back to 2005 (IUCN, 2015). National action plans are important, however, to obtain political support. Guidelines do exist to elaborate national elephant plans and are currently being used to elaborate more national action plans in Central Africa. They have been more recently updated in some countries (e.g., Gabon, Congo, etc.). The elaboration of national strategies and action plans is often less of a challenge than the implementation of the activities recommended. This is due to a lack of political will and conflicts of interest, particularly with other ministries, and a lack of funding to roll out human-wildlife conflict programs. Gabon is one exception with a detailed plan in human-elephant conflict that is put into practice (ANPN, 2016).

3.6 Changing agricultural patterns

One of the most effective deterrence to elephant damage is the modification of traditional agricultural patterns. This concerns the location of fields, planting alternative – unpalatable – crops (Gross *et al.*, 2016), and potentially changing the planting style (e.g., moving from slash-and-burn to regularly fertilized fields). However, more research is needed to evaluate whether changing farming practices can be an option. Overall, planting in wildlife habitats should be avoided; if needed, farms must be relocated out of wildlife habitats and away from paths or potentially attractive features such as natural fruiting trees. The closer the farms are located to the settlement, the easier it is to guard them. Scattered small fields within wildlife habitats will lead to increased crop raiding compared to large communal fields with straight edges. Fields should be grouped together and a collaborative effort to guard them must be set up. Working together buffers the individual damage done to a single farmer. Establishing teams that guard the fields will also allow farmers to concentrate their efforts on farming and not guarding (see Table 1).

Table 1 – Some conditions which encourage or deter elephant intrusions into farms

Most favoring conditions	Most deterring conditions
Farms far from villages	Farms near villages
Farms located in elephant corridors and preferred habitat	Setting farms far from elephant corridors and preferred habitat
Setting farms in areas where elephants go to collect food	Avoiding setting farms in areas where elephants go to collect food
Leaving standing trees whose fruits are eaten by elephants	Avoiding standing trees whose fruits are eaten by elephants
Setting patchy farm areas in the forest	Grouping farms
Setting farms near swamps used by elephants	Setting farms away from swamps used by elephants
Setting plantations in flat areas	Setting plantations in steep fields
Ignoring animals, their usefulness, and neglecting the specificities of elephant behavior	Making efforts to obtain knowledge on forest elephant behavior and their usefulness (e.g. use elephant's feces to fertilize crops)

However, farmers might argue that the location of farms further away from villages is a result of soil-depletion. Farmers need to have a thorough understanding of the growing conditions (soil, water, climate, topography, etc.) of various crops. Particularly, research into the impact of different farming practices (with or without slash-and-burn and usage of fertilizers) on soil nutrition of farms is needed to understand the suitability of these modified practices.

Changing to alternative crops might not be easy, and farmers need to be convinced that there is a market for their alternative crops. Often local people state that they are willing to plant crops that elephant do not raid (unpalatable crops). However, local people remain highly reliant on basic foods, such as cassava, tubers and bananas. Imports of these staple foods might be an option. Alternative crops should either be consumable, or the farmers should be able to easily sell them. The list of proposed alternative crops is long and includes, for example, chili (*Capsicum* sp.), tea (*Camellia sinensis*), tobacco (*Nicotiana tabacum*), cacao (*Theobroma cacao*), medicinal or aromatic plants, vegetable gardens (near houses) and many more (Barnes *et al.*, 1995; Gross *et al.*, 2016). If these crops only provide low income (and need high financial and technical investment), it is unlikely that farmers will change to them. Furthermore, when changing to alternative crops that elephants do not eat, crop-raiding by other wildlife species might still occur.

If alternative crops are used as a buffer zone, the buffer zone must be wide enough (several kilometers) and should contain only unpalatable crops. However, trampling damage might still occur, particularly when the buffer zone is not wide enough. Lastly, the technical skills and efforts to plant, cultivate and harvest these alternative crops should be comparable to the typical low-input agriculture that is widespread in Central Africa. If not, increased capacity building and support is needed to make them competitive with common crops.

3.7 Alternative activities and benefits from wildlife conservation

Alternative activities to agriculture might include handcrafts, beekeeping, ecotourism benefits, harvesting of non-timber forest products, and payments for ecosystem services (Wright *et al.*, 2016; Wicander & Coad, 2018). These income generating activities often are conducted not as an alternative but as a complement to farming activities. Ideally benefits should be linked to wildlife conservation or related activities, but this is overall challenging.

Some argue that natural resource use (e.g., trophy hunting, ecotourism, timber and non-timber forest product usage) can positively influence local attitudes and perceptions of resource users. More research is needed to establish links between distribution of revenue and conservation activities.

Improving livelihoods through human-elephant conflict mitigation through agroforestry and beekeeping in Northern Republic of Congo

V. H. Kandza, AJSEC

Problem statement and objective

Conflict over elephant conservation is common in Northern Congo. In the Likouala Department, east and north of the Nouabale-Ndoki National Park (PNNN), forest elephant poaching is extremely prevalent. Nevertheless, forest elephants come into conflict with people, and impact human livelihoods, particularly through crop raiding. Mitigation measures are largely absent. The *Association des Jeunes pour l'éducation et la Sauvegarde des Éléphants au Congo* (AJSEC) therefore initiated a human-elephant conflict project aiming to: 1) provide alternative income opportunities for local and indigenous communities with an emphasis on elephant poachers; 2) test various mitigation methods around a permanent agroforestry plot, most notably beehives; and 3) provide access to environmental education and awareness-raising information related to forest elephants.

Approach

The project was conducted between the logging town of Thanry-Congo and the local village of Makao-Linganga in the northeast of PNNN. After consultation meetings with village authorities and elders, the chief of the village selected 15 young hunters, nine Bayaka (indigenous or foragers) and six Bantus (farmers). This selection was based on specific criteria such as courage, good knowledge of the forest (knowing trees species useful for elephants, knowing fruit availability season). Therefore, training and working with these young men also allowed the project to collect more detailed information about elephant poaching in the area. This information made it possible to define a new strategy through awareness and the promotion of agroforestry activities as a new alternative income and food supply opportunity. AJSEC taught the young hunters new methods to grow crops and manage beehives, including diverse species to be grown and specific methods to increase production. Women were employed to harvest the crops and to sell the excess harvest to nearby towns. Additionally, AJSEC emphasized the urgency and the fundamental need to protect forest elephants and enhance biodiversity, including their ecological value for forest regeneration.

Equipment and farming technique

This sustainable agricultural approach made it possible to grow many different plant species (e.g., manioc, pineapple, bananas, trees) and set up beehives in the same area to produce food and honey for a long period. Nine species of crops and nine trees species have been cultivated. Surrounding the cultivated land, 80 beehives have been placed. Plants, tubers and seeds were bought in Brazzaville and transported to the project area. Basic equipment was provided to famers, including wheelbarrows, shovels, hoes, rakes, machetes, a chainsaw and an outboard motor. They also constructed a small storage house. The first part of the project (cleaning the land) was finalised at the end of July 2019. This was followed by the installation of the beehives and the planting of crops and trees species between August and September 2019. The first harvest of tomatoes and vegetables occurred in October 2019. Thereafter, the harvest of different crops species will continue until December 2020. The harvest of different fruits species will start around September 2020.

3.8 Preventing and mitigating impacts in the conflict zone

The aspect of prevention and mitigation of human-wildlife conflict has been the subject of many manuals and tools (Nelson *et al.*, 2003; Osei-Owusu & Bakker, 2008; Gross, 2019). Again, it is important to emphasize that prevention and mitigation methods should be used in combination and with flexibility at different spatial scales as elephants quickly become accustomed to these mitigation methods. Unfortunately, there is a paucity of monitoring data on the effectiveness of these measures, particularly in Central Africa. Most often they are applied in isolation from other important tools of human-wildlife conflict. However, a set of tools (e.g., toolbox) should be provided (Hoare, 2015; Nguinguiri *et al.*, 2017; Shaffer *et al.*, 2019; Snyder & Rentsch, 2020) so that they can be applied in combination or rotated as wildlife – especially elephants – can quickly learn to overcome a single tool used in isolation. Ideally, a mixture of both passive (e.g., fencing) and active (e.g., guarding) interventions should be applied.

Traditionally, the use of mitigation strategies has been relatively uncommon in Central Africa; even basic guarding is not done regularly (Barnes, 1996; Lahm, 1996; Walker, 2010; Fairet, 2012; Nsonsi *et al.*, 2018). Despite a willingness to apply prevention and mitigation measures, existing strategies where they exist are often inadequate and ineffective. Furthermore, the lack of trust in wildlife authorities makes farmers reluctant to apply proposed prevention and mitigation methods. Most often prevention and mitigation measures are implemented by individual farmers, but there is a clear need for cooperation and sharing of responsibilities.

The involvement of local people in the development of prevention and mitigation strategies is crucial to the success of all sustainable prevention and mitigation measures and should therefore be based on local knowledge and be specific to the species and area concerned (Snyder & Rentsch, 2020). Such measures emphasize existing positive aspects of human-wildlife relationships. When tools are simple and creative, their long-term usage and success is much higher than when they are based on external and expensive ideas.

New prevention and mitigation techniques are emerging, ranging from guarding, repelling, fencing and many more. Many different methods have recently been summarized in the FAO (United Nations Food and Agriculture Organization) and CIRAD (*Centre de Coopération Internationale en Recherche Agronomique pour le Développement*) human-wildlife conflict toolbox (FAO *et al.*, 2014). Only a selection of some of the more recent applications is presented here as case studies (Angoran, 2016; Nguinguiri *et al.*, 2017).

Many of these deterrence tools and mitigation techniques have been applied in Central African countries but most of them are not well documented (Nsonsi, n.d.; Madzou, 1999; Ongognongo *et al.*, 2006; Walker, 2010; Fairet, 2012; Ngama *et al.*, 2016, 2018; Nsonsi *et al.*, 2018). There is a clear need for detailed species-specific information of the success of mitigation tools in different local situations. If deterrents are coupled with tangible benefits (e.g., honey in the case of beehives or pepper in the case of chili-pepper fences or bombs), communities are more likely to become engaged over the long term, thereby increasing the likelihood of human-wildlife co-existence (Hedges & Gunaryadi, 2010; Le Bel, 2015; King *et al.*, 2017; Branco *et al.*, 2019).

We can draw some conclusions and formulate recommendations on these mitigation methods based on the factors impacting vulnerability to crop raiding. For example, we know that crop raiding (not trampling damage) is not random and takes place when crops are ripening, thus most mitigation efforts (e.g., guarding) should take place when the likelihood of raids is highest (e.g., when crops are ripening). Please note that other wildlife might raid crops during other periods of the crop growth cycle.

Recently, the application of mitigation measures, particularly the use of bees and chili to deter elephants, has been conducted in Gabon on fruiting trees. When testing the use of beehives, even though elephants could adjust their feeding strategies to overcome the bee threat by feeding at night, bees have been found able to recruit more fighters and grow their colonies. The ability of bees to defend hives from elephants depends on multiple environmental factors. For that, farmers need to manage their beehives to reach an optimum level enabling bees to effectively deter elephants and produce honey. This includes protecting beehives against predators, which is not an easy task.

A Human-Wildlife Conflict Mitigation Toolkit for Central Africa

S. Ngama, IRAF-CENAREST and T. Breuer, WWF Germany

Content of the toolkit

Based on the lack of information on methods to mitigate human-wildlife conflict in Central Africa and the need of the *Commission des Forêts d'Afrique Centrale* (COMIFAC) and the *Réseau des Aires Protégées d'Afrique Centrale* (RAPAC) to provide tools to conservation practitioners, a Human-Wildlife Conflict Mitigation Toolkit (FAO *et al.*, 2014) has been developed by FAO, CIRAD, Awely and various partners (Le Bel *et al.*, 2016; Nguinguiri *et al.*, 2017). The toolkit is a device which includes five documents gathered in a canvas bag:

- 1. A **Wildlife Book** presenting the 17 animal taxa occurring in Central Africa that come in conflict with people;
- 2. A **Conflict Booklet** presenting the five main types of impact caused by animals, consequences on communities and introducing ways of human-wildlife co-existence;
- 3. The **Solution Book** bringing together various practical solutions planned to (i) prevent conflicts, (ii) block access to wildlife, (iii) repel wildlife and (iv) remove the most dangerous animals;
- 4. The **Law Book** introducing the national legislation related to wildlife protection in Cameroon, Gabon, and Central African Republic;
- 5. The **Evaluation Notebook** offering a monitoring and evaluation strategy for human-wildlife conflict.

An application in Gabon

In Gabon, some trials have been performed, all focused on human-elephant conflict. FAO promoted this tool in collaboration with CIRAD, the Ministry in Charge of Wildlife and the NGO *Fruitière Numérique*. They organized a capacity-building session to train local artisans on the manufacture and use of low-cost pepper dispensers as a repellent method. ANPN tested the

efficiency of chili bullets and straps in different parks and obtained mixed results for chili bullets and better crop protection effects with chili straps. The *Institut de Recherches Agronomiques et Forestières* of the *Centre National de la Recherche Scientifique et Technologique* (IRAF-CENAREST) started to assess the use of beehives in the Gamba complex of protected areas with satisfactory results.

To monitor the use of the toolkit, KoBoCollect, an Android application, offers an interesting alternative for collecting and transmitting information in real time. The NGO WCS (Wildlife Conservation Society) assessed the use of the KoBoCollect tool in *Monts de Cristal* National Park and obtained satisfactory results. However, local communities mostly do not use Android smartphones.

Lessons learned

Obviously, the FAO toolkit still needs to be spread among the farmers who most need it and solutions need to be adapted according to site specificities. A lack of effective tools and low technical capacity are significant issues for the staff of protected areas and wildlife services who are supposed to assist farmers in addressing human-wildlife conflict. COMIFAC, RAPAC and the respective national agencies should be involved either via the implementation of national strategies or through monitoring activities.

The lack of on the ground activities and funds to implement the toolkit remain a further challenge. In that regard, the toolkit needs further improvement. For example, it would be useful to include a community training book and/or books of solutions according to each animal species in conflict with people. Standing alone, the toolbox cannot simply be applied. It is also clear that it needs to be fully adapted to any local context. In this regard, it is important to provide more in-depth details related to rainforest wildlife, as many of the examples are only useful for the savanna ecosystem and link to other sources of information.

We strongly recommend that other tools are needed to complement this mitigation toolkit, as improvement of tolerance and human-wildlife co-existence needs to be achieved, and this requires a holistic approach.

Web link: https://ur-forets-societes.cirad.fr/outils/boite-a-outil-bo-chf

When using beehives, it is important to take all safety measures and evaluate where to place hives. African bees are known for their aggressiveness and the risk they pose to human health. Using beehives will benefit both humans and elephant conservation if properly managed and maintained.

As a biological strategy, the use of beehives presents many challenges including: i) parasites and diseases which diminish honey production and could also have a negative effect on the efficiency of beehives as elephant deterrents; ii) bee stings which could discourage people from practicing beekeeping; iii) the inability to maintain beehives at the optimum activity level could lead to a failure of the hive to deter elephants. Given these challenges, people must master beekeeping and be properly trained to successfully use beehives, and more research is necessary to test the ability of hives to deter elephants in plantations.

Use of chili pepper to mitigate human-elephant conflict in the Gamba Complex, Southeast Gabon

S. Ngama, IRAF-CENAREST

Problem statement

To prevent elephant damage on crops, the use of chili is promoted under different forms (unpalatable crop, burning bricks, chili guns, chili bombs, chili bullets, etc.) as a non-lethal method. As the Gamba complex, in Southeast Gabon, is one of the human-elephant conflict hotspots, low tech devices using chili to keep elephants away from fruiting mango trees were tested. In this experiment, we were particularly interested to understand how forest elephants react to devices using chili pepper as a deterrent based on sequential camera trap photos (Ngama *et al.*, 2018).

Approach

The experimental approach consisted in using three different simple devices, which could target three different elephant senses: 1) bottles filled with the chili pepper concentrate, and hung on mango trees to release the smell of chili in order to disturb and then prevent elephants from collecting and eating mango fruits; 2) bottles filled with chili pepper hung on wired fences to reach the elephant's face and eyes in order to prevent them from entering an area; 3) chili pepper concentrate coated onto mango fruits to force elephants to collect and eat chili pepper, or avoid and leave mango fruits.

Results and lessons learned

The chili pepper device that resulted in splashing concentrate on the elephant's face proved to be the most effective at deterring elephants. Surprisingly, chili pepper concentrate directly applied to mango fruits did not deter elephants from eating the fruits, although it caused discomfort. To make effective deterrent devices with chili pepper, results from this trial suggest focusing on exploring practices to reach elephants' faces with the least, safest quantity of chili pepper with a sufficiently strong painful deterrent effect. Eye exposure to chili pepper produces intense tearing. This might explain why even at the first device the elephants reversed while challenging the chili fence. The young elephant that received chili pepper in its face never came again in contact with the fence and no more contact events were recorded there.

These results also explain why failures have been recorded in other places in Gabon where chili pepper guns have been used. When elephants are approaching a crop field, it requires courage for guarding people to target the animal face. Moreover, as elephants mostly raid on crops during night times, this is obviously too difficult, even impossible to locate, target and reach it face.

Permanent and mobile fences can be used for fencing as a mitigation option. Mobile fences are suitable for small farms, particularly farms which are mobile due to slash-and-burn practices. Fencing might be particularly useful around permanent fields or even around villages, but also potentially around the island protected areas. An electrical fence has been established around Akagera National Park in Rwanda, and a stone wall fence system is practiced around Virunga National Park in DRC and Volcano National Park in Rwanda to prevent wildlife from moving out of the protected area.

Practical human-elephant conflict mitigation: lessons learned from first test to beehives in Gabon

S. Ngama, IRAF-CENAREST

Context

The use of beehives to protect plantations has successfully reduced elephant damage on crops in many savanna areas throughout Africa (King *et al.*, 2009, 2011, 2017; Goodier & King, 2017; Branco *et al.*, 2019; Scheijen *et al.*, 2019). Beekeeping has the additional advantage of producing honey, potentially diversifying and increasing the livelihoods of local farmers. While promising, this method needs further research because no comparable work has been conducted on forest elephants or with *Apis mellifera adansonii*, the only species of African honey bee in Central Africa. The trials presented here had two objectives: (1) experimentally examining whether the presence of the African honey bee species present in Central Africa deters forest elephants from feeding on fruit trees; (2) assessing whether local communities could adopt the strategy on using beehives to both protect their crops and enhance their livelihoods (Ngama *et al.*, 2016).

Methods and results

We conducted trials with local people to adopt modern beekeeping around Monts de Cristal National Park and in the Gamba Complex. Ten villages were involved, and residents were sensitized on the importance of bees and modern beekeeping. Technical, financial and human limitations were considered by setting trials according to available resources. Thus, fruit trees were used to set beehives (two beehives per tree) instead of plantations which would require more material (about hundred beehives per site). The trial involved governmental agencies (IRAF-CENAREST, ANPN), local companies (Colas-Gabon, Shell-Gabon) and non-governmental actors (WCS, Smithsonian Institution).

The trials did not allow a direct assessment of human-elephant conflict. Yet about 150 people were trained on beekeeping with twenty of them receiving beekeeping equipment in Monts de Cristal National Park. Most of the people trained adopted modern beekeeping. Results from the Gamba Complex showed that beehives colonized by *Apis* bees can be effective elephant deterrents, but people must actively manage hives to maintain bee colonies at the optimum activity level which enables bee colonies to deter elephants and produce honey.

Lessons learned

Beekeeping is a promising initiative to reduce human-elephant conflict and enhance local people´s livelihoods in Central Africa and supports conservation activities. For that, we must transfer the necessary knowledge and technologies to local people. Modern beekeeping has many advantages: 1) benefits for the preservation of local wild bee colonies, as modern beekeeping prevents traditional honey harvests leading to the destruction of wild bee colonies, 2) benefits for agriculture production through pollination, 3) protection of sites against elephants, 4) may generate additional revenues.

Akagera Park electric fence to mitigate human-wildlife conflict

E. Hakizumwami, Independent consultant

Context

Founded in 1934, Akagera National Park once covered over 2,500 km^2. In 1997 it was reduced in size by close to 50% to provide land for refugees. Unfortunately, wildlife such as buffaloes, elephants, hippos (*Hippopotamus amphibius*), wild pigs and baboons (*Papio* sp.) were raiding crops and farmers had problems holding them down.

Solution

In 2013, the Rwanda Development Board (RDB) inaugurated an electric fence to reduce human-wildlife conflict in the area and to bring to an end life, crop and livestock losses due to animals straying from the park. Officials hope that it will also end poaching, which has led to the loss of some animal species. The fence was commissioned by the Government of Rwanda and cost over US$2.5 million.

It stretches along 120 km on the southern and western boundary of the park. It has 1.8 m high-line of metallic posts with 8 horizontal electrified wires. The posts support a mesh to allow higher resistance and the passage of small animals like rodents. The fence is powered with solar energy. Nine fence attendants' houses have been built, spaced approximately 20 km apart, which also serve as bases for the solar equipment. Akagera Management Company currently has 42 fence attendants patrolling the entire fence line on a daily basis.

Results

The fence is substantially reducing human-wildlife conflict on the boundary of the park while helping to reduce incidents of poaching inside the park. The establishment of the fence also marked an important step towards the re-introduction of lions (*Panthera leo*) and black rhinos (*Diceros bicornis*) into Akagera. The fence is reducing crop and livestock losses, which previously had led to food shortages in the districts neighbouring the park.

Piloting an electric fence design for mitigating elephant crop raiding in Northern Congo

T. M. Brncic, WCS Congo.

Problem statement and tested solution

Forest elephants regularly range around the village of Bomassa, around the Nouabale-Ndoki National Park. People are unable to successfully farm without an effective method of protecting their fields. Previous attempts at mitigation included cable fences with chili grease, burning chili bricks, beehive fences, and night guarding with a gun (to fire in the air), all with limited success and lack continued use by the community (Madzou, 1999; Ongognongo, 2006; Nsonsi, n.d.). Following the successful implementation of two solar-powered electric fences to protect research camps in PNNN against persistent elephant raids, WCS piloted a 4-ha community agriculture project to evaluate the potential benefits of this system to prevent crop-raiding by elephants. The fence was installed in June 2019. The design includes 85 cm-long flexible electrified barbs. These barbs aim to prevent elephants from touching the trees or breaking the wire with their non-conductive tusks. In order to avoid theft of materials, a custom-built cage was welded and planted in a cement base to house the equipment. Live large trees (>25 cm

diameter where possible) were used as posts to avoid financial and labor costs of installing and maintaining posts, and to make it difficult for elephants to push them over. The fence was electrified on the day of installation and has remained on at all times since. Fifteen camera traps were installed around the field to evaluate elephants' responses over time.

Installation and maintenance costs

Fixed costs (approximately US$1,550) are one-off installation costs (e.g., fence charger, solar battery, solar panel, ground rods, airfreight of materials, etc.) that are the same whether the fence is 200 m or 50 km long. Per-meter costs are dependent on the final length of the fence (e.g. wire, insulators, and labor to clear the fence line) : in this case US$2.3/m. The maintenance costs included a participant hired by the community at US$50 per month to check the fence daily for faults and make minor repairs when necessary. Extra labor was hired on one occasion to cut back vegetation outside the fence line and several times to remove tree falls (approx. US$100 in the first year). The replacement costs for the entire system would likely be incurred after 5-10 years. In total, in the first year, installation costs were approximately US$3,450, with US$700 of maintenance costs for 825 m of fence protecting approximately 4 ha of agricultural land. Assuming a 5-year equipment life, the total cost per year would be US$1,390 (US$350/ha) and thus US$23/yr or just over US$2/month/participant.

Involvement of communities

Request for participation by community members was high and the land was divided into 59 small plots of 25 m x 25 m for 58 families. Participants took responsibility for helping set up the fence, clearing, planting and weeding their own plots. Most participants gathered for one hour each week to rake the fence line and agreed to contribute 1,000 FCFA per month to hire a community member to check the fence daily, and save for repairs. Families with more limited financial means contributed to the weekly sweeping.

Preliminary results

As of May 2020, there have been zero elephant incursions or damage inside the trial plot. All elephants who received a shock immediately fled. Participants have already harvested maize, peanuts, manioc leaves and some manioc tubers. Consequently, several participants declared they would be willing to increase their monthly contribution if necessary. Many participants have requested an expansion of the project, indicating that they would ideally like to farm 3-4 times as much area and would be willing to increase their monthly contribution accordingly.

Solar-powered electrical fencing around parts of protected areas is also now being applied successfully in Gabon (Avomo Ndong, 2017) and Northern Congo. However, in general, such measures are too expensive, difficult to maintain and likely largely ineffective within a larger landscape when there is a lack of strong financial and political community and governmental commitments. However, it should be clear that, most often, fencing only solves human-wildlife conflict locally as it shifts problems elsewhere.

Most successful crop harvests throughout the region are performed by local farmers implementing a mix of locally based methods and actively guarding their fields. To achieve these results, they use both acoustic and visual systems such as beating empty barrels and putting fires around farms to chase away elephant raiders. However, these measures are not viable in the long-term as they are time consuming and require the continual presence of farmers.

Furthermore, elephants quickly get used to such techniques. A better understanding of the usage of the environment by forest elephants might help to find solutions. For example, mitigation strategies could use steep slopes as an elephant deterrent, but implementation of the strategy would differ at small and large scales (Ngama *et al.*, 2019). At the small scale, the most effective strategy might be to incorporate topography with other deterrents such as encircling fields on steep slopes with wire fences. Such methods could be easily implemented by local farmers themselves. However, on flat terrain where hillsides do not exist, dirt walls could be built around fields, mimicking the skid trail walls that were effective in deterring elephants. More details about the potential and practicality of using steep fields as an elephant deterrent could be found in the mentioned literature.

3.9 Compensations and insurance schemes

Compensation is a payment to "compensate" a monetary loss of property (crops, infrastructure, livestock, etc.) as a direct result of a wildlife conflict (Nyhus *et al.*, 2003, 2005; Ravenelle & Nyhus, 2017). Compensation payments might be related to species-specific schemes (e.g., elephants, large carnivores, etc.) or related to any activity (e.g., crop raiding). Generally speaking, compensation for losses has not been very successful in practice (Nsonsi, n.d.; Morrison *et al.*, 2009; Fairet, 2012; Hoare, 2012, 2015; Barua *et al.*, 2013; Shaffer *et al.*, 2019; Umuziranenge, 2019). However, many locals state compensation as a priority. Wherever they occur in Central Africa, national compensation schemes appear to be largely ineffective. Compensations are cumbersome and slow to administer, insufficient and are often delayed for months and occasionally even years. Mostly, public funds are not enough to cover all compensation claims. There are various flaws that include: slow administration, so that people must wait for a long time before receiving a payment; unfair payments, as most often only a fraction of the actual value of the loss is paid and payments might be given to some but not all claimants.

Insurance system for crop damage caused by animals in Odzala-Kokoua National Park

A. Edé, APN

Assessment of the problem and the solution tested

In the Republic of the Congo, the State is supposed to pay compensation for damage caused by protected wildlife (Decree No. 06/970 of 1986). However, this system is not working in the field. Faced with the distress of rural communities, the managers of Odzala-Kokoua National Park decided to set up an insurance scheme to help the people who were most affected and depended on their fields for their livelihoods. This system was not, however, intended to replace the role of the State, which remains responsible for crop compensation payments.

An insurance fund was created with the support of partners such as the European Union, and thanks to members who pay a membership fee of 2,500 FCFA/ha/year (about US$4/ha/year) to insure their fields. When there is damage, policyholders notify park managers, who come to draw up a damage report. Compensation is calculated proportionally in relation to several parameters: the damage (based on Decree 06/970), the state of the fields, and the farmer's monitoring efforts. Policyholders are then compensated twice a year.

Following difficulties encountered during the first four years of operation, a new insurance program was set up. It is no longer based on Decree 06/970, which had a compensation scale that was outdated and unsuitable, and it defines more appropriate and simplified compensation rules. The maximum payment (200,000 FCFA/ha) is reached when the sum of the devastated areas is equal to or surpasses 25% of the field size; below that, the policyholder is compensated according to the severity of the damage, up to a maximum of 100,000 FCFA/ha.

Results and lessons learned

This insurance scheme provides monetary compensation for damage while seeking to encourage the most appropriate behavior. However, it faces many problems. First, it is not financially self-sufficient. Second, to register the reports, significant human resources and means of transportation are required. This insurance system also can have perverse effects and encourage communities to not protect their fields. Furthermore, communities do not necessarily understand the complicated insurance process, particularly the calculation of payments. This renders the process opaque and raises the possibility of corruption, misuse of funds and tribalism, and policyholders sometimes accuse the management team of being involved in such practices. Lastly, the reaction of communities may not be commensurate with the actual damage, and some villages may complain that they have not been sufficiently compensated compared to other villages.

To overcome these problems, the following is needed: 1) effective awareness-raising about how the insurance system works with the support of government officials; 2) a capacity to rapidly record damage reports; 3) the use of a standard damage assessment method that has been approved by members; 4) the use of a simple compensation system that is understood by the majority of members and which they can follow up with receipts of damage reports provided by the management team; and 5) the system must encourage practices to resolve human-wildlife conflict and be able to guarantee the amount of compensation. Without all of these parameters, it is highly likely that the insurance system will have a negative impact on human-wildlife relations around protected areas. If misunderstood, this system also could reduce community support for conservation.

Compensations are difficult to manage, particularly over large landscapes, since it is often impossible to attribute a loss (e.g., crop raiding) to a specific species. Often wildlife and/or agriculture authorities are not reliable and come late when signs of damage are no longer visible. Obviously, they are open to considerable abuse and fraudulent claims or blatant corruption. Illiterate farmers have difficulties submitting claims. Some studies point out that representatives from the agricultural ministry are notoriously absent in the field, do not use accurate assessment methods and that claims are not processed for years and most of them are not paid. When they are paid out to some (not all), this might cause resentment or social problems among recipients.

Since they do not tackle the underlying causes of human-wildlife conflict, compensations can result in sloppy livestock and crop protection practices and do not promote co-existence. Some authors even argue that at worst compensations exacerbate human-wildlife conflicts. In the worst case, compensations might have the unintended consequence of subsidizing agricultural expansion and might increase the conflict between people when only a few, and not all people, receive compensations. Finally, compensation and efforts to address tangible costs might have little impact on farmers' tolerance to co-exist with elephants, particularly when intangible costs influence tolerance levels more than tangible costs.

To overcome these challenges, various locally managed insurance schemes have emerged (Morrison *et al.*, 2009; Chen *et al.*, 2013; Wilson-Holt & Steele, 2019). To improve the effectiveness of compensation schemes, clear guidelines must be elaborated that address the conditions of payments. The administrative burden should be kept to a minimum to allow quick payments, and the system should be flexible to include new rules. A monitoring scheme must be in place that allows time effective validation of claims. Payments should reflect levels of losses and should be made within a short timeframe after verification of the damage/loss.

Damage and losses must by verified through systematic and proven methods to avoid mistakes and subjectivity, and to raise confidence in compensation decisions. Lastly, a certain level of local ownership is needed to reduce abuse. More recently, community-based micro-insurance systems have been introduced around protected areas in Central Africa.

3.10 Killing of problem animals and translocations

The killing and translocation of problem elephants are far more challenging to carry out than other response measures and are therefore only considered after all other measures have failed (Fernando *et al.*, 2012; Hoare, 2015; Shaffer *et al.*, 2019). This is because of the heavy logistics involved and the difficulty to efficiently target the real problem animals.

Performing killings or translocations of problem animals are risky activities which require the intervention of specialized teams and heavy logistics. Moreover, they only relocate the issue rather than solving it. Transferring problem animals to other locations will surely transfer the issue to that new location, and is thus futile. In addition, the killing of problem elephants has always been reported as being a useless strategy in mitigating human-elephant conflict. Retaliation killings of problem elephants usually do not target the right animals. After a crop raiding event, the animal(s) responsible usually move far away from the site, and it is impossible to be 100% sure that the real problem animal has been identified and targeted. When group of elephants is involved, it is even more difficult to identify the right problem elephant.

3.11 Transforming the conflict by increasing tolerance through awareness and community engagement

It is important to recognize that it is crucial not only to mitigate the conflict, but also more importantly to change human behavior to achieve human-wildlife co-existence (Madden & McQuinn, 2014, 2017; Frank, 2016; Kansky *et al.*, 2016; Nyhus, 2016; Frank *et al.*, 2019), and human-elephant co-existence in particular (Hoare & Du Toit, 1999; Guerbois *et al.*, 2013; Gross, 2019; Shaffer *et al.*, 2019). Co-existence can be defined as "a dynamic but sustainable state in which humans and wildlife co-adapt to live in shared landscapes governed by effective institutions that ensure long-term wildlife population persistence, social legitimacy, and

tolerable levels of risk" (König *et al.*, 2020). The participation and engagement of local communities is crucial for any human-wildlife conflict approach and the success of such a transformation process (Madden, 2004; Treves *et al.*, 2006, 2009).

Tolerance in the context of human-wildlife conflict can be defined as the ability of an individual to absorb the potential or actual costs of living with wildlife. To increase tolerance, we first need a complete understanding of the factors impacting tolerance. Recent research findings are demonstrating that tangible (monetary) costs have little impact on people's attitudes. Intangible costs, on the other hand, seem to be driving tolerance for co-existence with wildlife (Saif *et al.*, 2020).

Various activities can help to increase local tolerance, ranging from knowledge increase, reducing intangible costs, and increasing intangible benefits. Essentially, awareness raising should aim to revert hostility and increase levels of tolerance and pro-conservation behavior (Espinosa & Jacobson, 2012). Where forest elephants occur, it is important to provide knowledge on their natural behavior and their historic distribution. Raising community awareness of the conflict and the ecological role of wildlife in general and of elephants is crucial to increase tolerance among local people, whether they reside around an isolated protected area or within an intact landscape with free-ranging forest elephants.

Helping people to understand historical and current distribution will help to raise understanding of the danger (and associated tangible costs) of establishing new farms in elephant habitats and will lower expectations of mitigation strategies. This knowledge gain might be particularly relevant for recent immigrants who have not experienced long-term co-existence with elephants, for example on the danger of close encounters with elephants to reduce life-threatening contact with elephants in the forest and around farms. Awareness raising can happen from a young age, for example in rural schools or in nature clubs (Breuer & Mavinga, 2010), but also with targeted focus group discussions, such as meetings with farmers, local natural resource use communities and underrepresented groups such as women and minorities. Finally, informal and formal leaders, including local, regional and national decision-makers, must be particularly informed.

Next, activities can aim to reduce the costs of living with wildlife. Above, we have described various prevention and mitigation activities that can potentially reduce the monetary costs of co-existence, particularly when they are based on strong community support and are combined with alternative income-generating activities that are likely to be successful (beehives and chili pepper). To reduce intangible costs, various activities such as the creation of specialized teams might ultimately lead to increased tolerance, which include collective management of risks and income-generating activities. Farmers will have enough sleep and can focus their efforts on farming activities. Thus, to achieve such attitude changes and encourage co-existence, it is crucial that local communities are involved from

the start of a human-wildlife project. This would also concern increased ownership for wildlife and protected area management through participation in decision making. Engagement is only possible when local communities take ownership of the project and help to develop and decide relevant interventions.

Ideally, locally led conflict resolution committees made up of local stakeholders should be created instead of inactive national wildlife and protected area authorities. Such committees can help to share knowledge, identify strategies to change perceptions, and principally help to manage natural resources in a sustainable way by pooling their resources. Potential solutions can be based on existing positive interactions with and attitudes towards elephants. Similarly, when compensations or insurance systems are based on local ownership and local financial contributions, there is a much better chance that they will be accepted among the local stakeholders.

3.12 Integrated landscape management

Human-wildlife conflict must be addressed at various spatial scales. Land-use planning helps to address the causes of the conflict and goes beyond treatment of the symptoms (mitigation strategies, compensations, etc.). A landscape-based approach (some of them transboundary) has been promoted in Central Africa where people and wildlife share resources (Angu *et al.*, 2011). Integrating human-wildlife conflict programs into such an approach is considered as one of the greatest long-term activities to increase human-elephant co-existence (Osborn & Parker, 2003; Dublin & Hoare, 2004; Walker, 2010; Fairet, 2012). Such an exercise will involve the input of many stakeholders with the aim to protect key forest elephant habitats and natural resources while simultaneously considering people's needs for space to secure their livelihoods. Protecting key areas for elephants, creating buffer zones, and investing in alternative land uses can be some of the successful solutions.

Large landscapes will allow natural movements of forest elephants, allowing them to use more space which will reduce locally high elephant numbers and potentially extreme conflict zones. Identification and creation of wildlife corridors between high density zones, such as protected areas or high conservation value forest within logging concessions, is of crucial importance in this land-use exercise. This planning concerns elephants that move out of isolated protected areas and come into conflict with riverine communities and farms in the vicinity of the protected area border. In that case, land-use planning including wide buffer zones (e.g., planted with unpalatable crops such as medical herbs or chili) can be an option. For example, a buffer zone with forest plantations (eucalyptus and acacia) and tea plantations has been set up around Nyungwe National Park in Rwanda.

Taking into consideration elephant needs within a landscape is much more challenging as we have little understanding about their seasonal movements. Detailed knowledge on wildlife behavior (where available) needs to be included in such planning and zoning exercises as in the case of savanna elephants (Graham *et al.*, 2009; Granados *et al.*, 2012; Bastille-Rousseau *et al.*, 2020; Snyder *et al.*, 2020). For example, we must consider the wide-ranging nature of forest elephants and particularly the explorative behavior of younger male elephants.

Settlements and farms should not be created along known elephant paths, close to natural forest clearings (*bais*) and salt licks and should not disturb migration corridors to seasonal available fruiting trees. Any planning should model how potential habitat changes and losses of high conservation value forest impact forest elephant distribution.

The success of any planning exercise will be based on a government's commitment. Too often, we have seen that existing land-use plans are not respected and are not included in legislation and policy. Despite the existence of inter-ministerial exchange committees, the different ministries often do not consult each other, resulting in land use overlaps; mining concessions are overlapping with protected areas and/or large oil palm or timber concessions are attributed without consultation of relevant stakeholders (Javelle, 2012; Schwartz *et al.*, 2012). Improvement of the legal framework related to land-use planning and reforms is currently taking place in some and is starting in other Central Africa countries. This is particularly important as Central Africa is undergoing rapid changes due to major development corridors, and the building of infrastructure for mining and timber operations, as well as large scale agricultural and palm oil production in the near future.

5. Conclusion

Human-wildlife conflict is undoubtedly one of the main threats to conservation in Central Africa, along with the destruction of habitats and the commercial hunting of wildlife to supply markets with bushmeat. It is a real challenge for governments, wildlife managers, conservation and development organizations and local communities.

Human-elephant conflict has long existed, and sometimes is the result of human encroachment into elephant habitats. It is not, as is often mistakenly stated, due to a natural increase in elephant populations. These are only increasing when the last remaining elephants that have not been exterminated are pushed back into areas where they feel less threatened by poaching.

Conflict can have substantial monetary and non-monetary costs and mitigation measures are often absent or ineffective. Addressing this conservation challenge is very complex, and has a strong emotional and political dimension as the conflict is the outcome of a combination of human and elephant behaviors as well as social aspects related to human-human relationships where the elephant becomes a symbol of the overall conservation conflict.

Given the fact that overall, the conflict arises due to encroachment of people into former wildlife habitats such as elephant migration corridors, it is impossible to expect that wildlife will disappear, and the conflict cannot be mitigated to zero levels. Instead, people should try to get used to co-existing as much as possible with wildlife. To achieve co-existence where conflict occurs, a holistic human-wildlife conflict program needs to be set up that integrates social and biological sciences. Such a program should look beyond simple impact mitigation measures and aim to understand the various dimensions of the conflict. Protected area managers in Central Africa are encouraged to set up holistic approaches such a "SAFE" system, which can be beneficial for the overall acceptance of their conservation work (see Appendix 1).

Beyond elephants, the success of human-wildlife conflict management also will require the characterization of agricultural activities and local strategies for the control of other animals known to be crop pests in the surroundings of protected areas (buffaloes, baboons, carnivores, rodents, etc.). Although much is being done by COMIFAC and some national agencies and partners to address this issue, much remains to be done in order to cover equally different types of ecosystems (rainforests, dry forests and woodlands, as well as savannas) and different key species involved in human-wildlife conflicts.

Bibliography

Agam A. & Barkai R., 2018. Elephant and mammoth hunting during the Paleolithic: a review of the relevant archaeological, ethnographic and ethno-historical records. *Quaternary* 1: 3.

Angoran E.J., 2016. Human-Wildlife conflict management toolbox: feedback from the field test in Crystal Mountain national park (Gabon). *Nature & Faune* 30(2): 89–92.

Angu K., Tchamou N. & Yanggen D. (Eds.), 2011. Landscape-Scale conservation in the Congo Basin: lessons learned from the Central African Regional Program for the Environment (CARPE). IUCN, Gland, Switzerland.

ANPN., 2016. Projet de gestion de la faune et des conflits homme-élephant dans le sud du Gabon : Cadre fonctionnel pour la réduction des impacts sociaux potentiels dus à la restriction potentielle d'accès aux ressources naturelles dans les parcs nationaux de Waka, de Moukalaba-Doudou, de Loango et de Mayumba. ANPN, Libreville, Gabon.

Arlet M.E. & Molleman F., 2007. Rodents damage crops more than wildlife in subsistence agriculture on the northern periphery of Dja Reserve, Cameroon. *International Journal of Pest Management* 53: 237–243.

Asaha S. & Deakin L., 2016. Land-use change and its influence on rural livelihoods, food security and biodiversity conservation in the Southwest region of Cameroon. *In* : Deakin L., Kshatriya M. & Sunderland T. (Eds.), Agrarian change in tropical landscapes. CIFOR, Bogor, Indonesia: 54-90.

Avomo Ndong S.S., 2017. Human-wildlife conflict and ecotourism: comparing Pongara and Ivindo National Parks in Gabon. Master thesis, University of Oregon, USA: 155 p.

Barnes R.F.W., 1996. The conflict between humans and elephants in the Central African forests. *Mammal Review* 26: 67–80.

Barnes R.F.W., 1999. Is there a future for elephants in West Africa? *Mammal Review* 29: 175–199.

Barnes R.F.W., 2002. Treating crop-raiding elephants with Aspirin. *Pachyderm* 33: 96–99.

Barnes R.F.W., Azika S. & Asamoah-Boateng B., 1995. Timber, cocoa, and crop-raiding elephants: a preliminary study from southern Ghana. *Pachyderm* 19: 33–38.

Barnes R.F.W., Hema E.M., Nandjui A., Manford M., Dubiure U.-F., Danquah E.K.A. & Boafo Y., 2005. Risk of crop raiding by elephants around the Kakum Conservation Area, Ghana. *Pachyderm* 39: 19–25.

Barnes R.F.W.W., Danquah E., Hema E.M., Dubiure U.-F., Manford M., Nandjui A. & Boafo Y., 2015. Retrospective versus prospective designs for studies of crop raiding by elephants. *Pachyderm* 1: 44–50.

Barua M., Bhagwat S.A. & Jadhav S., 2013. The hidden dimensions of human–wildlife conflict: Health impacts, opportunity and transaction costs. *Biological Conservation* 157: 309–316.

Bastille-Rousseau G., Wall J., Douglas-Hamilton I., Lesowapir B., Loloju B., Mwangi N. & Wittemyer G., 2020. Landscape-scale habitat response of African elephants shows strong selection for foraging opportunities in a human dominated ecosystem. *Ecography* 43: 149–160.

Bauer H., 2003. Local perceptions of Waza National Park, northern Cameroon. *Environmental Conservation* 30: 175–181.

Bauer H., De Iongh H. & Sogbohossou E., 2010. Assessment and mitigation of human-lion conflict in West and Central Africa. *Mammalia* 74: 363–367.

Baynham-Herd Z., Redpath S., Bunnefeld N. & Keane A. 2020. Predicting intervention priorities for wildlife conflicts. *Conservation Biology* 34: 232–243.

Baynham-Herd Z., Redpath S., Bunnefeld N., Molony T. & Keane A., 2018. Conservation conflicts: Behavioural threats, frames, and intervention recommendations. *Biological Conservation* 222: 1801–188.

Beirne C., Meier A.C., Brumagin G., Jasperse-Sjolander L., Lewis M., Masseloux J., Myers K., Fay M., Okouyi J., White L.J.T. & Poulsen J.R., 2020. Climatic and resource determinants of forest elephant movements. *Frontiers in Ecology and Evolution* (early view).

Bennett N.J., Roth R., Klain S.C., Chan K., Christie P., Clark D.A., Cullman G., Curran D., Durbin T.J., Epstein G., Greenberg A., Nelson M.P., Sandlos J., Stedman R., Teel T.L., Thomas R., Veríssimo D. & Wyborn C., 2017a. Conservation social science: Understanding and integrating human dimensions to improve conservation. *Biological Conservation* 205: 93-108.

Bennett N.J., Roth R., Klain S.C., Chan K.M.A., Clark D.A., Cullman G., Epstein G., Nelson M.P., Stedman R., Teel T.L., Thomas R.E.W., Wyborn C., Curran D., Greenberg A., Sandlos J. & Veríssimo D., 2017b. Mainstreaming the social sciences in conservation. *Conservation Biology* 31: 56–66.

Berzaghi F., Longo M., Ciais P., Blake S., Bretagnolle F., Vieira S., Scaranello M., Scarascia-Mugnozza G. & Doughty C.E., 2019. Carbon stocks in central African forests enhanced by elephant disturbance. *Nature Geoscience* 12(2): 725–729.

Blake S., 2002. *The ecology of forest elephant distribution and its implications for conservation*. PhD Dissertation, University of Edinburgh, Edinburgh, U.K.: xii + 308 p.

Blake S., Deem S.L., Mossimbo E., Maisels F. & Walsh P.D., 2009. Forest elephants: tree planters of the Congo. *Biotropica* 41: 459–468.

Boafo Y., Dubiure U.-F., Danquah E.K.A., Manford M., Nandjui A., Hema E.M., Barnes R.F.W. & Bailey B., 2004. Long-term management of crop raiding by elephants around Kakum Conservation Area in southern Ghana. *Pachyderm* 37: 68–72.

Bobo K.S. & Weladji R.B., 2011. Wildlife and land use conflicts in the Mbam and Djerem conservation region, Cameroon: status and mitigation measures. *Human Dimension of Wildlife* 16: 445–457.

Boukoulou H., Mbete P., Mbete R., Ngokaka C., Akouango F., Klaid Rhaysaint Excelh B. & Vouidibio J., 2012. Conflit Homme/Eléphant : étude de cas dans le village Miélékouka au nord du Parc national d'Odzala Kokoua (Congo). *Journal of Applied Bioscience* 50: 3478–3484.

Branco P.S., Merkle J.A., Pringle R.M., King L., Tindall T., Stalmans M. & Long R.A., 2019. An experimental test of community-based strategies for mitigating human–wildlife conflict around protected areas. *Conservation Letters* 13(1): e12679.

Brand C.M., Johnson M.B., Parker L.D., Maldonado J.E., Korte L., Vanthomme H., Alonso A., Ruiz-Lopez M.J., Wells C.P. & Ting N., 2020. Abundance, density, and social structure of African forest elephants (*Loxodonta cyclotis*) in a human-modified landscape in southwestern Gabon. *PLoS One* 15: e0231832.

Breuer T., Bout N., Fishlock V. & Maisels F., 2015. Protecting bais and elephants: law enforcement and anti-poaching. *In* : Fisklock V. & Breuer T. (Eds.), Studying forest elephants.. Neuer Sportverlag, Stutgard, Germany: 72-83.

Breuer T., Maisels F. & Fishlock V., 2016. The consequences of poaching and anthropogenic change for forest elephants. *Conservation Biology* 30: 1019–1026.

Breuer T. & Mavinga F.B., 2010. Education for the conservation of great apes and other wildlife in Northern Congo - The importance of nature clubs. *American Journal of Primatology* 72: 454–461.

Brooks A., 2019. SAFE System approach to Human-Wildlife Conflict Management. WWF Tigers Alive, WWF International, Gland, Switzerland.

Bush E.R., Whytock R.C., Bahaa-el-din L., Bourgeois S., Bunnefeld N., Cardoso A.W., Dikangadissi J.T., Dimbonda P., Dimoto E., Edzang Ndong J., Jeffery K.J., Lehmann D., Makaga L., Momboua B., Momont L.R.W., Tutin C.E.G., White L.J.T., Whittaker A. & Abernethy K., 2020. Long-term collapse in fruit availability threatens Central African forest megafauna. Science, 0.1126/science.abc7791.

Chardonnet P. (Ed.), 2002. Conservation of the African Lion : contribution to a status survey. International Foundation for the Conservation of Wildlife, Paris, France & Conservation Force, USA: 171 p.

Chen S., Yi Z.F., Campos-Arceiz A., Chen M.Y. & Webb E.L., 2013. Developing a spatially-explicit, sustainable and risk-based insurance scheme to mitigate human-wildlife conflict. *Biological Conservation* 168: 31–39.

Chiyo P.I. & Cochrane E.P., 2005. Population structure and behaviour of crop-raiding elephants in Kibale National Park, Uganda. *African Journal of Ecology* 43: 233–241.

Chiyo P.I., Cochrane E.P., Naughton L. & Basuta G.I., 2005. Temporal patterns of crop raiding by elephants: A response to changes in forage quality or crop availability? *African Journal of Ecology* 43: 48–55.

Chiyo P.I., Moss C.J. & Alberts S.C., 2012. The influence of life history milestones and association networks on crop-raiding behavior in male african elephants. *PLoS One* 7: e31382.

Chiyo P.I., Moss C.J., Archie E.A., Hollister-Smith J.A. & Alberts S.C., 2011. Using molecular and observational techniques to estimate the number and raiding patterns of crop-raiding elephants. *Journal of Applied Ecology* 48: 788–796.

Clark C.J., Poulsen J.R., Malonga R. & Elkan P.W., 2009. Logging concessions can extend the conservation estate for central African tropical forests. *Conservation Biology* 23: 1281–1293.

Compaore A., Sirima D., Hema E.M., Doamba B., Ajong S.N., Di Vittorio M. & Luiselli L., 2020. Correlation between increased human-elephant conflict and poaching of elephants in Burkina Faso (West Africa). *European Journal of Wildlife Research* 66: 24.

Crawford A., 2012. Conflict-sensitive conservation in Nyungwe National Park: conflict analysis. International Institute for Sustainable Development, Winnipeg, Manitoba, Canada.

Davies T.E., Wilson S., Hazarika N., Chakrabarty J., Das D., Hodgson D.J. & Zimmermann A., 2011. Effectiveness of intervention methods against crop-raiding elephants. *Conservation Letters* 4: 346–354.

Dickman A.J., 2010. Complexities of conflict: the importance of considering social factors for effectively resolving human-wildlife conflict. *Animal Conservation* 13: 458–466.

Dublin H.T. & Hoare R.E., 2004. Searching for solutions: the evolution of an integrated approach to understanding and mitigating human–elephant conflict in Africa. *Human Dimensions of Wildlife* 9: 271–278.

Edwards D.P., Sloan S., Weng L., Dirks P., Sayer J. & Laurance W.F., 2014. Mining and the African environment. *Conservation Letters* 7: 302–311.

Espinosa S. & Jacobson S.K., 2012. Human-wildlife conflict and environmental educatione evaluating a community program to protect the Andean Bear in Ecuador. *Journal of Environmental Education* 43: 55–65.

Eyebe A.J., Dkamela G.P. & Endamana D., 2012. Overview of human wildlife conflict in Cameroon. Poverty and Conservation Learning Group Discussion Paper No 5. IIED.

Fairet E.M.M., 2012. Vulnerability to crop-raiding: an interdisciplinary investigation in Loango National Park. PhD Thesis, Faculty of Social Sciences and Health, Department of Anthropology, Durham University, U.K..

FAO, CIRAD & Awely, 2014. Boîte à outil d'atténuation des conflits homme-faune. FAO, Libreville, Gabon, CIRAD, Montpellier, France & Awely, Orléans, France. https://ur-forets-societes.cirad.fr/outils/boite-a-outil-bo-chf

Fernando P., Kumar A.M., Williams C.A., Wikramanayake E., Aziz T. & Singh S.M., 2008. Review of human-elephant conflict mitigation measures practiced in South Asia. WWF International, Gland, Switzerland.

Fernando P., Leimgruber P., Prasad T. & Pastorini J., 2012. Problem-elephant translocation: translocating the problem and the elephant? *PLoS One* 7: e50917.

Fishlock V., Lee P.C. & Breuer T., 2008. Quantifying forest elephant social structure in Central African bai environments. *Pachyderm* 44: 17–26.

Fishlock V. & Turkalo V., 2015. Studying elephant behaviour at bais. *In* : Fishlock, V. & Breuer, T. (Eds.), Studying forest elephants. Neuer Sportverlag, Stuttgart, Germany: 106-117.

Frank B., 2016. Human–Wildlife conflicts and the need to include tolerance and coexistence: an introductory comment. *Society and Natural Resources* 29: 738–743.

Frank B., Glikman J.A. & Marchini S. (Eds.), 2019. Human-Wildlife Interactions: Turning Conflict into Coexistence. Cambridge University Press, Cambridge, U.K..

Fraser-Celin V.L., Hovorka A.J. & Silver J.J., 2018. Human conflict over wildlife: exploring social constructions of African wild dogs (*Lycaon pictus*) in Botswana. *Human Dimensions of Wildlife* 23: 341–358.

Fritz H., 2017. Long-term field studies of elephants: understanding the ecology and conservation of a long-lived ecosystem engineer. *Journal of Mammalogy* 98: 603–611.

Gladman T., Redpath S.M., Vedeld P.O., van Eeden L., Pascual U., Sherren K. & Murata C., 2020. Non-material costs of wildlife conservation to local people and their implications for conservation interventions. *Biological Conservation* 246: [108578].

Goswami V.R., Medhi K., Nichols J.D. & Oli M.K., 2015. Mechanistic understanding of human-wildlife conflict through a novel application of dynamic occupancy models. *Conservation Biology* 29: 1100–1110.

Graham M.D., Douglas-Hamilton I., Adams W.M. & Lee P.C., 2009. The movement of African elephants in a human-dominated land-use mosaic. *Animal Conservation* 12: 445–455.

Graham M.D., Notter B., Adams W.M., Lee P.C. & Ochieng T.N., 2010. Patterns of crop-raiding elephants, *Loxodonta africana*, in Laikipia, Kenya, and the management of human–elephant conflict. *Systematics and Biodiversity* 8: 435–445.

Granados A., Weladji R. & Loomis M., 2012. Movement and occurrence of two elephant herds in a human-dominated landscape, the Bénoué Wildlife Conservation Area, Cameroon. *Tropical Conservation Science* 5: 150–162.

Granados A. & Weladji R.B., 2012. Human-Elephant Conflict Around Bénoué National Park, Cameroon: Influence on Local Attitudes and Implications for Conservation. *Human Dimensions of Wildlife* 17: 77–90.

Gross E.M., Lahkar B.P., Subedi N., Nyirenda V.R., Lichtenfeld L.L. & Jakoby O., 2018. Seasonality, crop type and crop phenology influence crop damage by wildlife herbivores in Africa and Asia. *Biodiversity and Conservation* 27: 2029–2050.

Gross E.M., McRobb R. & Gross J., 2016. Cultivating alternative crops reduces crop losses due to African elephants. *Journal of Pest Science* 89: 497–506.

Gross E.V., 2019. *Tackling routes to coexistence Human-elephant conflict in sub-Saharan Africa*. GIZ, Bonn, Germany.

Guerbois C., Chapanda E. & Fritz H., 2012. Combining multi-scale socio-ecological approaches to understand the susceptibility of subsistence farmers to elephant crop raiding on the edge of a protected area. *Journal of Applied Ecology* 49: 1149–1158.

Guerbois C., Dufour A.B., Mtare G. & Fritz H., 2013. Insights for integrated conservation from attitudes of people toward protected areas near Hwange National Park, Zimbabwe. *Conservation Biology* 27: 844–855.

Gunaryadi D., Sugiyo & Hedges S., 2017. Community-based human-elephant conflict mitigation: The value of an evidence-based approach in promoting the uptake of effective methods. *PLoS One* 12: e0173742.

Gunn J., Hawkins D., Barnes R.F.W., Mofulu F., Grant R.A. & Norton G.W., 2014. The influence of lunar cycles on crop-raiding elephants; evidence for risk avoidance. *African Journal of Ecology* 52: 129–137.

Hartter J., 2009. Attitudes of rural communities toward wetlands and forest fragments around Kibale National Park, Uganda. *Human Dimensions of Wildlife* 14: 433–447.

Hatchwell M., 2014. Public-private partnerships as a management option for protected areas. *Animal Conservation* 17: 3–4.

Hedges S. & Gunaryadi D., 2010. Reducing human–elephant conflict: do chilies help deter elephants from entering crop fields? *Oryx* 44: 139–146.

Hill C.M., 1998. Conflicting attitudes towards elephants around the Budongo Forest Reserve, Uganda. *Environmental Conservation* 25: 244–250.

Hill C.M., 2004. Farmers' perspectives of conflict at the wildlife–agriculture boundary: some lessons learned from African subsistence farmers. *Human Dimensions of Wildlife* 9: 279–286.

Hill C.M., 2017. Understanding human-wildlife interventions. *In*: Hill C.M., Webber A.D. & Priston N.E.C. (Eds.), Understanding conflicts about wildlife: a biosocial approach. Berghahn Books, New York, USA and Oxford, U.K.: 1-14.

Hill C.M., 2018. Crop foraging, crop losses, and crop raiding. *Annual Review of Anthropology* 47: 377–394.

Hoare R., 1999. A training package for enumerators of elephant damage. IUCN African Elephant Specialist Group Report.

Hoare R., 2000a. African elephants and humans in conflict: the outlook for co-existence. *Oryx* 34: 34–38.

Hoare R.E., 2000b. Data collection and analysis protocol for Human-Elephant conflicts situation in Africa. A document prepared for the IUCN African Elephant Specialist Group's Human-Elephant Conflict working group. IUCN and WWF International, Gland, Switzerland: 41 p.

Hoare R., 2012. Lessons from 15 years of human elephant conflict mitigation: management considerations involving biological, physical and governance issues in Africa. *Pachyderm* 51: 60–74.

Hoare R., 2015. Lessons from 20 years of human–elephant conflict mitigation in Africa. *Human Dimensions of Wildlife* 20: 289–295.

Hoare R.E. & Du Toit J.T., 1999. Coexistence between people and elephants in African savannas. *Conservation Biology* 13: 633–639.

Inogwabini B.-I., Mbende L., Bakanza A. & Bokika J.C., 2014. Crop-damaging by elephants at Malebo, Democratic Republic of Congo: ecological correlates and financial implications for conservation programs. *Pachyderm* 54: 59–65.

IUCN., 2015. Central African elephant conservation strategy. IUCN SSC African Elephant Specialist Group: 40 p.

Jackson T.P., Mosojane S., Ferreira S.M. & van Aarde R.J., 2008. Solutions for elephant *Loxodonta africana* crop raiding in northern Botswana: moving away from symptomatic approaches. *Oryx* 42: 83–91.

Jadhav S. & Barua M., 2012. The Elephant vanishes: impact of human-elephant conflict on people's wellbeing. *Health Place* 18: 1356–1365.

Javelle A.G., 2012. Managing Land for Mining and Conservation in the Democratic Republic of Congo. WRI, Washington DC.

Kamiss A. & Turkalo A., 1999. Elephant Crop Raiding in the Dzanga-Sangha Reserve, Central African Republic. GIZ & WCS, Bangui, CAR.

Kansky R., Kidd M. & Knight A.T., 2016. A wildlife tolerance model and case study for understanding human wildlife conflicts. *Biological Conservation* 201: 137–145.

Kansky R. & Knight A.T., 2014. Key factors driving attitudes towards large mammals in conflict with humans. *Biological Conservation* 179: 93–105.

King L.E., Lala F., Nzumu H., Mwambingu E. & Douglas-Hamilton I., 2017. Beehive fences as a multidimensional conflict-mitigation tool for farmers coexisting with elephants. *Conservation Biology* 31: 743–752.

Kleinschroth F., Gourlet-Fleury S., Sist P., Mortier F. & Healey J.R., 2015. Legacy of logging roads in the Congo Basin: How persistent are the scars in forest cover? *Ecosphere* 6(4): 1-17.

Kleinschroth F. & Healey J.R., 2017. Impacts of logging roads on tropical forests. *Biotropica* 49: 620–635.

Kleinschroth F., Laporte N., Laurance W.F., Goetz S.J. & Ghazoul J., 2019. Road expansion and persistence in forests of the Congo Basin. *Nature Sustainability* 2: 628–634.

Kofi Sam M., Danquah E.K.A., Oppong S.K. & Ashie E.A., 2005. Nature and extent of human-elephant conflict in Bia Conservation Area, Ghana. *Pachyderm* 38: 49–58.

Köhler A., 2005. Of apes and men: Baka and Bantu attitudes to wildlife and the making of eco-goodies and baddies. *Conservation and Society* 3: 407–435.

König H.J., Kiffner C., Kramer-Schadt S., Fürst C., Keuling O. & Ford A.T., 2020. Human-wildlife coexistence in a changing world. *Conservation Biology* (early view).

Lahm S.A., 1996. A nationwide survey of crop-raiding by elephants and other species in Gabon. *Pachyderm* 21: 69–77.

Lamarque F., Anderson J., Fergusson R., Lagrange M., Osei-Owusu Y. & Bakker L., 2009. Human-wildlife conflict in Africa. Causes, consequences and management strategies. FAO Forest Paper.

Lambini C.K., Bayer J., Beyer T., Engelbrecht K., Hokan M., Kiewitt Y., Mielich N. & Stöbesand H., 2019. Conflicts, participation and co-management in protected areas: A case study of Lobéké National Park, Cameroon. SLE Publication Series (S279), Berlin.

Laporte N.T., Stabach J.A., Grosch R., Lin T.S. & Goetz S.J., 2007. Expansion of industrial logging in Central Africa. *Science* 316(5830): 1451.

Laurance W.F., Croes B.M., Tchignoumba L., Lahm S.A., Alonso A., Lee M.E., Campbell P. & Ondzeano C., 2006. Impacts of roads and hunting on Central African rainforest mammals. *Conservation Biology* 20: 1251–1261.

Laurance W.F., Sloan S., Weng L. & Sayer J.A., 2015. Estimating the environmental costs of Africa's massive "development corridors". *Current Biology* 25: 3202–3208.

Le Bel S., 2015. Repelling elephants with a chilli pepper gas dispenser: Field tests and practical use in Mozambique, Zambia and Zimbabwe from 2009 to 2013. *Pachyderm* 56: 87–96.

Le Bel S., Chavernac D. & Stansfield F., 2016. Promoting a mobile data collection system to improve HWC incident recording: a simple and handy solution for controlling problem animals in Southern Africa. *In* : Angelici F.M. (Ed.), Problematic wildlife: a cross-disciplinary approach. Springer, Stutgart, Germany & New York, USA: 395-411.

Lee P.C. & Graham M.D., 2006. African Elephants *Loxodonta africana* and human-elephant interactions: implications for conservation. *International Zoo Yearbook* 40: 9–19.

Mackenzie C.A. & Ahabyona P., 2012. Elephants in the garden: financial and social costs of crop raiding. *Ecological Economics* 75: 72–82.

Madden F., 2004. Creating coexistence between humans and wildlife: global perspectives on local efforts to address Human–Wildlife conflict. *Human Dimensions of Wildlife* 9: 247–257.

Madden F. & McQuinn B., 2014. Conservation's blind spot: The case for conflict transformation in wildlife conservation. *Biological Conservation* 178: 97–106.

Madden F. & McQuinn B., 2017. Conservation conflict transformation: Addressing the missing link in conservation. *In* : Hill C.M., Webber A.D. & Priston N.E.C. (Eds.), Understanding Conflicts about Wildlife: a biosocial approach. Berghahn Books, New York, USA and Oxford, U.K.: 170-193.

Madzou Y., 1999. Situation conflictuelle des éléphants à Bomassa: un défi pour la gestion de la zone périphérique du Parc National de Nouabalé-Ndoki, Nord Congo. WCS, Bomassa, Congo.

Maisels F., Blake S. & Turkalo A., 2002. Wild forest elephants shake down fruit and leaves from trees. *Pachyderm* 33: 88–90.

Maisels F., Strindberg S., Blake S., *et al.*, 2013. Devastating decline of forest elephants in central Africa. *PLoS One* 8: e59469.

Mills E.C., Poulsen J.R., Fay M.J., Morkel P., Clark C.J., Meier A., Beirne C. & White L.J.T., 2018. Forest elephant movement and habitat use in a tropical forest-grassland mosaic in Gabon. *PLoS One* 13: e0199387.

Molina-Vacas G., Muñoz-Mas R., Martínez-Capel F., Rodriguez-Teijeiro J.D. & Le Fohlic G., 2020. Movement patterns of forest elephants (*Loxodonta cyclotis* Matschie, 1900) in the Odzala-Kokoua National Park, Republic of Congo. *African Journal of Ecology* 58: 23–33.

Momont L., Breuer T. & Schuttler S., 2015. Forest elephant ranging and habitat use. *In* : Fishlock V. & Breuer T. (Eds.), Studying forest elephants.. Neuer Sportverlag, Stuttgart, Germany: 132-139.

Moran B., 2019. Akagera National Park, Rwanda. National Geographic. https://www.nationalgeographic.com/environment/2019/05/akagera-national-park-rwanda-conservation/

Morrison K., Victurine R. & Mishra C., 2009. Lessons learned, opportunities and innovations in Human Wildlife conflict compensation and insurance schemes. WCS TransLinks Programme.

Mumby H.S. & Plotnik J.M., 2018. Taking the elephants' perspective: Remembering elephant behavior, cognition and ecology in human-elephant conflict mitigation. *Frontiers in Ecology and Evolution* 6: 122.

Muruthi P., 2005. Human wildlife conflict: lessons learned from AWF's African heartlands. African Wildlife Foundation, Washington DC, USA.

N'Goran K.P., Nzooh Dongmo Z.L. & Le-Duc Y.S., 2016. The status of forest elephant and great apes in Central Africa priority sites. WWF Biomonitoring report, Yaounde, Cameroon.

Naughton-Treves L., 1998. Predicting patterns of crop damage by wildlife around Kibale National Park, Uganda. *Conservation Biology* 12: 156–168.

Naughton-Treves L. & Treves A., 2005. Socio-ecological factors shaping local support for wildlife: crop-raiding by elephants and other wildlife in Africa. *In* : Woodroffe R., Thirgood S. & Rabinowitz A. (Eds.), People and wildlife: conflict or coexistence?.. Cambridge University Press, Cambridge, U.K.: 252-277.

Naughton J., Rose R. & Treves A., 1999. The social dimensions of human-elephant conflict in Africa: a literature review and case studies from Uganda and Cameroon. Gland, Switzerland.

Nchanji A.C. & Lawson D.P., 1998. A survey of elephant crop damage around the Banyang-Mbo wildlife sanctuary, 1993-1996. WCS, Yaounde, Cameroon.

Nelson A., Bidwell P. & Sillero-zubiri C., 2003. A review of human-elephant conflict management strategies. People and Wildlife, Wild CRU and Born Free Foundation Partnership.

Ngama S., Bindelle J., Poulsen J.R., Hornick J.L., Linden A., Korte L., Doucet J.L. & Vermeulen C., 2019. Do topography and fruit presence influence occurrence and intensity of crop-raiding by forest elephants (*Loxodonta africana cyclotis*)? *PLoS One* 14: e0213971.

Ngama S., Korte L., Bindelle J., Vermeulen C. & Poulsen J.R., 2016. How bees deter elephants: beehive trials with forest elephants (*Loxodonta africana cyclotis*) in Gabon. *PLoS One* 11: e0155690.

Ngama S., Korte L., Johnson M., Vermeulen C. & Bindelle J., 2018. Camera traps to study the forest elephant's (*Loxodonta cyclotis*) response to chili pepper repellent devices in Gamba, Gabon. *Nature Conservation Research* 3: 26–35.

Nguinguiri J.C., Czudek R., Larrubia C.J., Ilama L., Le Bel S., Angoran E.J., Trébuchon J.-F. & Cornelis D., 2017. Managing human-wildlife conflicts in central and southern Africa. *Unasylva* 68: 39–44.

Nsonsi F. (n.d.). Développement d'un modèle de gestion durable et intégrée du conflit Homme-Eléphant à la périphérie du Parc National de Nouabalé-Ndoki. University of Kinshasa, DRC.

Nsonsi F., Heymans J.-C., Diamouangana J. & Breuer T., 2017. Attitudes towards forest Elephant conservation around a protected area in Northern Congo. *Conservation and Society* 15: 59–73.

Nsonsi F., Heymans J.-C., Diamouangana J., Mavinga F.B. & Breuer T., 2018. Perceived human-elephant conflict and its impact for elephant conservation in northern Congo. *African Journal of Ecology* 56: 208–215.

Nyhus P., Fischer H., Madden F. & Osofsky S., 2003. Taking the bite out of wildlife damage. The challenges of wildlife compensation schemes. *Conservation in Practice* 4: 37–43.

Nyhus P.J., 2016. Human–Wildlife conflict and coexistence. *Annual Review of Environment and Resources* 41: 143–171.

Nyhus P.J., Osofsky S.A., Ferraro P., Madden F. & Fischer H., 2005. Bearing the costs of human–wildlife conflict: the challenges of compensation schemes. *In*: Woodroffe R., Thirgood S. & Rabinowitz A. (Eds.), People and Wildlife, Conflict or Co-existence? . Cambridge University Press, Cambridge, U.K.: 107-121.

Oerke E.C., 2006. Crop losses to pests. *Journal of Agricultural Science* 144: 31–43.

Ongognongo B., Ekoutouba D.B. & Stokes E.J., 2006. Conflit homme-éléphant dans la périphérie du Parc National de Nouabalé-Ndoki au nord Congo: evaluation des méthodes de lutte contre la dévastation des champs de manioc par les éléphants dans le village de Bomassa. WCS, Bomassa, Congo.

Osborn F.V., 2004. Seasonal variation of feeding patterns and food selection by crop-raiding elephants in Zimbabwe. *African Journal of Ecology* 42: 322–327.

Osborn F.V. & Parker G.E., 2003. Towards an integrated approach for reducing the conflict between elephants and people: a review of current research. *Oryx* 37: 80–84.

Osborn F.V., 2003. Seasonal influence of rainfall and crops on home range expansion by bull elephants. *Pachyderm* 35: 53–59.

Osei-Owusu Y., 2018. Technical manual: Human-wildlife conflict - elephants. UNEP African Elephant Fund and Conservation Alliance International.

Osei-Owusu Y. & Bakker L., 2008. FAO Conflit Homme-Animal: Eléphant Manuel Technique. FAO, Rome.

Parathian H.E., McLennan M.R., Hill C.M., Frazão-Moreira A. & Hockings K.J., 2018. Breaking through disciplinary barriers: Human–Wildlife interactions and multispecies ethnography. *International Journal of Primatology* 39: 749–775.

Parker G.E., Osborn F.V., Hoare R.E. & Niskanen L.S., 2007. Human-elephant conflict mitigation: a training course for community-based approaches in Africa - participant's manual Assessment. Livingstone, Zambia and Nairboi, Kenya.

Peterson M.N., Birckhead J.L., Leong K., Peterson M.J. & Peterson T.R., 2010. Rearticulating the myth of human-wildlife conflict. *Conservation Letters* 3: 74–82.

Pooley S., Barua M., Beinart W., Dickman A., Holmes G., Lorimer J., Loveridge A.J., Macdonald D.W., Marvin G., Redpath S., Sillero-Zubiri C., Zimmermann A. & Milner-Gulland E.J., 2017. An interdisciplinary review of current and future approaches to improving human–predator relations. *Conservation Biology* 31: 513–523.

Poulsen J.R., Koerner S.E., Moore S., Medjibe V.P., Blake S., Clark C.J., Akou M.E., Fay M., Meier A., Okouyi J., Rosin C. & White L.J.T., 2017. Poaching empties critical Central African wilderness of forest elephants. *Current in Biology* 27: 134–135.

Poulsen J.R., Rosin C., Meier A., Mills E., Nuñez C.L., Koerner S.E., Blanchard E., Callejas J., Moore S. & Sowers M., 2018. Ecological consequences of forest elephant declines for Afrotropical forests. *Conservation Biology* 32: 559–567.

Pozo R.A., Coulson T., McCulloch G., Stronza A.L. & Songhurst A.C., 2017. Determining baselines for human-elephant conflict: A matter of time. *PLoS One* 12: e0178840.

Ravenelle J. & Nyhus P.J., 2017. Global patterns and trends in human–wildlife conflict compensation. *Conservation Biology* 31: 1247–1256.

Redpath S.M., Gutiérrez R.J., Wood K.A. & Young J.C. (Eds.), 2015. Conflicts in conservation - navigating towards solutions. Cambridge University Press, Cambridge, U.K..

Redpath S.M., Young J., Evely A., Adams W.M., Sutherland W.J., Whitehouse A., Amar A., Lambert R.A., Linnell J.D.C., Watt A. & Gutiérrez R.J., 2013. Understanding and managing conservation conflicts. *Trends in Ecology and Evolution* 28: 100–109.

Rode K.D., Chiyo P.I., Chapman C.A. & McDowell L.R., 2006. Nutritional ecology of elephants in Kibale National Park, Uganda, and its relationship with crop-raiding behaviour. *Journal of Tropical Ecology* 22: 441–449.

Saif O., Kansky R., Palash A., Kidd M. & Knight A.T., 2020. Costs of coexistence: understanding the drivers of tolerance towards Asian elephants *Elephas maximus* in rural Bangladesh. *Oryx* (early view).

Salerno J., Bailey K., Gaugham A.E., Stevenes F.R., Hilton T., Cassidy L., Drake M.D., Pricope N.G. & Hartter J., 2020. Wildlife impacts and vunberable livelihoods in a transfrontier conservation landscape. *Conservation Biology* (early view).

Scheijen C.P.J., Richards S.A., Smit J., Jones T. & Nowak K., 2019. Efficacy of beehive fences as barriers to African elephants: A case study in Tanzania. *Oryx* 53: 92–99.

Schuttler S.G., Blake S. & Eggert L.S., 2012. Movement patterns and spatial relationships among African forest elephants. *Biotropica* 44: 445–448.

Schuttler S.G., Philbrick J.A., Jeffery K.J. & Eggert L.S., 2014. Fine-scale genetic structure and cryptic associations reveal evidence of kin-based sociality in the African forest elephant. *PLoS One* 9: e88074.

Schwartz B., Hoyte D. & Nguiffo H.S., 2012. Emerging Trends in Land-Use Conflicts in Cameroon: Overlapping Natural Resource Permits Threaten Protected Areas and Foreign Direct Investment. WWF CARPO, Yaounde, Cameroun.

Setchell J.M., Fairet E., Shutt K., Waters S. & Bell S., 2017. Biosocial Conservation: Integrating Biological and Ethnographic Methods to Study Human–Primate Interactions. *International Journal of Primatology* 38: 401–426.

Shaffer L.J., Khadka K.K., Van Den Hoek J. & Naithani K.J., 2019. Human-elephant conflict: A review of current management strategies and future directions. *Frontiers in Ecology and Evolution* 6: 235.

Sitati N.W., Walpole M.J. & Leader-Williams N., 2005. Factors affecting susceptibility of farms to crop raiding by African elephants: using a predictive model to mitigate conflict. *Journal of Applied Ecology* 42: 1175–1182.

Sitati N.W., Walpole M.J., Smith R.J. & Leader-Williams N., 2003. Predicting spatial aspects of human-elephant conflict. *Journal of Applied Ecology* 40: 667–677.

Sitters J., Kimuyu D.M., Young T.P., Claeys P. & Olde Venterink H., 2020. Negative effects of cattle on soil carbon and nutrient pools reversed by megaherbivores. *Nature Sustainability* 3: 360–366.

Smit J., Pozo R.A., Cusack J.J., Nowak K. & Jones T., 2017. Using camera traps to study the age–sex structure and behaviour of crop-using elephants *Loxodonta africana* in Udzungwa Mountains National Park, Tanzania. *Oryx* 53: 368–376.

Snyder K.D., Mneney P., Benjamin B., Mkilindi P. & Mbise N., 2020. Seasonal and spatial vulnerability to agricultural damage by elephants in the western Serengeti, Tanzania. *Oryx* (early view).

Snyder K.D. & Rentsch D., 2020. Rethinking assessment of success of mitigation strategies for elephant-induced crop raiding. *Conservation Biology* (early view).

Songhurst A. & Coulson T., 2014. Exploring the effects of spatial autocorrelation when identifying key drivers of wildlife crop-raiding. *Ecology and Evolution* 4(5): 582-593.

Stern M.J. & Coleman K.J., 2015. The multidimensionality of trust: Applications in collaborative natural resource management. *Society and Natural Resources* 28: 117–132.

Stokes E.J., Strindberg S., Bakabana P.C., Elkan P.W., Iyenguet F.C., Madzoké B., Malanda G.A.F., Mowawa B.S., Moukoumbou C., Ouakabadio F.K. & Rainey H.J., 2010. Monitoring great ape and elephant abundance at large spatial scales: measuring effectiveness of a conservation landscape. *PLoS One* 5: e10294.

Tchamba M. & Foguekem D., 2012. Human Elephant conflict in the Waza-Logone region of Northern Cameroon: an assessment of management effectiveness. *Tropicultura* 30: 79–87.

Tchamba M.N., 1995. The problem elephants of Kaele: a challenge for elephant conservation in northern Cameroon. *Pachyderm* 19: 26–32.

Tchamba M.N., 1996. History and present status of the human/elephant conflict in the Waza-Logone region, Cameroon, West Africa. *Biological Conservaion* 75: 35–41.

Thirgood S., Woodroffe R. & Rabinowitz A., 2005. The impact of human–wildlife conflict on human lives and livelihoods. *In*: Woodroffe R., Thirgood S. & Rabinowitz A. (Eds.), People and Wildlife, Conflict or Co-existence? Cambridge University Press, Cambridge, U.K.: 13-26.

Treves A., Wallace R.B., Naughton-Treves L. & Morales A., 2006. Co-managing human–wildlife conflicts: a review. *Human Dimensions of Wildlife* 11: 383–396.

Treves A., Wallace R.B. & White S., 2009. Participatory planning of interventions to mitigate human-wildlife conflicts. *Conservation Biology* 23: 1577–1587.

Tsuru D., 1998. Diversity of ritual spirit performances among the Baka pygmies in southeastern Cameroon. *African Study Monographs Suppl.* 25: 47–84.

Turkalo A.K., Wrege P.H. & Wittemyer G., 2013. Long-Term monitoring of dzanga bai forest elephants: Forest clearing use patterns. *PLoS One* 8: e85154.

Turkalo A.K., Wrege P.H. & Wittemyer G., 2017. Slow intrinsic growth rate in forest elephants indicates recovery from poaching will require decades. *Journal of Applied Ecology* 54: 153–159.

Tyukavina A., Hansen M.C., Potapov P., Parker D., Okpa C., Stehman S. V., Kommareddy I. & Turubanova S., 2018. Congo Basin forest loss dominated by increasing smallholder clearing. *Science Advances* 4(11): eaat2993.

Umuziranenge G., 2019. Community Perceptions of Human-wildlife Conflicts and the Compensation Scheme Around Nyungwe National Park (Rwanda). *International Journal of Natural Resource Ecology and Management* 4: 188–197.

Van Bommel L., Bij De Vaate M.D., De Boer W.F. & De Iongh H.H., 2007. Factors affecting livestock predation by lions in Cameroon. *African Journal of Ecology* 45: 490–498.

Vasudev D., Goswami V.R., Hait P., Sharma P., Joshi B., Karpate Y. & Prasad P.K., 2020. Conservation opportunities and challenges emerge from assessing nuanced stakeholder attitudes towards the Asian elephant in tea estates of Assam, Northeast India. *Global Ecology Conservation* 22: e00936.

Vucetich J.A., Burnham D., Macdonald E.A., Bruskotter J.T., Marchini S., Zimmermann A. & Macdonald D.W., 2018. Just conservation: what is it and should we pursue it? *Biological Conservation* 221: 23–33.

Walker K.L., 2010. Moving away from prescriptive pachyderm palliatives : toward an integrated assessment of farmer-elephant conflict in Gabon. PhD, University of Michigan, USA: 127 p.

Walker K.L., 2012. Labor costs and crop protection from wildlife predation: the case of elephants in Gabon. *Agricultural Economics* 43: 61–73.

Wallace G.E. & Hill C.M., 2017. Engaging farmers and understanding their behaviour to develop effective deterrents to crop damage by wildlife. *In*: Hill C.M., Webber A.D. & Priston N.E.C. (Eds.), Understanding Conflicts about Wildlife: A Biosocial Approach.. Berghahn Books, New York, USA and Oxford, U.K.: 170-193.

Walpole M. & Linkie M. (Eds), 2007. Mitigating Human-Elephant Conflict: Case Studies from Africa and Asia. Fauna and Flora International, Cambridge, U.K..

Webber A.D., Hill C.M. & Reynolds V., 2007. Assessing the failure of a community-based human-wildlife conflict mitigation project in Budongo Forest Reserve, Uganda. *Oryx* 41: 177–184.

Weladji R.B. & Tchamba M.N., 2003. Conflict between people and protected areas within the Bénoué Wildlife Conservation Area, North Cameroon. *Oryx* 37: 72–79.

West P., Igoe J. & Brockington D., 2006. Parks and peoples: the social impact of protected areas. *Annual Review of Anthropology* 35: 251–277.

Wicander S. & Coad L., 2018. Can the provision of alternative livelihoods reduce the impact of wild mMeat hunting in West and Central Africa? *Conservation and Society* 16: 441–458.

Wilson-Holt O. & Steele P., 2019. Human–wildlife conflict and insurance. Can insurance reduce the costs of living with wildlife? IIED Discussion Paper, London.

Wilson S., Davies T.E., Hazarika N. & Zimmermann A., 2015. Understanding spatial and temporal patterns of human-elephant conflict in Assam, India. *Oryx* 49: 140–149.

Wright J.H., Hill N.A.O., Roe D., Rowcliffe J.M., Kümpel N.F., Day M., Booker F. & Milner-Gulland E.J., 2016. Reframing the concept of alternative livelihoods. *Conservation Biology* 30: 7–13.

WWF, 2008. Common Ground Solutions for reducing the human, economic and conservation costs of human wildlife conflict. WWF International, Gland, Switzerland.

Yackulic C.B., Strindberg S., Maisels F. & Blake S., 2011. The spatial structure of hunter access determines the local abundance of forest elephants (*Loxodonta africana cyclotis*). *Ecological Applications* 21: 1296–1307.

Young J.C., Marzano M., White R.M., McCracken D.I., Redpath S.M., Carss, D.N., Quine C.P. & Watt A.D., 2010. The emergence of biodiversity conflicts from biodiversity impacts: Characteristics and management strategies. *Biodiversity Conservation* 19: 3973–3990.

Young J.C., Thompson D.B.A., Moore P., MacGugan A., Watt A., Redpath S.M. & Stephens P., 2016a. A conflict management tool for conservation agencies. *Journal of Applied Ecology* 53: 705–711.

Young J.C., Searle K., Butler A., Simmons P., Watt A.D. & Jordan A., 2016b. The role of trust in the resolution of conservation conflicts. *Biological Conservation* 195: 196–202.

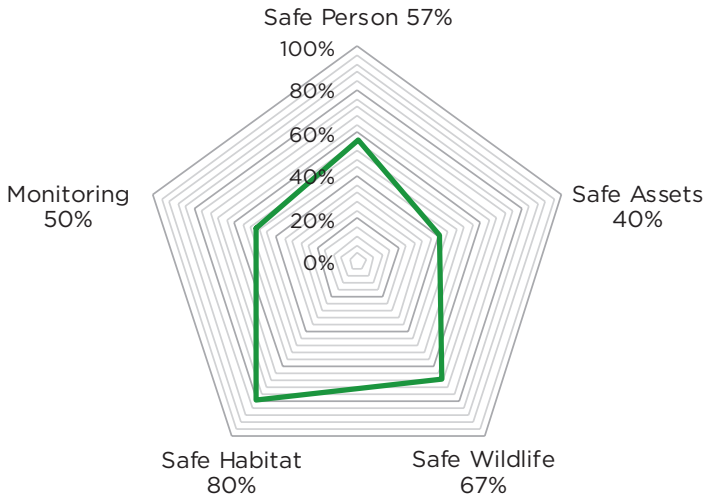
APPENDICES

Appendix 1 – The SAFE approach

A. Brooks, WWF Tigers Alive

The SAFE Approach to human-wildlife conflict is results-focused and delivered through five Strategic Outcomes: safe person, safe assets, safe wildlife, safe habitat, and effective monitoring (Brooks, 2019; Figure 2). Using lessons from global transport safety systems, this is a paradigm shift away from existing approaches to human-wildlife conflict globally. Calls are often made within human-wildlife conflict strategies to "resolve" and "mitigate" conflict, though these only address part of the problem and at only specific times of a conflict event.

Figure 2 – Example of a SAFE baseline at a site



Background and justification for the approach

Current approaches to human-wildlife conflict management are insufficient to tackle the dynamic, emotive and complex challenge of minimizing and managing human-wildlife conflict. Current approaches suffer from three critical weaknesses: 1) they have an isolated focus on the symptoms of conflict; 2) they lack coherent long-term direction; 3) there is no basis to measure progress and impact.

An isolated focus on the symptoms of conflict

Current approaches are site and context specific and are the result of many years of trial and error and are variously successful but result in minimal impact. They are readily grouped into six conflict elements: Policy, Prevention, Mitigation, Understanding the Conflict, Response and Monitoring.

While each action has served a valuable function at each site, in isolation, the actions: i) merely address symptoms of a dynamic challenge; ii) require constant fundraising; iii) do not address drivers of conflict; iv) can misdirect community and project focus onto conflict when it may only represent a relatively small component of what a community needs; v) have limited ability to impact on human progress and wildlife conservation in that area.

The lack of coherent long-term goals and direction

The current approach of dealing with symptoms is demonstrably weak as it does not coalesce around desired long-term goals nor thrust in any strategic direction that fosters co-existence into the future. Compensation, insurance schemes, or fencing for example, are merely dealing with the "current state" of a changing (social, climatic and ecological) context in an area. The actions are fundamentally limited in their ability to build a "better" future for people and wildlife in that space.

Without a coherent long-term direction that accounts for people, their assets, wildlife and their habitat, human-wildlife conflict actions are: i) having little impact on the drivers of conflict; ii) are often demonstrating false success by displacing the conflict; iii) can perpetuate the continuation of incompatible projects that only exacerbate conflict in that area (for example, where successful species recovery projects are pitted against successful small holder agroforestry expansion projects).

The lack of a basis to measure progress and impact

The focus on symptoms of conflict and the "current state" means that human-wildlife conflict actions only measure against the progress of these actions; e.g. the number of reported conflict incidents, the number of straying animals, the number of compensation claims made or the distance of electric fence installed. There is no ability to measure progress toward a "desired state" of co-existence nor to demonstrate wise investment.

The lack of a long-term goal means there is: i) no impetus to capture a baseline and therefore nothing to measure progress and impact against; ii) a lack of foundation for a long-term commitment; iii) a lack of ability to report at completion on the impact of the interventions; iv) ultimately a weak ability to argue for stronger regulatory and policy foundations in government to mainstream human-wildlife conflict.

Principles of SAFE

A SAFE approach to human-wildlife conflict provides a **holistic** view of the conflict in its entirety. It is **inclusive** in that it encompasses all the interactions between the people, their land, their livelihoods, decision-makers, commercial and government interests, and wildlife. It is **forgiving** as it accommodates human error and the "wildness" of the species involved. The SAFE System approach has four guiding principles:

1. it recognizes that all wildlife is wild, and conflict will occur. When conflicts occur however, the interventions across the system should ensure that the impact of an incident does not exceed the limits of community tolerance and does not result in retaliatory killing;
2. it stresses that individuals, communities, leaders and the public involved in the design of the system need to accept and share responsibility for the safety of the system, and those that use the system must accept responsibility for complying with the rules and constraints of the system;
3. it aligns conflict management decisions with wider development plans and processes that contribute to economic, human and environmental goals;
4. it guides interventions to meet the minimum standards and long-term goals, rather than setting specific targets.

How SAFE is delivered

A SAFE strategy and approach can be delivered through a cyclical stepwise approach (Figure 3):

Step 1. Capture existing human-wildlife conflict data and trends: local managers compile any existing information on human-wildlife conflict locally regardless if it is porous or robust. This data is used to guide the development of a stakeholder workshop.

Step 2. Managers lead a stakeholder Rapid Assessment workshop in the landscape. The outputs from the workshop are: a SAFE Baseline, a report on coverage of the six elements (Figure 4), a human-wildlife conflict monitoring plan, and actions to manage human-wildlife conflict.

Step 3. Development of the SAFE Strategy. Managers use the information and results gleaned from the Rapid Assessment workshop to formulate the strategy.

Step 4. The strategy is implemented across the site and with contribution by relevant stakeholders.

Step 5. The strategy is monitored over time, and data is collated, and trends reported back to the site. After an agreed period (e.g. 2 years), the cycle begins again with a new Rapid Assessment to assess progress and change.

Figure 3 – SAFE main steps

Figure 4 – The six elements of conflict

Implementation of a SAFE strategy should continue in the long-term and not be considered a project with a start and end date. Over time, the local human-wildlife conflict context under a SAFE system will gradually remove all the immediate risk areas and become safer for each outcome area.