ACTION PLAN FOR THE MITIGATION OF ELEPHANT-HUMAN CONFLICT IN INDIA

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Asian Nature Conservation Foundation (ANCF) is a Bangalore-based public charitable trust established in 1997, with objects relating to conservation of biodiversity across India. During the past decade, ANCF has used the Asian Elephant as the flagship species in guiding its scientific research, field surveys and assessments for a broader conservation effort, and has successfully influenced the enactment of critical legislation and policy for conserving the biodiversity wealth of the country.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF PHOTOGRAPHS

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INTRODUCTION

The official wild elephant numbers in India is estimated to be about 28,000 (Bist 2002) in 2001. Wild elephants are presently distributed over an area of about 109,500 km^2 (Santiapillai & Sukumar 2006); this is approximately 3% of India's geographical area. Adjacent to some of these areas, a segment of the elephant population killed an average of 350 people annually over the last five years (2005-2006 to 2009-2010) (Project Elephant), and damaged an average of 330 km^2 of crops every year for the last three years (2007-2008 to 2009-2010) (Project Elephant). Elephants and their habitat pay the price of conflict; while forty to fifty elephants are killed a year while crop-raiding (Johnsingh & Panwar 1992 in Williams *et al.* 2001, Project Elephant), forests are destroyed in the belief that it will prevent elephants from using the area (Ecosystems-India pers. comm.) and discontented local farmers aid poachers in killing problem wildlife (Belinda Wright[1] pers. comm., Boominathan *et al*. 2008). The Central and State Governments together spend Rs 10 to 15 crores every year on controlling elephant depredation and paying ex-gratia[2] to affected people (Bist 2002).

Protected Areas in India are estimated to form 22% of elephant habitat (Project Elephant n.d.). There are only 8 elephant populations of more than a thousand individuals each, living in large contiguous habitats; while all the others live in highly fragmented forests with much lower chances of long-term survival. While the rate of human population growth surrounding these areas is uncertain, the national annual growth rate for 1991-2001 was 1.93%[3]. While much of elephant range lies outside Protected Areas, increasing human density and intensification of pressure by humans on the same resources that elephants also need make conflict between humans and elephants almost inevitable.

Elephant-human conflict is a symptom of inappropriate land use practices such as permanent human settlements and growing irrigated food crops adjacent to elephant range lands (Lahiri-Choudhury 1991, Johnsingh & Joshua 1994, Sivaganesan & Johnsingh 1995, Hoare 2001a, Treves *et al*. 2006, IUCN 2006, Fernando *et al*. 2008). Loss or fragmentation of habitat and blocked traditional routes restrict elephants' access to forage, refuge areas, salt licks, and water. It is reported that they compensate for this loss by eating crops, while bulls in particular may take advantage of the easy availability of crops and stored grain (Sukumar 1989). Whether elephants are forced by circumstance or making the best of the opportunity, the interaction between elephants and humans sometimes leads to accidental deaths of

[1] Wildlife Protection Society of India, New Delhi

[2] Although this is the terminology used by forest officials, the dictionary meaning is 'payment made as a favour, not because one has a duty in law to do it.' Several states are bound by Government Orders to pay compensation whose rates are fixed by the State legislature.

[3] http://www.indiabudget.nic.in/es2001-02/chapt2002/chapt107.pdf

humans and deliberate poisoning, shooting or electrocution of elephants. Elephants are increasingly caught in the pincer grip of habitat loss/fragmentation and retaliation caused by increasing conflict.

Conflict drains local goodwill and creates animosity towards conservation (Madhusudan 2003). It is also an ethical issue as conservation programmes and policies worldwide declare that conservation goals cannot make poor people poorer and that they cannot be expected to bear the disproportionate costs of conservation (Walpole *et al.* 2006). Subsistence farmers and farmers with small holdings are the least able to withstand the risks posed by elephant-human conflict (Nath & Sukumar 1998), and in some extreme cases they have also been forced to abandon their farms (pers. obs. in Karnataka, Assam, Boominathan *et al*. 2008). Conflict with elephants can further marginalize already marginalized people while driving these large herbivores to take greater risks, thus jeopardizing the lives of both. While loss of crops and property damage can be quantified, the social costs to elephants and humans are incalculable. Unless timely, effective mitigation measures intervene, the conservation of elephants is in question throughout most of their range, in India and elsewhere in Asia.

There is a need for a clear policy and strategic planning to resolve elephant-human conflict and elephant conservation. The current approach to dealing with conflict has largely been ad hoc, and predisposed to failure because of inappropriate application of methods, lack of involvement of local people, lack of monitoring of conflict and conflict mitigation measures, and inadequate understanding of elephant ecology (IUCN 2006). Lack of a policy also leads to an inordinate focus on the symptoms rather than the causes of the problem. No single solution is effective and different approaches need to be integrated to address elephant-human conflict proactively (Hoare 2001b).

There are several projects and initiatives taking place around the country with little sharing of information. Wildlife managers in one state do not have access to research findings or results of mitigation measure testing being carried out in other states. This often results in ad hoc management decisions being taken. In an effort to aid wildlife managers in the field, this action plan provides current knowledge of the factors that influence conflict (Chapter 1), an assessment of the different conflict mitigation measures that have been tried (Chapter 2) and a synthesis of the two preceding sections in a decision making framework (Chapter 3).

Note: In the process of reviewing about 80 papers and reports on elephant-human conflict, about 40 emanate from studies on African elephants which also provide useful lessons.

CHAPTER 1

ECOLOGICAL DIMENSIONS OF CONFLICT

- A Review

"In the case of elephant and man we have one of the best examples known of two superficially dissimilar animals sharing common biological needs, and therefore competing vigorously whenever they contact each other." – Alistair Graham (1973).

SUMMARY

In elephant habitats that are large, homogenous and clearly defined, crop-raiding is seasonal and mostly caused by bulls; however, not all bulls crop-raid. Among crop-raiding elephants, there may be those that opportunistically raid unprotected crops and those that are forced to depend on crops for their survival. In areas where land use is a heterogenous mosaic of agriculture and forest (such as community managed forests), elephants and humans share an undifferentiated landscape, and crop-raiding by herds and bulls occurs throughout the year. These areas suffer considerably more crop-raiding as it appears to be essential to the elephants' survival (Fernando *et al*. 2005, Boominathan *et al*. 2008).

Social organization, cognition, diet, and home range influence how elephants use their habitat. Habitat loss and transformation, use of forest resources by people, poaching for ivory and retaliatory killing for crop raiding are some of the challenges facing elephant survival. However, humans sharing the landscape with elephants are more keenly aware of the destruction and damage caused to human life, property and crops. Several causes are ascribed to the crop-raiding behaviour of elephants such as the high nutritive value of crops, poor quality of forage, loss of habitat, agricultural areas being close to forests, and high density of people and elephants. To confound the situation further, the superior cognitive ability of elephants allows them to learn from experience and conspecifics. A few workers also suggest that the large body size of elephants predisposes them to raiding human-use areas and that some level of conflict is intrinsic to such areas.

The perception of conflict is shaped by extreme events, such as loss of life or livelihood. When the tolerance threshold of people affected by elephants is lowered, conflict is exacerbated. Several social parameters such as wealth, alternate income, the value of the crop, and ownership of land influence how keenly farmers feel the loss. However, there are very few such studies in India that analyze the socio-economic aspect of elephant-human conflict.

WHAT DRIVES CONFLICT?

When wild animals leave their "natural habitat," it is assumed to be aberrant behaviour and speculations about the causes, both in the media and among wildlife managers, range from increasing elephant numbers and/or density, widespread and intensifying conflict and insufficient resources within forests (Macnab 1985 in Barnes 2002). No reliable analysis indicates whether there has been an actual increase in conflict or an increase in the perception and publicity about conflict (Hoare 1999). However, as the human population increases across India, similar increases around elephant reserves is also expected to rise in tandem.

There has reportedly been an approximately 70% increase in elephant numbers countrywide between 1980 and 2002 (Project Elephant n.d.)[4], despite the loss of habitat across their range. Concurrently there has also been an increase in human mortality per year.

1. THE ELEPHANT PERSPECTIVE

Understanding the issue from the animal's perspective is the key to finding a long term solution.

1.1 Social Organization: Elephants are believed to have one of the most advanced mammalian social organizations (Sukumar 2003).

Herds: are family groups of one or two adult females (who may be siblings or offspring of the older females) and their juvenile and sub-adult offspring of both genders. The leader of the group is the oldest female of the family, the matriarch, and it was long assumed that the social organization of Asian elephants was similarly structured to the African relatives. However, a study in Sri Lanka suggests that Asian elephants do not show evidence of a complex hierarchy as known in the African savanna elephants. Observation of older females in family groups failed to establish any of them as leaders. Younger reproductive females actively defended the group and different members took leadership roles at different times (Gunawardene *et al.* 2004).

Bulls: leave the family group on reaching puberty and are generally solitary. They may associate with an older bull or other young bulls (these groups are called *maljuria* in Orissa and the Northeast) seasonally. In non-*musth* condition, the larger or older bulls are dominant but when younger or smaller bulls come into *musth* the situation is reversed (Sukumar 2003). Good nutrition and body condition are necessary for *musth* to run its course. Since the increased androgen levels cause weight loss during this period, bulls in poor body condition will not go into a full *musth* period. Females prefer to mate with *musth* bulls and therefore poor body condition puts bulls at a reproductive disadvantage (Poole 1982 in Bertschinger *et al.* 2008).

[4] Sukumar (1989) indicates that Asian elephant populations do not grow more than 2% per annum which would mean a maximum of 50% increase for the said period. The 1980 figures were probably underestimated.

In a comparative study in Sri Lanka, it was established that there was a difference between the social structures of bulls in two different areas. In Udawalawe, bulls were found in groups of 2 to 7 individuals in 59.6% of 321 encounters. In Yala, 98.4% of 172 encounters, bulls were solitary. Whether the associations between bulls is influenced by resource availability, distribution of a particular resource, over-crowding or some other unknown factor is not clear (Gunawardene *et al.* 2004) and social structure is expected to vary across habitats and populations (Sukumar 2003).

1.2 Cognition: With such large brains, elephants are capable of considerable learning. Most behaviours are learnt within a context. Being a long-lived species with a prodigious memory for individuals and events, they have a perception of history. Elephant herds display remarkable fidelity to their home range which they circumnavigate annually. They appear to return to a particular area at the same time every year, sometimes precise to the nearest week (Sukumar 2003)! Where home ranges overlap, there is a temporal separation in habitat use by competing herds or clans. African elephants are known to recognize differences between ethnic communities of people in their range and vary their reactions accordingly (Bates *et al*. 2007).

1.3 Diet: Adult Asian elephants spend anywhere from 40 to 75% of their time feeding on a varied diet of grasses, forbs, aquatic plants, foliage, bamboo, roots, bark, dry twigs, pith of bananas and fruits (Sukumar 2003). During the dry season when grass is scarce, the animals draw sustenance by browsing on plants. In fact, the nutrients derived from browse is far more important than grasses (Sukumar & Ramesh 1995). Elephants eat almost every food crop that humans do. They even eat parts of cash crops such as cotton, cocoa and timber trees (Hoare 2001a). They need about 150 to 300 kg of forage per day (Fernando *et al.* 2008). Elephants are capable of surviving on low quality forage (Balasubramanian *et al*. 1995, Owen Smith 1988 in Grant *et al*. 2008) while also taking advantage of high quality crops to supplement or compensate their diet.

1.4 Home Range: The average home range of a herd in India is 267 km^2 in Rajaji National Park (Williams in Sukumar 2003), 651 km^2 in south India (Baskaran *et al.* 1995), 588 km^2 in Buxa Tiger Reserve (Sukumar *et al.* 2003) and an amazingly vast 3,708 km^2 in southwestern[5] West Bengal (Chowdhury 1998 in Sukumar 2003)[6]. In Sri Lanka, elephants seasonally use different parts of their small home range which averages less than 100 km^2 and they are not known to move long distances as in India and elsewhere (Fernando *et al.* 2006). Resources that govern the home range size are availability of water or rainfall and the quality of forage or habitat type (Fernando 1995, Sukumar 2003).

[5] The citation erroneously says “northwestern”.

[6] The home ranges are based on Minimum Convex Polygon.

Elephants maintain fidelity to their home range in the short term (Baskaran *et al*. 1995) even in severely fragmented ranges (Datye & Bhagwat 1995a, Datye & Bhagwat 1995b, Sukumar *et al.* 2003); they even have fixed crossing points between forest patches (Weerakoon *et al.* 2004). They have different dry and wet season ranges (Verlinden & Gavor 1998 in Foley 2002). Sometimes home ranges include or abut cultivated areas but whether these cultivated areas were formerly part of any elephant's home range usually remains undetermined.

The large areas required by elephants are susceptible to a range of habitat related threats such as loss, degradation and fragmentation which lowers the capacity of that habitat to support previous densities of elephants (Williams *et al.* 2001, Madhusudan & Mishra 2003).

1.5 Use of Habitat by Herds: During the dry season in Samburu and Buffalo Springs National Reserves in Kenya, the dominant herds occupy the best habitat so they move less, expend less energy, are always close to a permanent water source and avoid unprotected areas where conflict is high. It is the low ranking herds that are forced by the quality of the habitat to seek larger home ranges including areas where humans grow crops, and have limited access to water through the lean season (Wittemyer *et al.* 2007). So in some parts of elephant range in India, it is possible that the marginalized herds of elephants may be eating the crops of marginalized farmers.

1.6 Impact of Human Actions on Elephant-Human Conflict:

a. Loss of habitat or loss of access to habitat

The information on habitat loss is patchy and not easily available. According to the Forest Survey of India, the northeastern states lost 1802 km^2 of elephant range habitat between 1991 and 1999 (Bist 2002). Assam alone has lost 65% of its lowland semi-evergreen forests since 1972 (Fernando *et al.* 2008). The forest cover of Meghalaya has declined from 33.1% in 1980-1982 to 18% in 1995 (Choudhury 1999).

A study estimated that Sonitpur (Assam), East and West Kameng Districts (Arunachal Pradesh) alone have lost 345 km^2 of different forest types of which moist deciduous forests of the *dooars* (foothills) were the most affected. The foothills provided plenty of forage to elephants and this therefore represents a critical loss of habitat. The study also estimated that in the last five years, 60% of the elephants in these areas have been wiped out[7] (Kushwaha & Hazarika 2004). In the North bank area of Assam there are several herds of displaced elephants that have lost their original forests ranges in recent times. These are chronically stressed herds whose members are as aggressive as bulls (Ecosystems-India pers. comm.).

In Orissa and Jharkhand, elephants have lost habitat to mining and (illegal) encroachments (Bist 2002). Shifting cultivation is a traditional practice in the central and northeastern

[7] No details provided on how the study arrived at this assessment.

states and the abandoned fields provide elephants with favourable habitat (Bist 2002). It creates a landscape mosaic of vegetation with a lot of weedy plants in various stages of succession which is favoured elephant habitat (Sukumar 1989, Fernando *et al*. 2006). There is more browse per unit area in such regenerating landscapes than in the forest (Barnes 2002), while the secondary vegetation may produce lesser toxins in response to herbivory (Foley 2002). However, with increasing human densities, the fallow periods become shorter and shorter (Sukumar 1989, Bist 2002) leading to degraded forest cover (Lahiri Choudhury 1980), plummeting soil fertility, erosion, decline in productivity (Sukumar 2003) and even desertification (Sukumar 1989). When much of the elephant habitat is under such intensive shifting cultivation, the quality of secondary forage available to elephants is poor and this may result in widespread crop-raiding (Sukumar 2003). Another study found that elephant densities are highest in fallow lands (with less than 10 years secondary growth) than in primary forests, plantations or grasslands (Williams & Johnsingh 1996). Similarly in peninsular Malaysia as well as Sabah, elephants were found in greater densities in secondary than primary forests (Olivier 1978 in Sukumar 2003, Alfred *et al*. 2007). In undisturbed forests, the density of elephants ranges around 0.1-0.2 per km^2, whereas, in regenerating scrub, there are 3-5 elephants per km^2 (Fernando *et al.* 2008).

The extent, rapidity and pattern of habitat loss influence the intensity of conflict. The greater the area and the faster it is lost, the larger the conflict. The more the habitat is fragmented or rendered inaccessible, especially by linear barriers such as roads, the more the conflict (Desai 2002).

Elephant habitats in places, such as Jharkhand, Orissa, Assam, and northern Karnataka, that have suffered considerable disturbances have caused elephants to greatly expand their range into neighbouring states which have had no history of elephant presence for several decades or centuries (Sarma & Easa 2006). Elephants traditionally left the plains and foothills for the higher elevations (reaching as high as 3300 m) of Arunachal Pradesh's Eaglenest Wildlife Sanctuary for the summer. According to local villagers, over the last few years elephants are staying longer, until autumn, while a few remain in the winter too. These changes may be related to the clear felling of vast swathes of lowland forests in adjacent Assam, where perhaps the animals had spent their winters earlier (Ramana Athreya pers. comm.). While in South Africa elephants moving into new territory indicates an increase in population numbers (Grant *et al.* 2008), in India it appears to be also driven by large scale disturbances to the habitat (Sarma & Easa 2006), extreme drought (Sukumar 1995), severe poaching, or when habitat within a home range is lost or highly degraded (IUCN 2006).

The degree of forest fragmentation across Asia impacted conflict more than any of the other factors such as extent of forest cover (Leimgruber *et al*. 2003). Areas smaller than the average home range are not likely to support elephants in the long-term (Baskaran *et*

al. 1995). The increasing rates of habitat loss is pushing elephants into shrinking islands of habitat and increasing conflict with humans (Leimgruber *et al*. 2003).

Elephants tend to spend a lot more time in the prime habitats of the river valleys and are affected by their loss to dam projects. Besides, dams disrupt the traditional routes and also cause further habitat loss by encouraging the expanse of cultivation (Sukumar 1989). However, there are exceptions like Periyar Reservoir where elephants appear to have adjusted to the dam project although we do not know how they were impacted by the dam in its early days. Additionally, when dams impound water, rivers run dry in summer forcing wildlife to congregate at water holes. This leads to over-utilization of the habitat and elephants may go in search of water into agricultural fields leading to conflict (Tyagi 1995, Baskaran *et al*. 1995).

In southern India, elephants have lost 20-25% of their habitat within a century of which 10% has been converted to monoculture plantations by the state Forest Departments. While the undergrowth could sustain elephants, it is cleared so that plantation trees can achieve maximum growth (Sukumar 1989).

Elephants prefer areas close to water sources and these areas are also preferred sites of human settlement (Sukumar 1989), resulting in the loss of prime habitat to elephants (Desai & Baskaran 1996, Buij *et al*. 2007). The density of elephants decreases when human presence increases and this is not specifically related to hunting (Blom *et al*. 2004).

b. Habitat transformation

There is a strong negative relationship between human population density and forest cover (Laurance 2007). However, development and proximity to human populations may not always be detrimental to elephants (Leimgruber *et al.* 2003) but if the land transformation threshold exceeds 40-50% or about half the available habitat is lost and the rest is fragmented, elephants will be extirpated (Hoare & du Toit 1999). Elephant populations are likely to persist in areas where human settlement occurs within untransformed elephant habitat. When land transformation exceeds the critical point, then elephant habitat is reduced to patches within a matrix of human settlement; the size and connectivity of the fragments determines whether elephants remain or move away (Hoare & du Toit 1999). In Nepal, there was a strong indication that the transformation of elephant habitat greatly increased the economic losses from elephant-agriculture conflict (WWF 2008).

Frequent fires are an indicator of increased human activity. Most tropical forests do not suffer from fire of natural causes whereas other ecosystems such as grasslands, savannas and shrublands suffer a few fires a year. The use of fire by graziers, forest produce collectors and other forest users causes profound changes in the habitat, drastically reducing the food availability to elephants (Sukumar 2003). Shrubs and young trees are important dry season browse for elephants while they graze on grasses after the rains (Sukumar 1990). However, fires set, during the dry season, burn grass completely while

shrubs and young trees are ashed, leaving only bare stems. Although fires may be localized, a succession of them may affect a large area. Repeated fires may encourage a vegetational shift towards fire-resistant plants and trees which may or may not be fodder for elephants (Sukumar 1989).

In Orissa, local communities, who are allowed to collect tendu leaves and mahua flowers, set fire to the undergrowth every year. This prevents regeneration of foliage between 0-10 metres, depriving elephants of forage. Therefore they use these forests to shelter during the day and raid crops at night (Rauf Ali pers. comm.). In Thailand, since the frequency and intensity of crop-raiding increases significantly when the forest is burnt, it was surmised that fire might affect elephants (Anon 2008).

However, elephants are known to prefer the fresh grass that grows quickly after the pre-monsoon showers in the burnt areas of tropical dry forests compared to the coarse stands in unburnt areas (Sukumar 1985b).

Any reduction in the availability of resources does not immediately reduce the population or density of elephants. Instead, a long-lived species like the elephant responds to such interference by expanding its home range (Madhusudan & Mishra 2003).

A study also indicates that elephants do not stop using 'high risk' areas which may have been part of their home range in the past, instead they change their behaviour by using these areas only at night or walking faster than normal (Foley 2002: "four times faster"; Douglas-Hamilton *et al.* 2005).

The shape and size of the forest also contributes to the intensity of conflict with large and square or circular forests faring better than long and thin ones (Sutton 1998, IUCN 2006, Boominathan *et al*. 2008).

c. Competition with humans for forest resources

Human use of resources such as cattle grazing, firewood collection and cattle pens within forests may degrade the habitat, reducing their ability to support elephant populations (Desai 1991, Silori & Mishra 2001, Madhusudan 2004). Bamboo, prime elephant fodder, has been largely overexploited in southern India (Prasad & Gadgil 1981), reducing the carrying capacity of the habitat (Sukumar 1985a). Weeds proliferate in areas overgrazed by livestock which suppresses the growth of grass and other food plants of elephants (Boominathan *et al*. 2008).

For instance, in Rajaji National Park, which has some pastoral communities of Gujjars, 57% of the total shrub cover were inedible species. Six preferred food-tree species showed little or no regeneration as Gujjar cowherds lopped the branches to feed their buffaloes. Elephants were also observed to avoid drinking from streams used by buffaloes (the water quality was compromised by their wallowing and defecation in the water) while there was competition between Gujjars and elephants for the clean spring water in summer

(Johnsingh & Joshua 1994). Of 289 headloads removed from an elephant corridor, 87% contained fodder or firewood, and nearly 21% consisted of bamboo. The top three elephant food plants formed nearly 47% of the headloads (Sunderraj *et al*. 1995).

In another corridor in south India, villagers removed 1800 tonnes of fuel wood, 800 tonnes of grass and 451 tonnes of cattle dung annually. More than 90% of the villagers were dependent on firewood for fuel. Nearly 8000 heads of cattle graze in the Mudumalai Wildlife Sanctuary for 6-7 hours a day, about 5-6 km inside the forest. Intense grazing by livestock has degraded and exposed the soil (Silori & Mishra 1995).

In Bhadra (Karnataka), heavy grazing by cattle reduced the palatable herb cover by 30% and shrub cover by 25% indicating a potential reduction in the carrying capacity of the area for elephants and other wild ungulates. Elephants could make up the shortfall in natural forage by eating crops (Madhusudan 2003). Villages and cattle pens within the forests effectively deny the use of those areas to elephants (Desai 1991) while transmission of diseases such as anthrax, rinderpest, and foot-and-mouth from domestic animals to elephants is also a threat (Sukumar 1989).

d. Poaching and retaliatory killings

Between 1977 and 1986, an estimated 100-150 bull elephants were killed each year in south India alone. Some of these were possibly crop-raiders while the others were poached for their ivory. Throughout India, between 1994 and 2000, about 80 to 100 elephants were killed each year by poachers, while there is speculation that as many as 200 elephants may have been poached annually (Sukumar 2003). As a result of poaching, the sex ratio of elephant populations is biased toward females in some states. In 1998, the adult male to female sex ratio in Periyar Tiger Reserve (Kerala) was a perilous 1:101 (Ramakrishnan *et al.* 1998) but the ratio (2001 to 2003) had recovered to 1:80 (Arivazhagan & Sukumar 2005).

Farmers in areas where conflict with elephants is relatively common, may electrocute or poison elephants in retaliation. An average of forty to fifty elephants are killed a year while crop-raiding in India (Johnsingh & Panwar 1992 in Williams *et al.* 2001, Project Elephant). Almost twenty years ago, 17-19% of female elephant mortality in southern India was a result of conflict (Sukumar 1989). Demographic modeling indicated that this was just sustainable, and any small increase in mortality was likely to cause population declines (Woodroffe *et al.* 2005).

Poaching negatively affects foraging behaviour, restricting access to critical parts of the range which results in nutritional stress. As a result of such disturbance, herds may tend to congregate in large numbers, thereby taking a toll on the habitat. Besides, herds that experienced poaching were prone to restlessness and breaking lots of trees (Ruggiero 1990).

Table 1: Impact of human actions on elephant-human conflict

Human Actions	Impacts on Elephants	Results	References
Ivory poaching	Biased sex ratio	??	Bist 2002; Sukumar 2003
Illegal encroachment	Loss of access to habitat	Crop-raiding, extension of range to new habitats, human and elephant mortality	Bist 2002; Kushwaha & Hazarika 2004
Shifting agriculture	Increased densities	Crop-raiding	Bist 2002; Williams & Johnsingh 1996
Monoculture plantations	Decreased forage	Crop-raiding	Sukumar 1989; Sukumar 2003
Fire	Decreased forage	Crop-raiding	Sukumar 2003; Rauf Ali pers. comm.; Anon 2008
Competition for resources with humans	Decreased forage	Human mortality	Sukumar 1989; Silori & Mishra 2001; Madhusudan 2004
Blocked traditional routes	Loss of access to habitat	Intrusion into human spaces, aggression, crop-raiding	Naughton *et al.* 1999; Kumar *et al.* 2004

2. THE HUMAN PERSPECTIVE

Loss of human life and injury, property damage and crop-raiding are the symptoms of elephant-human conflict seen from the human perspective.

2.1 Injury and Loss of Life: Compared to the numerous studies analyzing the crop-raiding behaviour of elephants, there are few studies that analyze the loss of human life caused by elephants. Who gets killed where differs from site to site depending on how humans and elephants use the habitat. Case studies from the Biligirirangans (on the Tamil Nadu-Karnataka border), Bihar and West Bengal, Kodagu (Karnataka) and Valparai (Tamil Nadu) are summarized below.

Of 123 human mortality cases reported in the Biligirirangans, 55% occurred in forests during the day and 45% in settlements at night (Sukumar 1989). A majority of those killed were adult men (77.3%), followed by adult women (17.4%) and children (5.3%). While elephants probably do not distinguish between gender or age of the people they attack and kill, these figures give us an idea of how local people use the habitat. Men commonly go into the forest to graze cattle by day and guard crops at night and therefore run a higher risk of being killed by elephants. While the identity of the elephants involved is largely unknown, both bulls and herds cause deaths of humans in forests while mainly sub-adult males and bulls are implicated in deaths around settlements. Bull elephants that wait near villages for nightfall to eat crops have also been known to kill people (Sukumar 2003). Eye witness accounts of 62 of these cases indicated that about 82% of the incidents were caused by bulls, 10% by females and the remainder by a herd member (presumably a sub-adult male or female) (Sukumar 1989).

Between 1980 and 1991, 134 and 74 people were killed in south Bihar and south West Bengal respectively (Datye & Bhagwat 1995c). Of 25 people killed by elephants from Dalma Wildlife Sanctuary, 24 occurred during the day within the forest. Of these 17 were men and 13 of them were intoxicated (Datye & Bhagwat 1995c) perhaps delaying their responses to elephants (Sukumar 2003). Of the 53 cases for which details were available, 41 (77.36%) human deaths were caused by herds while only 12 (22.64%) were caused by bulls (Datye & Bhagwat 1995c) unlike the situation in the Biligirirangans. These elephants were expanding their range into southern Bengal and local people, not experienced with elephants, may have been oblivious to the dangers of approaching wild elephants (Sukumar 2003).

Fig. 1: Elephant damage to a banana field.

However, in north Bengal (Buxa Tiger Reserve and Jaldapara Wildlife Sanctuary), 31 people were killed and 9 injured in 2002-2003 (Sukumar *et al*. 2003). Of the fatal attacks, 75% occurred in crop lands and villages and the rest in forests. Bulls were responsible for more than 90% of these encounters (Sukumar *et al*. 2003).

Over a ten year period (1994-2004), 77 elephant-human incidents (42 cases of human death and 35 cases of injury) were recorded in Kodagu (Karnataka) (Chaudhuri *et al.* n.d.). Of these 51% occurred in plantations (primarily coffee, cardamom, arecanut, banana, coconut and other fruits), 28% in forests and 21% in fields. Men (83% fatalities, 71% injuries) were affected more than women and the encounters were spread throughout the year. In 24 of 30

cases (80%), bulls were implicated (Chaudhuri *et al.* n.d.). An earlier study indicated that most adverse elephant-human interactions took place within the forest or along the boundary (Nath & Sukumar 1998).

Poor visibility in forests has been blamed for the accidental encounters (Datye & Bhagwat 1995c, Nath & Sukumar 1998, Sukumar 2003). Elephants are known to distinguish between 'safe' (forests) and 'higher risk' (open grasslands, farmlands, villages) areas and their behaviour may vary accordingly (Foley 2002, Douglas-Hamilton *et al*. 2005). Elephants that flee from croplands when encountered may become more confident and even aggressive when encountering people in forests (Hoare 2001a, Treves 2007). It is likely that human mortality in settlements and agricultural areas is caused by (1) the continued harassment and taunting when elephants are driven into forests from human dominated landscapes using *kumkis* (M.D. Madhusudan pers. comm.), (2) the frustration of being prevented from reaching fields by crop guarding farmers (Sukumar 1989), and (3) when people get too close to elephants which are traumatized, injured, harassed, in *musth*, or females with young calves (Leggat *et al.* 2001 in Twine & Magome 2008). Settlements and agriculture that block traditional routes also lead to aggressive elephant behaviour and conflict (Naughton *et al.* 1999).

In Valparai (Tamil Nadu), 27 human fatalities were recorded over a ten year period (1994-2003) with an average of three per year. While none were reported from forest areas or in any of the tribal settlements within the Indira Gandhi Wildlife Sanctuary, some occurred near forest fragments, and all the others took place in tea and coffee plantations, contrary to other case studies. Almost all incidents were caused by herds. These accidents occur during the seasonal movement of elephants (Kumar *et al.* 2004) and not as a result of herds expanding their home range.

A study in Assam and Arunachal Pradesh reported a positive correlation between deforestation and the number of people and elephant killings as a result of conflict. Deforestation of moist deciduous forests was severe between 1994 and 1999 when 226.76 km^2 was lost, compared to the 118.32 km^2 lost between 1999 and 2002. The corresponding human and elephant mortality data shows an increase in trend only from the year 2000 (Kushwaha & Hazarika 2004) and therefore this correlation appears to have little qualitative data to support its claim.

Other situations when people are in danger: People guarding crops from flimsy, ground level watch huts have been attacked by elephants, evidently annoyed by torch light or the barking of a dog (Sukumar 1989). Some bulls react aggressively to being chased away from crop fields and this may explain the large number of mortality in villages (Sukumar 1989). Elephants are difficult to see in the dark and farmers frequently blunder into them when crop guarding. They may assume that all the elephants have been chased away when one or more could be using the cover of darkness to continue feeding. Electric fences give people a false

feeling of confidence, increasing the chances of a dangerous encounter with an elephant that may have quietly broken through (Ram[8] pers. comm.).

Musth or gunshot wounds and other injuries are known to enhance aggressiveness in elephants (Sukumar 1985b). While elephants in any population show a wide range of temperaments, they are also influenced by the behaviour of people; in areas where elephants are not persecuted, they tend to be milder mannered than in areas where they are (Sukumar 1989).

In areas where maize is grown, people are killed as they cannot see the elephants standing among the tall plants (Srikumar Sunuar[9] pers. comm.). Near Gorumara Wildlife Sanctuary, a female herd member killed nearly a dozen people in two days before she was shot by the authorities. In this instance, it was suspected that the female elephant was infected with rabies (Gautam Basu[10] pers. comm.). In some villages in North Bengal, when elephants break into houses to obtain salt, stored grain and liquor, falling walls and beams kill people. In these areas, this is the primary cause of human mortality (interviews with villagers).

It is worth noting that dangerous encounters between elephants and people that do not result in injury or death are not recorded (Boominathan *et al*. 2008). In the absence of quantitative data on the number of people who share habitat with elephants and the number of chance encounters that did not lead to injury or mortality, these mortality figures provide anecdotal information only.

2.2 Property Damage: There is little published data on property damage caused by elephants across their range. Presented below are two studies from Valparai (Tamil Nadu) and Manas (Assam).

Tea plantations dominate the Valparai plateau and property damage is the more prevalent form of conflict unlike other elephant conflict areas in India (Kumar *et al.* 2004). Elephants occasionally damage school kitchens, ration shops and houses. A one year study (2002-2003) recorded 117 incidents of building damage, 31 incidents of eating stored provisions and about 8 miscellaneous events involving office equipment and automobiles. The perceived loss averaged Rs. 4038 per incident with just 24 (15%) incidents accounting for 75% of the total monetary cost of conflict. Most of the damage was caused by herds. Tea companies chase elephants from one estate to the other and frequently the harassed animals are stranded in the middle of tea plantations with no shelter or forage. When night falls, the elephants seek the nearest food source which may just happen to be shops and kitchens. However, it is instructive that not all the shops are targeted and that most of the incidents occur close to the

[8] Beat Officer, Gorumara-Mal Squad Range

[9] Forest Guard, Sibchu village in Chapramari Wildlife Sanctuary

[10] Ranger, Gorumara-Khunia Squad Range

major traditional routes of the elephants across the plateau. Buildings that have been damaged in the past were likely to get damaged again (Kumar *et al.* 2004). In similar tea estate dominated parts of Sonitpur District (Assam), property damage was the main form of conflict (Ecosystems-India pers. comm.).

In Manas National Park (Assam), there were 172 incidents of property damage over a 13 year period (1991-92 to 2005-06). Some of these may have been provoked by attempts to chase away crop-raiding elephants, but most of the incidents (93.6%) were house break-ins (Lahkar *et al.* 2007). In Kaziranga (Assam) where natural vegetation was more intact, house damage was less (Di Fonzo 2007).

Bulls cause conflict throughout the year whereas herds visit villages only when crops are ripe (Lahkar *et al.* 2007). Villagers interviewed in Bengal and Assam say that bulls typically eat bamboo, bananas, grass, tubers that grow in kitchen gardens near houses which leads to incidental property damage. But they also deliberately break into houses looking for salt, stored grain, home brewed alcohol, wheat and maize flour (Williams *et al.* 2001, Lahkar *et al.* 2007). One village elder of Garo Basti[11] said that the salt licks put out by the Forest Department encouraged elephants to come looking for it in houses.

Fig. 2: Elephant damage to a banana field.

In North Bengal where houses are built on stilts, one elephant trying to find the food store got stuck underneath a house and in attempting to free itself, brought the house down (a villager[12] pers. comm.).

In the township of Masinagudi (Tamil Nadu), much of the conflict centres around water installations. Residents complain of water pipes being pulled up and water tanks being destroyed during the dry season (pers. obs.). Elephants also tend to deliberately damage structures (Desai 2002).

[11] near Alipur Duar, West Bengal

[12] Tia Mari village, West Bengal

2.3 Crop-Raiding: Crop-raiding is the most wide-spread form of elephant-human conflict.

Causes of crop-raiding:

a. Bulls choose to eat crops: the nutritional factor

Some studies indicate that despite the availability of abundant natural forage, relatively intact and extensive natural habitats, some elephants indulge in eating crops (Sukumar 1989, Barnes *et al.* 1995, Naughton-Treves 1998). Bulls are also known to utilize exclusive habitats, the so-called bull areas, which are usually too marginal or poor in resources to be used by female herds (Sukumar 2003). Given a choice, bull elephants are more prone to eating crops because of its availability in high densities, and its higher nutritive value (Sukumar 1985b, Hoare n.d.b, Chiyo *et al.* 2005, Sitati *et al.* 2005). It is these few elephants that cause the bulk of the damage. In a single night, a bull can travel up to 6 km through cultivated fields (Sukumar 1986), while herds eat crops opportunistically, not venturing further than 1 km from the forest boundary (Sukumar 1989). If undeterred, bulls can become habitual crop-raiders (Boominathan *et al*. 2008).

By eating crops more frequently and ranging farther than herds, bulls are at an increased risk of being injured or even killed by crop-guarding farmers. But when they succeed in eating crops, elephants receive enormous gains from the highly nutritious plants ("high-risk, high-gain") (Sukumar & Gadgil 1988). Solitary bulls try to minimize the risk by forming groups of 2 to 4 before entering cultivation (Sukumar 1986). In fact, some bulls appear to be disturbance-tolerant, as they were consistently found closer to settlements than females (Hoare 1999).

The condition of bulls determines how they fare in male-male contests. Crops provide bulls with a distinct nutritional advantage (Sukumar 1985b) to sustain longer periods of *musth* and still survive the long dry season (Seidensticker 1984). And yet in Mudumalai (Tamil Nadu) a chronic crop raider was frequently injured as a result of conflict and did not come into *musth* during the 2 year study period (Desai & Baskaran 1996). Crops form 9% of the annual diet of adult bulls (about 6,500 kg of crops per year per crop-eating bull) whereas it is only 2% for herds. For some notorious crop-eaters, it forms as much as 20% of their diet (Sukumar 1985b).

Yet, in Africa, variability in rainfall did not attract more elephants to better crops (better nutrition per unit area) (Hoare 1999) but more productive farms were damaged to a greater extent than less productive farms (de Boer & Ntumi 2001). A study in Africa showed that elephant density, proximity to Protected Areas, area of human settlement, human density or local rainfall could not predict conflict spatially. The only predictable feature was the unpredictability of bull elephant behaviour (Hoare 1999). "Prime bulls" in the middle age class are known to restrict their movements to areas frequented by herds (Osborn 1998). Presumably it is the younger bulls then who eat crops.

In some areas bull elephants cause more damage than herds (Sukumar 1989, De Silva 1998, Fernando *et al*. 2005, Lahkar *et al.* 2007) whereas in others, herds cause more damage (Balasubramanian *et al.* 1995, Datye & Bhagwat 1995a, Smith & Kasiki 2000, Williams *et al.* 2001, Kumar *et al.* 2004, Fernando *et al*. 2005); in some parts of southern India this may merely reflect the paucity of adult bulls in the population as a consequence of ivory poaching (Sukumar 2003).

Table 2: The relative abundance of bulls and the proportion of damage they cause.

Place	Proportion of bulls in the population	Proportion of total damage caused by bulls	References
Mudumalai Wildlife Sanctuary	3%	34.9%	Balasubramanian *et al.* 1995, Sukumar 2003
Mudumalai Tiger Reserve	3%	49.5%	Daniel *et al*. 2008
The Biligirirangans	7%	70%	Sukumar 2003
Rajaji National Park	15.8%	24%	Williams 2004, Williams *et al.* 2001

The elephant population in Rajaji National Park is one of the least affected by ivory poachers (Williams 2004) and despite the higher proportion of bulls in the population, herds damaged three times more area than bulls though the proportionate damage by bulls was greater (Table 2). There was little difference in the amount of damage caused by one elephant per night between the sexes. Both bulls and females eat crops mainly within 1 km of the forest boundary. None of the elephants that ate crops bore gunshot injuries from irate farmers, bulls did not form groups, and since more herds seem to eat crops than bulls, there is uncertainty whether the "high-risk, high-gain" theory can be applied in that region (Williams *et al.* 2001).

b. Elephants are forced to eat crops: adverse habitat factors

Habitat factors are important in determining the nature and extent of crop raiding by elephants; thus the reduction of natural habitat or its fragmentation may leave elephants with little choice but to seek a part of their forage needs from cultivated fields (Sukumar 1985b, 1989).

Studies conducted in Mudumalai Wildlife Sanctuary and Rajaji National Park found that not all bulls raided crops despite their easy accessibility (Balasubramanian *et al.* 1995, Williams *et al.* 2001). While crop-raiding bulls have larger home ranges (~ 400 km^2) than other bulls (150-200 km^2), they eat crops in a restricted area within their home range and for only part of the year (Williams *et al.* 2001). Similarly in Sri Lanka, elephants that inhabit areas of high usage by humans had relatively larger home ranges (male: 183.6 km^2; female: 157.9 km^2) than those that did not (male: 53.6 km^2; female: 48.3 km^2) (Weerakoon *et al.* 2004). The chances of losing a part of a large home range to human endeavour is high (Williams *et al.* 2001), making it the most important trigger of conflict (Balasubramanian *et al*. 1995, Madhusudan & Mishra 2003).

Analysis of 222 dung piles of two radio collared clans whose home ranges abutted crops did not have any crop remains. Of 147 dung samples from 41 other herds in the vicinity of agricultural areas only 12.2% of the herds were found to eat crops. A similar analysis of the dung of 22 different bulls found crop remains in only 6 (27.3%) of them (Balasubramanian *et al.* 1995). This suggests that only some elephants in a population raid crops. However, there are elephant populations such as in northern W. Bengal where most, if not all, elephants raid crops; a study of 13 radio-collared elephants here showed that all of them raided crops to some extent.

Elephants found in extensive forests ate crops the least while the elephants that have lost habitat ate crops the most. This led to the conclusion that some elephants eat crops, although others in the same vicinity and with overlapping home ranges do not do so even when they have the opportunity, and that habitat loss was a force driving elephants to eat crops (Balasubramanian *et al.* 1995). In Africa, Chiyo *et al*. (2005) came to a similar conclusion.

Elephants remain faithful to their home range even if the habitat suffers some degree of fragmentation or transformation (Datye & Bhagwat 1995a, Datye & Bhagwat 1995b, Sukumar 2003) as they are capable of withstanding a lot of environmental stress (IUCN 2006). When the available natural resources within their home range are no longer adequate, they are forced to make up the shortfall in their dietary requirements by eating crops (Balasubramanian *et al.* 1995, Madhusudan 2003). These studies therefore demonstrated that some elephants take to eating crops out of necessity.

Bull elephants are not influenced by habitat loss as much as females (Balasubramanian *et al.* 1995). But just one study indicated that a crop-raiding bull elephant had presumably

lost a part of his range to agriculture 20-30 years before (Williams *et al.* 2001). Whether he began eating crops as a result of this presumptive loss of his range as the authors suggest, or whether he was a habitual crop-raider even before this change occurred is unknown.

In summary, elephants that share habitat with humans have large home ranges (Weerakoon *et al.* 2004); elephants with large home ranges are likely to lose some of it to agriculture (Williams *et al.* 2001); elephants that suffer from habitat loss are more prone to eating crops (Balasubramanian *et al.* 1995). At the same time, the increased fragmentation of habitat increases the frequency of such conflict over larger regional scales (Sukumar 2003).

c. Proximity to Protected Areas or forest patches

Many studies have quantified conflict to be intense in the proximity of a forest area (Graham 1973, Sukumar 1989, Kiiru 1995, Nath & Sukumar 1998, Osborn 1998, Naughton *et al.* 1999, Nyhus *et al.* 2000, Talukdar *et al.* 2006, Lahkar *et al.* 2007, Riddle 2007, Daniel *et al*. 2008: about 80%), others have found that conflict intensifies further away from the forest boundary (Smith & Kasiki 2000, Kumar *et al.* 2004, Chaudhuri *et al.* n.d.) while still others found no correlation at all (Osborn 1998, Hoare 1999, Di Fonzo 2007). One African study found that conflict levels were significantly lower in areas bordering the forest but suggested that there was anecdotal evidence of successful mitigation strategies being practiced by local farmers as well as the wildlife authorities[13] (Smith & Kasiki 2000). In Nepal, sites with good forests along edge habitats suffered less conflict (WWF 2008). To what extent refuges and corridors influence the distribution and intensity of conflict outside Protected Areas requires further study (Sitati *et al.* 2003).

The spatial distribution of damage was highly skewed even within this high risk zone closest to the forest, some fields were totally destroyed whereas other areas nearby were left untouched (Hoare n.d.b, Naughton *et al.* 1999: only 10% of the farms affected, Naughton-Treves & Treves 2005, Sitati *et al.* 2005, Lahkar *et al*. 2007, Parker *et al*. 2007). In Uganda, some villages, more than others, have been consistently visited by elephants since 1951 (Naughton-Treves 1998). This suggests that large-scale factors may determine which locations are affected and that elephants continue to target the same areas even when these factors change (Smith & Kasiki 2000). In India, a distributional analysis of damage along the periphery of forests is yet to be done.

In fragmented forests, the longer boundary shared with cultivation increases the likelihood of elephant visits (Nath & Sukumar 1998, Smith & Kasiki 2000, Sukumar 2003, Madhusudan 2003, Boominathan *et al*. 2008) and worsens the damage (Daniel *et al*. 2008)

[13]The farmers have stopped growing crops that are attractive to elephants and wildlife authorities focus their mitigation efforts on these areas too.

though some studies in Africa and Indonesia found otherwise (Hoare 1999, Nyhus *et al.* 2000).

Village enclaves within forests suffered significantly more damage than settlements in corridors and the periphery (Sukumar *et al*. 2003).

d. Blocked paths

Elephant herds move across three different scales: (1) daily movement between feeding and water sources, (2) seasonal movement between dry and wet season forage areas within home ranges and (3) medium-term movements between sectors of the seasonal home range (Seidensticker 1984). In some areas, elephants are forced to move through human dominated landscapes to water sources (Sukumar 1989), and/or different parts of the home range. They adhere to their time-honored routes even if they have been severely transformed. For instance, elephants of the Valparai plateau move from the Protected Areas in the west to those in the east by crossing the vast tea plantations (Kumar *et al.* 2004). Some writers mention that when herds seasonally traverse from one area to another through agricultural areas, they may opportunistically eat crops along the way (Sukumar 1986, Nath & Sukumar 1998). However, they do not eat crops all along the route but rather only at a few locations (Nath & Sukumar 1998). As with property damage, perhaps what can be said with certainty is that farms that have been visited before are likely to be visited again (Sitati *et al.* 2005, Stewart-Cox & Ritthirat 2007). The clustering of crop damage events may be a function of elephants' long memories and usage of traditional routes. They may return to areas where they remember eating crops successfully in the past (Sitati *et al*. 2003).

e. Trampling

Elephants not only eat crops but they also damage them by trampling. In the Biligirirangans, of the crops lost to elephants, 60% was eaten while the rest had been trampled. Elephants walk through fields of young, standing crops to reach mature crops, or when fields with crops have to be crossed to the only source of water (Sukumar 2003). Another study from Mudumalai found that bulls and herds trample equally, causing about 20% of the total damage[14]. Damage to the early stages of crop growth is mostly caused by trampling (Balasubramanian *et al.* 1995). In Sri Lanka, however, trampling greatly exceeded the quantity actually consumed (Wickramanayake *et al.* 2004).

[14] The study doesn't say whether damage caused by herds was considered as a unit or per individual elephant.

f. Increasing elephant numbers/density[15]

Throughout 20th century Africa, there was widespread elephant control, decline in range and numbers and yet conflict continued in many parts (Hoare 1999). In Bengal, capturing half the herds and killing about 20 rogue elephants did not make any significant difference to elephant depredations through the 1980s and therefore it is unlikely that population numbers influenced conflict (Barua & Bist 1995). The northeastern area of Kodagu has very little forests and a low estimated elephant density but suffered more conflict than the rest of the district (Nath & Sukumar 1998, Boominathan *et al*. 2008). Similarly in Assam, while the elephant population is decreasing, conflict is escalating (M.C. Malakkar[16] pers. comm.). On the other hand, the Nilgiri Biosphere Reserve has very high crude elephant densities and yet crop loss was considered low (Balasubramanian *et al.* 1995). One study found increasing human and elephant populations led to a corresponding increase in conflict (Smith & Kasiki 2000). Bell (1984) found elephant densities to be higher in valleys than plateaus and therefore villages located in valleys suffered greater levels of crop loss. He also found that elephants approached fields along streamlines as Osborn & Welford (1987) found throughout southern Africa (Osborn 1998). Others found no significant relationship between local elephant numbers/density and crop loss (Hoare 1999). If elephants are compressed into small habitats, then the resulting habitat degradation could make crop-raiders out of all the resident elephants (Boominathan *et al*. 2008).

g. Learned behaviour

Eating crops may also be a learned behaviour (Sukumar 1985b, 1995). While calves may learn from the adults in the herd; young bulls that disperse from herds that do not eat crops may learn by associating with bulls that do (Osborn 1998). This may not only explain the widespread nature of the phenomenon but also the difference in behaviour between sympatrically occurring animals. The hundreds of bottlenose dolphins at Moreton Bay, Australia, are split into two communities that do not interact socially although they share the same area. While one forages with trawlers, the other does not. This difference in foraging strategy appears to be a result of learning from older members of the community (Whitehead *et al*. 2004), providing another possible explanation why some elephants of a population eat crops while others in the same vicinity do not (Balasubramanian *et al*. 1995, Williams *et al*. 2001).

[15] Seidensticker (1984) makes an important distinction between crude and ecological density "because density estimates are frequently employed by wildlife managers. Crude density estimates take the average density of the species over the entire sample space. Ecological density is the crude density estimate corrected for habitat differences within a non-homogenous habitat. Through some habitat modifications, the ecological density of elephants in a specific area might shift (a behavioral response), but the overall or crude density of elephants in the region might not (a numerical response)."

[16] Principal Chief Conservator of Forests (Wildlife), Assam.

h. Problem component

It appears that almost any elephant population may have a problem 'component'. One segment of any elephant population is involved in the conflict events of the area. Therefore, no matter how many problem elephants are removed, others replace them and the conflict continues unabated (Hoare n.d.a). For instance, in Kodagu (Karnataka), the frequency of crop loss did not reduce as elephants from adjoining habitats replaced the ones that were removed (Nath & Sukumar 1998). Alternately, the problem 'component' may not be the animals themselves but the situation (such as loss of habitat or obstructed routes) that creates problem elephants (T.R. Shankar Raman pers. comm.).

i. Other factors

While there is a suggestion that it is not the area of individual farms that increases the risk of elephant damage but the total area of farmlands in the region (Madhusudan 2003, Sitati *et al.* 2005), another study disagrees and speculates that it is the small, isolated farms that may be vulnerable (Malima *et al.* 2004).

Intensive, irrigated agriculture in semi-arid areas promotes conflict (Fernando *et al*. 2005). In recent years, loans provided to farmers has seen an increasing number of bore-wells around Bandipur National Park attracting elephants to succulent crops as well as water installations exacerbating conflict (M. Ananda Kumar pers. comm.).

Extreme weather events like El Niño may trigger elephants' travel into new areas (Sukumar 1995). During the drought of 1983, several herds moved from Hosur (Tamil Nadu) into Andhra Pradesh where people had not seen elephants for over a century. In 1987, during another drought, the elephants from Jharkhand made significant inroads into southern Bengal (Sukumar 1995). Such events pit the new migrants against people who have no experience of living with elephants, thus causing conflict.

While conflict causes direct monetary loss, local communities incur other costs that are difficult to quantify. For instance, in areas where conflict is severe, farmers abandon farming (pers.obs. in Karnataka and Assam, Boominathan *et al*. 2008), they risk contracting malaria while keeping watch at night (Bibhuti Lahkar pers. comm., Hoare 2000) and in some other areas such as Nepal, young men are unable to find brides (WWF 2008). In addition, these farmers are not only at a financial disadvantage compared to those who do not have to contend with elephants, they risk getting attacked by aggressive elephants while guarding their crops (Sitati *et al.* 2005). Whatever the intensity of conflict, farmers, who work hard during the day, are forced to stay up awake at night as well, leading to loss of productivity (M.D. Madhusudan pers. comm.) and a range of stress-related diseases which has not been acknowledged (Sutton 1998, Desai 2002).

It is the amount of crop loss, rather than frequency of raids, which apparently influences tolerance. In a single foray elephants can cause the most extensive damage although

cumulatively, domestic goats damaged more than all the other animals put together in one location in Africa (Naughton-Treves & Treves 2005). While biologists quantifying crop loss quote average loss per annum, to a farmer who has lost his entire season or annual production in one night, the loss is catastrophic and this is what shapes local perceptions and responses to conflict. For instance, in Uganda, the average loss was less than 10% but 7% of the farmers lost more than 50% of their crops (Naughton-Treves 1997). It is also worth noting that dangerous encounters between elephants and people that do not result in injury or death are not recorded (Boominathan *et al*. 2008) but such incidents aggravate the communities' tolerance levels.

On the other hand, researchers and management authorities feel that complaints about elephant conflict are greatly in excess of the actual problems (Hoare n.d.b). While one farmer may easily tolerate a 15% loss of a food crop (influenced by a range of factors such as size of farm, alternate avenues of income, etc.), a neighbouring sharecropping farmer may be unable to withstand the loss. Loss of crops during a drought is felt more keenly than in a good year. Therefore, average crop loss cannot be used to justify local tolerance or intolerance as there are clearly other factors that shape local people's perceptions (Naughton-Treves & Treves 2005). The biological approach also does not take into account the power dynamics within the human communities that guide their responses to human-wildlife interactions. The local peoples' negative attitudes led to the extermination of carnivore species across most of Europe and North America (Treves & Karanth 2003).

Conflict is as much a social problem as it is a technical challenge (Treves 2007) and achieving conservation goals is largely a matter of human choice (Cowling & Wilhelm-Rechmann 2007). Conflict mitigation also requires an increase in local tolerance to damage (Osborn & Hill 2005). Although the perception of conflict is dependent on the farmer's vulnerability and risk tolerance, this has not been addressed adequately in conflict studies. For instance, wealth reduces the vulnerability of a farmer to loss (Naughton *et al.* 1999), yet the wealthiest farmers (growing cash crops) are sometimes the least tolerant of conflict (pers. obs. in Anaikatti (Tamil Nadu), Gunaratne & Premarathne 2006 in Sri Lanka) whereas in other areas, they may be the more tolerant group (Nath & Sukumar 1998, Naughton *et al.* 1999). In the Biligirirangans, the people who shot or electrocuted crop-raiding elephants were wealthier but this was not always the case (Sukumar 1985b).

Researchers should also remember that the ones who complain loudly and vociferously about conflict may not be the most vulnerable (Treves *et al*. 2006). The tolerance for imposed risk is less than voluntarily assumed risk (Naughton-Treves & Treves 2005). Farmers accept the loss of subsistence crops better than cash crops (M.D. Madhusudan pers. comm., Naughton-Treves & Treves 2005). In areas such as Masinagudi (Tamil Nadu), the private resorts owned by outsiders are electric fenced, whereas the local villages remain unprotected (pers. obs.). Rich farmers also wield more political clout than subsistence farmers (M.D. Madhusudan pers. comm.). Therefore local perceptions of conflict complement quantitative assessments of loss and are equally important in managing the problem (Treves 2007).

Contemporary social conditions such as restriction on the use of forest resources, disintegration of traditional extended family land holdings and political empowerment of people aspiring to a higher quality of life contribute towards lessening tolerance for conflict (Naughton *et al.* 1999). Farmers view elephants as "the Forest Department's animal" and since relations with the state Forest Departments is frequently poor, tolerance for incursions into farmlands is low (Lahkar *et al.* 2007, Chaudhuri *et al.* n.d.). Large extended families with enough manpower to guard crops suffered considerably less loss from conflict than individual nuclear families (Naughton *et al.* 1999) whereas the breakdown of community management has led to the over-utilization and illegal encroachment of common property resources, further eroding the quality of elephant habitat (Nath & Sukumar 1998).

Fig. 3: Encroachments in Nameri Tiger Reserve, Assam.

There is some indication of differences between tribal and non-tribal tolerance of conflict (Chaudhuri *et al.* n.d., Nath & Sukumar 1998). They suggest that tribals know ways of living with elephants besides possessing a greater tolerance for loss. In landscapes where tribals and people from other communities coexist, tribal communities complain to the Forest Department significantly fewer times than the others. It could also mean that they are too intimidated by officials to seek state redress (pers. obs.) or they might seek alternate ways of coping with the threat to their livelihoods such as emigration to cities, minor forest produce collection (Nath & Sukumar 1998). In the tea plantations of North Bengal, where tribals from Bihar and Jharkhand were brought decades ago as estate labour, native tribals apparently

have significantly higher tolerance thresholds than the "outside" tribals (interviews with foresters).

The overwhelming majority of conflict studies focus on the ecology of the animal (Treves *et al*. 2006) implying that the causes may lie in elephant behaviour. Little is known of the perception of conflict. For instance, compare the patchy information under the elephant perspective to the extensive analysis under the human perspective.

Table 3: Factors influencing local tolerance (adapted from Naughton *et al.* 1999)

TOLERANCE		INTOLERANCE
	Socio-economic factors	
Abundant land	Land availability	Scarce land
God, self, community	Ownership of animal	Government
Varied, unregulated	Coping strategies	Narrow, highly regulated
Community, group	Social unit absorbing loss	Individual, household
Abundant, inexpensive	Labour availability	Rare, expensive
Low	Capital and labour investment in crop	High
Subsistence	Type of crop damaged	Cash crop
Various	Alternate sources of income	None
Traditional, homogenous	Community structure	Recent immigrant, heterogenous
	Ecological Factors	
Small, non-threatening	Size of raiding species	Large, dangerous
Early	Time relative to harvest	Late
Solitary	Pest group size	Large
Cryptic	Damage pattern	Obvious
Narrow, one crop	Crop preference of pest	Any crop
Leaves only	Part of crop damaged	Fruit, tuber, pith, grain
Diurnal	Circadian timing of raid	Nocturnal
Limited	Damage per raid	Unlimited
Rare	Frequency of raiding	Chronic

DISCUSSION

The conflict between elephants and humans is not only pitching two intelligent and adaptable animals against each other but it is also a face-off between two complex societies competing for resources. Therefore conflict should be addressed as a whole, rather than focusing attention on the reported dysfunctional behaviour of a few recalcitrant elephants. Individuals within both communities are capable of learning although their behaviour is rooted in culture.

Lack of Quantitative Data: While the spatial distribution of conflict is highly variable and localized, there are few regional assessments of damage. Most studies are focused on high conflict areas and while they provide valuable information, there is little quantified data on the extent of the problem. Without data on the proportion of farmers affected by conflict, it is inappropriate to extrapolate data from the few project sites to an entire park or region (Naughton *et al.* 1999). In the absence of a control, most studies treat conflict as an aberration. There have only been two studies that compare the movements and foraging choices of crop-raiding and non crop-raiding elephants living in the same habitat (in Mudumalai Wildlife Sanctuary and Rajaji National Park) (Balasubramanian *et al.* 1995, Williams *et al.* 2001) whose results have been quoted at length above. Our current knowledge is inadequate in explaining the wide variation in the intensity of conflict across the elephant-human interface.

It is important to study elephant-human interactions across the landscape as conflict is not uniformly intense. For instance, there are some villages in and around elephant reserves such as in Satkosia Gorge Wildlife Sanctuary (S. Nanda[17] pers. comm.), Similipal Tiger Reserve (L.A.K. Singh[18] pers. comm.) and Indira Gandhi Wildlife Sanctuary (Kumar *et al.* 2004) that do not appear to suffer from conflict while others presumably do.

Conflict studies from India quote crop losses caused by elephants to the exclusion of other pests such as non-human primates, wild boar, wild ungulates, and birds. Almost none of the studies place crop loss in the context of total loss caused by disease, weather, rodents and other pests in that area. In Africa, studies suggest that people complain about elephants the most although they may not cause the most damage because they fear elephants more than other animals (Hill *et al*. 2002). In Kibale (Uganda), elephants and other large mammals damage less than rodents and invertebrate pests. Livestock caused almost two-thirds of the damage while the rest was caused by wildlife (Naughton-Treves & Treves 2005).

Adult men comprise the largest proportion of human mortality figures. Loss of bread-winners could be catastrophic to a family's ability to continue farming and survival. While loss of life is an extreme price of conflict and may promote local intolerance of elephants, the media sensationalizes the events further promoting intolerance among the wider public.

[17] DFO, Satkosia Gorge WLS

[18] Orissa Forest Department

Contradictions abound in the conflict literature (Table 4), and the lack of understanding of elephant foraging patterns, habitat use, movement patterns and behaviour leave us with little understanding of why elephants eat crops. Although there have been many studies, they are not comparable because they were conducted at different times, and in different areas.

There appears to be an increasing trend in conflict based on the figures maintained by the state Forest Departments. Since these are based on compensations paid out and there is widespread dissatisfaction with the process of filing compensation claims (Nath & Sukumar 1998), cases may go unreported. Conversely, with increased awareness of available compensation schemes, there may be a corresponding rise in the reportage of conflict incidents. Therefore, the Forest Department's data is inadequate for assessing conflict trends and data collection is a major need in understanding conflict (Daniel *et al*. 2008). One study conducted in Mudumalai Wildlife Sanctuary, however, indicated that conflict levels were decreasing. Damage to crops declined from 2.1% in the early 1990s to 0.98% in the 2006-2008 period (Daniel *et al*. 2008). This is attributed to a shift from subsistence crops (paddy, ragi and maize) to commercial tree crops (banana, coconut, arecanut) and increased crop protection by rich farmers while poorer ones have abandoned farming to work as farm labour.

Quantitative conflict studies use a range of methods to measure the direct effects of loss that do not allow comparison between sites. It is imperative to devise data forms that are standardized (Parker *et al*. 2007).

Lack of Qualitative Data: The challenge is to manage conflict without compromising wildlife population viability or human life and livelihoods. This can be done by combining technical expertise with local knowledge while embracing a transparent and democratic process of participatory planning (Treves 2007). The process of participatory management is likely to improve local people's perceptions (Treves *et al*. 2006). Their decreased tolerance contributes to the negative preception of conflict, and the resulting antagonism to wildlife cannot be assessed in terms of bags of grain lost or km^2 of damaged cropland. And yet a majority of studies focus largely on the frequency of visits, number of incidents, area of damage, and cost of the loss while little is done to understand or assess local attitudes and the factors that shape tolerance.

There is also a tendency among biologists lacking social science methology to conduct attitudinal surveys. These surveys may be clouded by the size of the crowd gathered for the interview, their expectations of receiving compensation (Naughton *et al.* 1999), how the interviewees perceive the surveyor, the time lag between the last conflict incident and the time of interview and several other factors such as the degree of dissatisfaction with government agencies. At best, such surveys merely represent the perceptions of the community at that particular moment in time. Villagers may identify the biologist as a representative of the Forest Department and may exaggerate their discontent of the government policies in dealing with conflict in the hope of receiving compensation.

Attitudinal surveys may highlight a disproportionate concern about damage caused by elephants and is likely to be contradicted by data gathered from quantitative surveys. While biologists are usually skeptical of people's assessments of threats and losses that they face, social scientists address the role played by the local community's vulnerabilities and coping strategies in their tolerance of conflict. It is therefore essential that trained social scientists conduct these surveys and that they be integral players in the design and implementation of the overall project, and are not just called in for limited activites. Biologists and social scientists need to work together to address the causes of conflict, and help identify viable ways to resolve the problems. Local people should be equally engaged in this process, to make meaningful mitigation an achievable goal.

In the absence of key information on the ecological and sociological drivers of conflict, attempts at selecting and designing interventions or monitoring their impact may be ineffective (Treves 2007).

Table 4: Parameters that influence elephant-human conflict as cited in literature

Note: Several studies did not indicate whether conflict was high or low so these have been included in a separate column "Conflict."

	Conflict	High Conflict	Low Conflict	No Conflict	No Correlation
HABITAT					
Fragmentation of habitat	x[19]				
Availability of extensive natural forests	x[20]		x[21]		
Degraded forests	x[22]			x[23]	
Loss of resources/habitat	x[24]				x[25]
Proximity to forests		x[26]	x[27]		x[28]

19 Nath & Sukumar 1998, Kumar *et al.* 2004, WWF 2008, Chaudhuri *et al.* n.d.

20 Sukumar 1989, Barnes *et al.* 1995, Datye & Bhagwat 1995a, Naughton-Treves 1998

21 Balasubramanian *et al.* 1995

22 Balasubramanian *et al.* 1995, Sukumar 1986, Sukumar 2003, Di Fonzo 2007

23 Balasubramanian *et al*. 1995, Sukumar 1990

24 Balasubramanian *et al.* 1995, Barnes 2002, Sukumar 2003

25 Hoare 2000

26 Sukumar 1989, Kiiru 1995, Nath & Sukumar 1998, Naughton *et al.* 1999, Nyhus *et al.* 2000, Talukdar *et al.* 2006, Lahkar *et al.* 2007, Riddle 2007, Daniel *et al*. 2008

27 Kumar *et al.* 2004, Chaudhuri *et al.* n.d.

28 Osborn 1998, Hoare 1999, Di Fonzo 2007

Access to water	x[29]			x[30]	x[31]
Poor natural forage quality	x[32]			x[33]	
Competition with humans and livestock	x[34]				
Long interface between agriculture and forest refuges	x[35]				
Transformation of elephant habitat to agriculture & plantations	x[36]				
Construction of dams in river valleys	x[37]				
Bamboo in home gardens	x[38]				
Absence of bamboo in forest fragments	x[39]				
Conservation efforts – reafforestation, protection	x[40]				
Seasonal preferences for specific habitat types	x[41]				
Rainfall	x[42]			x[43]	
ELEPHANT ECOLOGY					
Bull elephants		x[44]	x[45]		

29 Sukumar 1986, Desai & Baskaran 1996, Smith & Kasiki 2000, Harris *et al.* 2008
30 Nyhus *et al.* 2000
31 Sarma & Easa 2006
32 Sukumar 1989, Osborn 1998
33 Balasubramanian *et al.* 1995, Williams *et al.* 2001, Chiyo *et al.* 2005
34 Nath & Sukumar 1998, Silori & Mishra 2001, Madhusudan 2003, Madhusudan 2004
35 Nath & Sukumar 1998, Sukumar 2003, Madhusudan 2003, Daniel *et al*. 2008
36 Blair *et al.* 1979, Nath & Sukumar 1998, Barnes 2002, Boafo *et al*. 2004, Riddle 2007, WWF 2008
37 Sukumar 1989, Stewart-Cox & Ritthirat 2007
38 Lahkar *et al.* 2007
39 Kumar *et al.* 2004
40 Naughton *et al.* 1999, Barnes 2002, Chaudhuri *et al.* n.d.
41 Sukumar 2003
42 Osborn 1998, Nyhus *et al.* 2000, Sukumar 2003, Sitati & Walpole 2006
43 Hoare 1999, Chiyo *et al.* 2005
44 Sukumar 1990, Lahkar *et al.* 2007
45 Williams *et al.* 2001, Balasubramanian *et al.* 1995, Datye & Bhagwat 1995a, Kumar *et al.* 2004

Large home range	x[46]				
Corridors, routes and paths	x[47]				
Lack of corridors and paths	x[48]				
Colonization of new areas	x[49]				
Elephant density		x[50]	x[51]		x[52]
Availability of crops	x[53]			x[54]	
Availability of better crops (better nutrition per unit area)					x[55]
HUMAN IMPACTS					
Area of human settlement					x[56]
Human density	x[57]			x[58]	x[59]
Cash crops	x[60]				
Relationship with Forest Department	x[61]				
Aspirations of local people for a higher quality of life	x[62]				
Large families			x[63]		
Tribal communities			x[64]		

46 Williams *et al.* 2001

47 Desai 1991, Johnsingh & Williams 1999, Venkataraman 2007

48 Sukumar 1986, Desai 1991, Balasubramanian *et al.* 1995, Kangwana 1995, Nath & Sukumar 1998, Naughton *et al.* 1999, Sukumar 2003, Kumar *et al.* 2004, Sitati *et al.* 2005, Stewart-Cox & Ritthirat 2007, Riddle 2007

49 Sukumar 2003, Sarma & Easa 2006

50 Barnes *et al.* 1995, Nath & Sukumar 1998, van Aarde & Jackson 2007, Riddle 2007, Chaudhuri *et al.* n.d.

51 Balasubramanian *et al.* 1995

52 Barua & Bist 1995, Nath & Sukumar 1998, Hoare 1999, Hoare 2000

53 Hoare n.d.a, Chiyo *et al.* 2005, Sukumar 1985b, Daniel *et al*. 2008

54 Balasubramanian *et al.* 1995, Williams *et al.* 2001

55 Hoare 1999

56 Hoare 1999

57 Naughton *et al.* 1999, Barnes 2002, Kagoro-Rugunda 2004, Parker *et al.* 2007

58 Hoare 1999

59 Naughton-Treves 1998

60 M.D. Madhusudan pers. comm., Naughton-Treves & Treves 2005, Daniel *et al*. 2008

61 Lahkar *et al.* 2007, Chaudhuri *et al.* n.d.

62 Kangwana 1995, Ngure 1995, Naughton *et al.* 1999

63 Naughton *et al.* 1999

64 Chaudhuri *et al.* n.d., Nath & Sukumar 1998

CHAPTER 2

ASSESSMENT OF CONFLICT MITIGATION MEASURES

INTRODUCTION

In areas where humans and elephants coexist, human welfare is inversely related to elephant welfare. Ideally, it would be best for both species if the other were totally absent. However, there is a need to strike a balance between human welfare and elephant conservation and this is where mitigation strategies are helpful (IUCN 2006).

Identifying what drives conflict in an area is critical in determining how to resolve it. If the elephants opportunistically eat crops, they can be deflected by any of the short-term measures such as guarding and electric fencing. However, if they are forced to rely on crops for their survival, barriers are needed to stop them (Boominathan *et al*. 2008) but if these are successful, the future of such elephants is threatened (Fernando *et al*. 2005). Alternately, problem elephants need to be removed (Sukumar 1989, Boominathan *et al*. 2008). The choice of intervention should not only depend on effectiveness but also sustainability (Treves *et al*. 2006).

Elephant-human conflict mitigation measures fall under two categories: the short-term (tactical) ones that address the symptoms and the long-term (strategic) solutions that address the underlying causes (Boafo *et al.* 2004, Parker *et al.* 2007). However, targeting problem elephants and applying short-term conflict mitigation at the interface between expanding agriculture and diminishing elephant range will achieve only limited success (Hoare 1999, Parker *et al.* 2007).

1. SHORT-TERM METHODS

1.1 Traditional or Local Methods

Traditional methods are devised by local communities and these include prayer, noise (shouting, beating drums, burning bamboo, bursting fire crackers), light (fire at entry points to fields, powerful spotlights), and missiles (stones, spears). Platforms on trees (*machan*) or huts at ground-level are used as look-outs (Nelson *et al.* 2003, Fernando *et al.* 2008). Guarding involves several degrees of organization, from individual farmers guarding their own fields to groups of farmers guarding several fields cooperatively (Fernando *et al.* 2008).

Fig. 4: Fire crackers used to scare away elephants in Assam

Fig. 5: *Machans* to guard fields

In Assam, some NGOs have organized Anti-Depredation Squads to chase elephants. Members of these squads keep watch from *machans* and burst crackers, and shine spotlights when elephants approach. Very often, youth vigilante groups called Village Defense Patrols

(for fighting insurgency) pitch in to ward off elephants (Ecosystems-India and Hiten Baishya[65] pers. comm.).

Pros: Traditional methods of chasing elephants utilize locally available materials and are, therefore, cheap. A study that compared defended and undefended fields concluded that guarding reduces crop loss significantly. Groups of men are more aggressive and faster in chasing elephants away from fields than individual farmers, which may contribute to the reduced crop loss (Nelson *et al.* 2003, Fernando *et al*. 2005). Elephants that are not intent on eating crops can be easily dissuaded from crop fields by these simple measures. Guarding and patrolling is the simplest and most effective means of crop protection (Desai 2002).

Fig. 6: A community scaring squad posing in front of their *machan* and displaying their tools of the trade – spotlight, fire crackers and a pipe to amplify the explosion of the cracker.

Cons: The inability of farmers to stay awake for several nights gives elephants the opportunity to sneak into croplands (Boominathan *et al*. 2008). People endanger their lives by getting too close to elephants or directly confrontating them (Nath & Sukumar 1998, Desai 2002, Nelson *et al.* 2003, Boafo *et al.* 2004, Fernando *et al.* 2008) and some villagers in north Bengal have even given up actively guarding their fields for fear of their lives (interview with villager[66], Boominathan *et al*. 2008).

If these measures are used repeatedly with little variation, eventually they become ineffective (Parker *et al.* 2007) as elephants get used to measures that don't hurt (Nath & Sukumar 1998, Hoare 2001a). But should any of these methods cause injuries, they become aggressive

[65] WWF-India, Guwahati

[66] Chipra village, Buxa, West Bengal

(Boafo *et al*. 2004). On the other hand, elephant herds panic when chased and damage more crops (Sitati *et al.* 2005, M. Ananda Kumar pers. comm.). Frequently, the job of chasing elephants falls on the farmers whose land abuts the forest while others take little interest in cooperating (Daniel *et al*. 2008). Some commonly used methods in Assam such as flaming arrowheads and spears, and homemade guns grievously injure the animals (Sarma 2007).

Considerations: Watch towers need to be well-positioned to be effective (Di Fonzo 2007). Spotlights are effective when used judiciously and strategically but not when elephants are pinned by light beams from different directions (Bibhuti Lahkar[67] pers. comm.). If the spotlights are weak, or small torches are used, elephants are provoked to attack (a Bengali villager[68]). In Assam, the Forest Department aids villagers by building watch towers and distributing fire crackers, spotlights, and kerosene but in many cases these are monopolized by the dominant community or family within the village. They may prevent the elephants from using their traditional paths thereby resulting in more damage to a poorer villager (M.C. Malakkar[69] pers. comm.). Traditional methods work by merely displacing the problem to another area (Nelson *et al*. 2003, Sukumar 2003).

Guarding and patrolling require the farmer to stay awake which affects the next day's work productivity (Sukumar 1989). Trials in Transmara (Kenya) showed a 93% decline in crop loss in guarded fields compared to 31% background decline (caused by increased rainfall) in control farms (Sitati & Walpole 2006).

Elephants are also known to stamp out fires, kick the burning logs out of the way or douse them with water. Therefore fires by themselves may not act as a deterrent (Chong & Dayang Norwana 2005, M. Ananda Kumar[70] pers. comm.). Combinations of two or more methods may work for a short time (Nelson *et al*. 2003, Chong & Dayang Norwana 2005, Lahkar *et al*. 2007) however, evaluation is subjective as several measures may be used simultaneously (Hoare2001a).

Bulls appear to lose their fear of these methods more readily than females (Fernando *et al.* 2008). Encouraging local communities to guard their own crops is tantamount to encouraging a confrontation between elephants and people which has led to loss of human and elephant lives. Therefore it is ethically challenging to recommend this as a conflict mitigation measure.

[67] Aaranyak, Assam

[68] Golma Tea Estate, near Siliguri, West Bengal

[69] Chief Conservator of Forests (Wildlife), Assam

[70] Nature Conservation Foundation, Mysore

1.2 Early Warning

It is easier to chase elephants before they enter fields and therefore, most damage can be averted (Sitati *et al.* 2005). Guarding from watch towers, patrolling and trip wire alarms provide farmers with advance warning of approaching elephants. Once the animals are detected, active crop guarding devices using light and noise are deployed to chase them away.

1.2.1 Guarding and Patrolling

See 'Traditional methods' for more details.

1.2.2 Trip Wire Alarms

In its simplest form, it is no more than a string fence with bottles, tin cans with pebbles and bells tied at frequent intervals (Fernando *et al.* 2008). At its most sophisticated, it involves a nylon cord with a trip switch connected to electricity or battery powered alarm. When an elephant pushes against the cord, it trips the switch, setting off the alarm (O'Connell-Rodwell *et al*. 2000). In the Mudumalai area (Tamil Nadu), farmers use a local variation which sets off a fire cracker instead of an alarm (Boominathan *et al*. 2008).

Pros: Trip wire alarms are temporarily effective for individual, small farms (O'Connell-Rodwell *et al*. 2000, Nelson *et al.* 2003, Sitati & Walpole 2006), especially in detecting family herds (Lahm 1995 in Kulkarni *et al.* 2007). They allow farmers to sleep while maintaining a modicum of vigilance (Nelson *et al.* 2003, Chong & Dayang Norwana 2005, Parker *et al*. 2007).

Cons: Across a landscape, trip wire alarms made no difference to the overall number of conflict incidents (Nelson *et al.* 2003) as they deflect crop raiding elephants to other fields (Nelson *et al.* 2003, Kulkarni *et al.* 2007). In some cases, bulls investigated the source of sound instead of fleeing (Lahm 1995 in Kulkarni *et al.* 2007).

In Sonitpur district of Assam, trip wire alarm systems are set up largely to protect houses. In some cases, elephants avoid them presumably because they mistake them for electric fences. At one location, a trip wire alarm system was badly damaged as the wire snagged on cattle horns, while at another site villagers were reluctant to maintain it, allowing tall grass blowing in the wind to set off false alarms (Ecosystems-India pers. comm.).

In Rajaji National Park, trip wire alarms were not successful as the farmers found it hard to determine which of the several alarms had sounded and therefore could not pinpoint the location of elephants (Ujjal Sarma[71] pers. comm.).

Considerations: Electrical systems are difficult to maintain in high rainfall areas (Parker *et al*. 2007) while the alarms did not deter elephants (Fernando *et al.* 2008).

[71] Wildlife Trust of India, Delhi

1.2.3 Informant

The average annual human mortality of three was reduced to just one in 2 years in Valparai (Tamil Nadu). Researchers studying elephants provided the location of the herds everyday to the local cable television channel which broadcast the information innovatively, in the form of a ticker. At least two tea company managements agreed to stop chasing elephants from one estate to another and people were instructed to stay away from elephants. Storing grain in a separate building and moving ration shops away from residential areas reduced property damage (M. Ananda Kumar, pers. comm.). When the 2-year study wrapped up, information on elephant movements was no longer available, and resulted in one person getting killed accidentally. This highlights how conflict in one situation was almost completely mitigated with minimal intervention (M.D. Madhusudan pers. comm.). However, it should be noted that there are few elephants and hardly any food crops on the Valparai plateau. The prevalence of tea plantations allows elephants to be detected easily.

1.3 Barriers

Wherever conflict is severe, barriers are popular as they separate people and elephants. The commonly used types are fences and trenches (Nelson *et al.* 2003).

The earliest known barrier against elephants may have been the network of earthen walls and ditches constructed around 1150 AD in the rainforests of Benin, Africa. Sungbo's Eredo is Africa's largest single ancient monument, 160 km long enclosing an area of 1,400 km^2. In Benin City, even more elaborate earth works extend 16,000 km covering an area of 6,500 km^2 and are thought to be the largest single archaeological phenomenon on the planet (Clutton-Brock 1999, Pearce 2005).

Pros: It serves to keep elephants away from farmland (Fernando *et al*. 2008).

Cons: Villages surrounding those protected by barriers suffered an increase in conflict (Chong & Dayang Norwana 2005, Sitati & Walpole 2006: "four-fold increase"; Fernando *et al.* 2008) indicating that elephants were being displaced to neighbouring areas. Barriers suffer a high rate of failure as they are undermined by people who need access to forests. They cut the fence wires or created bridges across trenches (Nath & Sukumar 1998). When habitual elephant routes are blocked, they are prone to failure (Sitati & Walpole 2006).

Considerations: Barriers are effective when (1) they do not deflect elephants to other areas, (2) do not cut off their access to parts of their habitat, and (3) elephants are not dependent on crops (Chong & Dayang Norwana 2005). While stabilizing trenches with concrete walls

Fig. 7: The 10-km long Chila-Motichur canal near Rajaji National Park, Uttaranchal, is paved with concrete thus preventing elephants from crossing and impeding gene flow and access to the waters of the Ganges nearby. However, bulls began to use the narrow bridge across the canal to cross over, and more recently family herds too have learnt to use the bridge.

makes them effective, it could be dangerous to elephants that fall into them (Fernando *et al*. 2008). Badly planned barriers are just as bad as "development" barriers such as highways, rail roads or canals; denying access to a critical water source or foraging area can be detrimental to elephant survival and may even aggravate conflict (Fernando *et al*. 2008, Boominathan *et al*. 2008).

Barriers should be constructed along ecological boundaries so elephants are restricted to one side of the fence (Fernando *et al*. 2008). For example, Reserved Forests are administered by the Territorial Division of the Forest Department, whereas the Wildlife Sanctuaries and National Parks are administered by the Wildlife Division. Should the Wildlife Division construct a barrier around the forest under its jurisdiction, it effectively separates the Reserved Forest from the National Park or Sanctuary. In Bandipur, for instance, a trench separates the Reserve Forest from the National Park and there are elephants on both sides of the trench. Instead of excluding elephants from the human landscape, such barriers prevent the animals from moving between forests. However the trench is undermined in several locations (pers. obs.).

Barriers around forests prevent the natural dispersion of animals in response to over-crowding or compression (Graham 1973). Elephants encountering an obstacle tend to walk along it, sometimes for several kilometers. To be effective, all gaps including those that accommodate streams and roads need to be secured (Fernando *et al.* 2008). Both electric fences and trenches are unsuitable for hilly, rugged, rocky terrain and high rainfall areas. Besides they are expensive, invasive, and labour intensive (M. Ananda Kumar pers. comm.). Barriers work when there is a sharp edge between forests and farmlands and are unlikely to work in a mosaic of forest fragments and fields as in Orissa.

1.3.1 Electric Fences

Pros: They are seen as the most effective method of containing elephants within an area (Grant *et al.* 2008). Corridors connecting elephant-use areas and specific buildings such as grain stores can be protected by electric fences (Hoare 2001a, Omondi *et al*. 2004, T.R. Shankar Raman pers. comm.).

Fig. 8: A defunct electric fence

Cons: Electric fences are seen by local people as a permanent solution and there is a temptation to install fences wherever there is conflict. They are expensive to install (Hoare 2003), require constant and high maintenance

(Fernando *et al.* 2008) and the owner needs some technical expertise (Chong & Dayang Norwana 2005, Gunaratne & Premarathne 2006). In one case, comparison of conflict levels before and after fence construction indicated that overall conflict levels remained the same in the region (Smith & Kasiki 2000) and in others, conflict was displaced to other areas (Sitati & Walpole 2006) which may not have suffered any conflict until the installation (Blair *et al.* 1979, Barua 1995, O'Connell-Rodwell *et al*. 2000, Chong & Dayang Norwana 2005, Ecosystems-India pers. comm.).

There is a high rate of failure of electric fences. Of 49 fences examined in West Bengal, only 12 were effective (Chowdhury *et al*. 1998), whereas in Karnataka and Kerala, approximately 19 of 37 fences were functional (Nath & Sukumar 1998). Fences that illegally tap into mains AC power supply have killed crop raiding elephants.

Considerations: Fences need to be electrified before dusk and well after dawn and throughout an overcast day when elephants may test it. Once an elephant breaches a fence, it will do it again (Chong & Dayang Norwana 2005). Smaller fencing projects are both cost and functionally effective (Hoare 2001a). A comparison between electric fencing projects in different parts of Sri Lanka indicated that differences in land-use patterns, farming practices, geographical variations, and a range of social factors coupled with the temperament of the resident herds contribute to the efficacy of electric fences (Gunaratne & Premarathne 2006).

There are very few published cost-benefit analyses of electric fences (Sukumar 2003). Unless the value of the saved crops exceeds the cost of installation and maintenance of an electric fence over the years, it cannot be rated as cost effective (Bell 1984 in Masunzu 1998). On the basis of figures quoted for the Malaysian oil palm plantations in the 1970s, electric fencing saved US$74 for every dollar invested over a five year period, but this rate of return is possible only for commercial crops. Since it is the poorer farmers who are least able to withstand the losses engendered by conflict, it is unlikely that at current costs, an electric fence would bring any relief to them (Sukumar 2003).

Electric fences may not be able to mitigate conflict single-handedly. In Negande (Zimbabwe) an electric fence reduced crop damage by 65% in the first year, but the following year damages increased by 42% indicating that other factors may play an active role (Grant *et al.* 2008). Around Yala National Park (Sri Lanka), although elephants break fences, most of the crop damage is caused by feral and domestic buffaloes who enter the farms thus left unprotected (Manori Gunawardene pers. comm.).

The various factors that determine the efficacy of electric fences are listed below (Table 5).

Table 5: Factors that contribute to the effectiveness of an electric fence

	Effective	Ineffective	No correlation
Good layout – strategic placement	x[72]	x[73]	x[74]
Small size	x[75]		
Encircling (not linear) design Encircle fields and/or settlements	x[76] x[77]		
Good maintenance	x[78]		
Construction	x[79]		
High voltage Low voltage	x[80] x[81]		x[82]
Only in combination with active protection	x[83]		
High rainfall	x[84]	x[85]	
Non-rocky soil	x[86]		
Non-hilly terrain	x[87]		
Private ownership	x[88]		

[72] Kangwana 1995
[73] Balasubramanian *et al.* 1995, Sukumar 2003, Chong & Dayang Norwana 2005
[74] Thouless & Sakwa 1995a
[75] Hoare 2001b
[76] O'Connell-Rodwell *et al*. 2000, Hoare 2003
[77] Hoare 1995
[78] Balasubramanian *et al.* 1995, Nath & Sukumar 1998, Gunaratne & Premarathne 2006
[79] Nath & Sukumar 1998, Gunaratne & Premarathne 2006
[80] Thouless & Sakwa 1995b
[81] Thouless & Sakwa 1995b
[82] Sukumar 2003, Kioko *et al*. 2008
[83]Balasubramanian *et al.* 1995, Chong & Dayang Norwana 2005
[84] Nath & Sukumar 1998
[85] M. Ananda Kumar pers.comm.
[86] Nath & Sukumar 1998
[87] M. Ananda Kumar pers.comm.
[88] Barua 1995, Nath & Sukumar 1998, Parker *et al.* 2007

Elephants' learning capacity and behavioural response	x[89]		
Availability of natural forage	x[90]		
Unpalatable crops	x[91]		
Proximity to forest		x[92]	

Layout: Before installation of a fence, the local ecology and movement of elephants should be well-established so ecological areas to which elephants require access are not cut off (Kangwana 1995, Hoare 2003). Maintenance of traditional routes is critical to the success of electric fences (Gunaratne & Premarathne 2006). Installing electric fences along administrative boundaries instead of ecological boundaries aggravates conflict as it may split elephant populations (Fernando *et al.* 2005). In such cases, the remaining animals cause more conflict than before the split (Gunaratne & Premarathne 2006). The efficacy of the fence is also determined by the proximity of the forest where crop raiders can seek shelter, and which harbour a high density of elephants (Kioko *et al*. 2008).

The West Bengal Forest Department installed a 70 km electric fence to stop the elephants from Dalma Wildlife Sanctuary (Bihar) from crossing the state boundary. The elephants thus held in check damaged crops in Bihar until the local people surreptitiously cut the fence to mitigate the problem (Datye & Bhagwat 1995d)!

Design: An encircling fence is better than a linear one which funnels elephants to areas at either of the open ends (O'Connell-Rodwell *et al*. 2000, Hoare 2003, Kioko *et al*. 2006). A 30 km long linear electric fence did not dissuade elephants from entering crop fields in Tsavo, Kenya. Since they have well-established home ranges, the pachyderms were not put off by the long detour (Smith & Kasiki 2000).

Studies indicate that electric fences are more effective in keeping out elephants (from agricultural areas) than containing them (inside parks) (Hoare 1995). Yet conflict mitigation recommendations for some areas include fencing elephants inside parks (Kulkarni *et al.* 2007). Limiting elephants to Protected Areas is neither a viable conservation strategy nor a successful tactic for mitigating conflict (Fernando *et al.* 2005). Besides, enclosing a forest requires a long fence that is likely to be ineffective (Nelson *et al.* 2003). Since most of the elephant range lies outside Protected Areas, enclosing them within small areas may lead to inbreeding (Archie *et al.* in van Aarde *et al.* 2008) and overabundance within fenced parks (van Aarde & Jackson 2007) as elephant populations can continue to grow even if the quality

[89] Thouless & Sakwa 1995b, Sukumar 2003
[90] Blair *et al.* 1979, Rice 1990 in Thouless & Sakwa 1995b, Fernando 1995
[91] Nelson *et al.* 2003
[92] Kioko *et al*. 2008

and quantity of forage is poor (Owen-Smith 1988 in Grant *et al.* 2008). However, the Forest Department is constrained to install fences on government land rather than private land (T.R. Shankar Raman[93] pers. comm.).

When the human population increases and the resulting demand for land rises, fences were perceived to offer security from wildlife depredations. Therefore fence construction promoted human settlements, while agricultural practices expanded, intensified, and became commercialized with the increased use of chemical fertilizers and pesticides leading to pollution of rivers. The study in Kenya also found that fencing led to habitat becoming degraded and water resources becoming over-used while at the same time aggravating human-human hostility (between pastoralists and agriculturalists) as well as human-wildlife conflict. Yet the failure of badly maintained fences eroded support for conservation. Even the intact sections of an electric fence were rendered ineffective by the damaged sections (Okello & D'Amour 2008).

Type: Electric fences range from a simple, single strand to sophisticated 11 or 12 strand types; and none were elephant proof (Thouless & Sakwa 1995b). While high voltage fences will keep out most elephants, low voltage ones (i.e., poorly maintained) may merely irritate an elephant provoking it to destroy a section of it (Hoare 2001a). One study (Kenya) surmised that it did not notice any correlation between voltage and fence breakage because the habitual raiders knew how to break fences without getting a shock (Kioko *et al*. 2008).

Ownership: If a government agency installs the fence, local people see it as a "government fence" and do not participate in its maintenance. Maintenance of electric fences by the government is unsustainable. Therefore when the community sets it up and has ownership, it has a better chance of success, albeit short-lived (Parker *et al.* 2007). Just like the electric fence it seeks to maintain, community maintenance has a long chain of responsibility which breaks down at the weakest link. Vandalism and theft of components not only deactivate community fences but the constant need to replace parts makes them unsustainable (Hoare 2003).

In Assam, the Forest Department is promoting a scheme called '*Janata* fence'. The Department supplies the materials and trains the villagers to install and maintain the fence (M.C. Malakkar pers. comm.). Unless the community is homogenous and small, the collective maintenance of electric fences is a challenge (M. Ananda Kumar pers. comm.). In one case, the dominant family of the village monopolized the energizer and battery during the fallow season to power their television and never returned it to the community (interview with a villager[94]). In other cases, government-subsidized electric fences provide a ready source of good steel cables which are stolen by villagers for their personal use (interviews

[93] Nature Conservation Foundation, Mysore

[94] Tiamari village, North Bengal

with villagers[95]). In Sri Lanka, initial participation levels could not be sustained over the years (Gunaratne & Premarathne 2006).

Private ownership works better than government or community ownership (Nath & Sukumar 1998, Parker *et al.* 2007). Of the 18 private fences examined in Kodagu and nearby areas, more than 70% of the owners were satisfied with its performance (Nath & Sukumar 1998). Only farmers who own the land they farm would invest in an electric fence. It is too expensive for a sharecropper or tenant farmer (M.D. Madhusudan pers. comm.). Electric fences may cause a greater social problem if the fences of the richer farmers deflect elephants to the crops of farmers who can least afford the loss.

Elephant past experience: In Kenya, electric fences were effective for many years when there was a policy of shooting fence-breaking elephants (Thouless & Sakwa 1995b). However, the proportion of fence breakers in a population is unknown. Even a simple fence encircling a maize field in the middle of an elephant corridor was effective for 10 years as a result of this policy (Thouless & Sakwa 1995a).

Elephants learn to break fences using a variety of methods, from toppling trees onto the fence to using their non-conductive tusks to rip the wires. Elephants also break fences by holding the wooden posts with their trunks and kicking the middle of the post without touching the live wire (Choudhury 1999). If trees are used as fence posts, elephants push them down to enter the fields (Boominathan *et al*. 2008) or merely step on the wires with their thickly soled feet (Fernando *et al*. 2008). There are also anecdotes of elephants ripping fences by running into them (interview with a villager[96]). In one study in Kenya, the lower third of the tusks of 8 bull elephants was removed to reduce fence breakage. These de-tusked elephants went on to break 20 fences in the subsequent 5 days (Thouless & Sakwa 1995a).

The unknown: Elephants may go through a 6 strand, 7 kV electric fence but respect a non-electrified 2 strand fence (Kangwana 1995, Thouless & Sakwa 1995b). While high voltage fences were generally effective, some low voltage (3-4 kV) fences were also effective. Fences that were well-built, well-maintained, adequately powered and earthed were broken repeatedly (Thouless & Sakwa 1995b). It is not known how to make previously non-functional fences effective; mere technical modifications are not adequate. There is no guarantee that technologically sophisticated fences (using many strands, high voltage) will continue to remain effective (Thouless & Sakwa 1995a).

Electric fences are at best psychological barriers which can be used to demarcate "no go" areas rather than act as physical barriers. Therefore it is better to focus on active management than high specification fences (Thouless & Sakwa 1995b).

[95] West Bengal

[96] West Bengal

1.3.2 Elephant Proof Trenches (EPT)

Trenches should be wide and deep enough to prevent elephants from crossing over it (Fernando *et al.* 2008).

Pros: They are effective in protecting small areas or buildings such as grain stores (Omondi *et al*. 2004) and work well in combination with electric fences (Desai 2002, Kulkarni *et al*. 2007, Parker *et al*. 2007).

Cons: EPTs are plagued by some of the same shortcomings as electric fences. Elephants are known to kick the unearthed spoil into the EPTs until they can cross it (Thouless & Sakwa 1995b, Chong & Dayang Norwana 2005). Even trenches made to specifications have been crossed by elephants. They select a point, create steps by kicking in the earth (Blair *et al.* 1979). EPTs are expensive to excavate, require regular maintenance (Nelson *et al.* 2003) and are ineffective near streams (Nyhus *et al.* 2000). Of 23 trenches examined in Karnataka, none were found to be functional and about half the crossing points had been created by people (Nath & Sukumar 1998). Even trenches used in combination with electric fences have been rendered ineffective by poor design, construction, and maintenance (Desai 2002).

Considerations: They are unsuitable for sloping terrain, wet areas, or where soil is prone to erosion. Planting the unearthed spoil with plants can prevent the loose dirt from washing into the trench (Chong & Dayang Norwana 2005). Lack of cooperative maintenance of trenches led to their failure. Whatever the length of a trench, if its integrity is not maintained for several kilometres at a stretch, it was prone to failure (Nath & Sukumar 1998). Elephant calves are known to fall into trenches, and if they were reinforced with concrete may prevent their escape (Fernando *et al*. 2008).

1.3.3 Walls

a. Rubble wall

Construction of rubble walls is limited by the availability of stones. They are expensive to make and easy to push over unless bound with chain-link nets (Sukumar 2003). Elephants are known to push down stone walls with their chests (Thouless & Sakwa 1995b) or destroy them by removing the rocks (Omondi *et al*. 2004). A 3.5 km stone wall was broken 101 times in 3 months in Kenya. In another ranch, stone walls were moderately successful as "stern action" was taken against animals that breached it (Thouless & Sakwa 1995b). They work well in combination with electric fences (Hoare 2003).

b. Wall

In Tezpur (Assam), two fighter aircraft belonging to the Indian Air Force were damaged by elephants. A huge boundary wall was built and now the elephants have been denied access to a Reserve Forest close to the airport. The deflected elephants have started raiding an area that traditionally had low levels of conflict (Ecosystems-India pers. comm.).

1.3.4 Punji Sticks

Setting a number of bamboo stakes or iron rods, with the sharp end pointing outwards at an angle, at regular intervals on the ground for a width that is wider than an elephant's stride is known to prevent elephants from crossing (Andau & Payne 1992 in Chong & Dayang Norwana 2005). Installation is labour intensive and time consuming (Parker *et al*. 2007). These spikes will cause grievous injury to elephants. In 2003, this measure was used to control the movement of elephants in the Chandaka Wildlife Sanctuary (Orissa), no assessment of its efficacy is available (Biswajit Mohanty pers. comm.).

1.3.5 Covered Trenches

Elephants are insecure about stepping on trenches covered with flimsy mats, branches or leaves, even if the trenches are shallow and no more than 30 cm deep (Chong & Dayang Norwana 2005, Parker *et al*. 2007). They are reportedly successful in India. These shallow trenches too require maintenance, are labour intensive to create and, in high rainfall areas may be prone to erosion (Parker *et al*. 2007).

1.3.6 Mechanical Barriers

The elephants of Addo Elephant Park in South Africa are contained in a 1640 km^2 area that is fenced with tram rails and lift cables. Between 1954 and 2003, it was broken only once by a bull. The cost of fence was about US $ 10,000 per km in 2007 (Graham Kerley pers. comm.). Outside Bannerghatta National Park (Karnataka), an electrical station is protected by a fence made of railway lines. To some extent, elephants have been prevented from being killed on railway tracks in North Bengal using a similar fence. Although it is expensive, maintenance costs are relatively low. If sufficient provisions are made for cattle movement, local people may accept it (pers. obs.).

Fig. 9: The Armstrong Elephant Proof Fence at Addo National Park, near Port Elizabeth, in South Africa. This mechanical barrier, constructed in 1954 by Graham Armstrong, from discarded pieces of tramline, has stood the test of time in containing a growing population of elephants within the park.

1.4 Experimental

Elephants were deterred more rapidly by experimental methods than traditionally used methods (Osborn & Parker 2002a).

1.4.1 Bio-Fence

Thorny plants such as agave, and cacti have been tried in Sri Lanka and were found to be ineffective. In fact, one of the preferred food plants of elephants is *Acacia eburneum* which has 3-6 cm long thorns. The elephants' thick hides are impervious to thorns (Fernando *et al*. 2008). Elephants have been recorded eating agave (Hoare 2001a).

1.4.2 Habitat Enrichment

Planting food trees in elephant habitat and corridors to augment resources available to elephants has been recommended (Sivaganesan & Sathyanarayana 1995, Chong & Dayang Norwana 2005, Talukdar *et al*. 2006). While one recommendation was to regenerate bamboo along stream courses (Sivaganesan & Johnsingh 1995), another was to cultivate "lure crops" such as bananas and sugarcanes (Chong & Dayang Norwana 2005). It is not practical to grow such crops and trees over large areas and its limited long term effectiveness is limited (Osborn 1998, Kulkarni *et al.* 2007). In West Bengal, the Forest Department planted bamboo and fodder grass on a large scale for elephants. While the plantations raised in Jaldapara Wildlife Sanctuary succeeded in encouraging the animals to stay within the park, the efforts were frustrated by villagers who grazed their livestock, illegally collected firewood, fodder, and caused wild fires. Besides, it takes some time for such supplementary feed to grow (Barua 1995). Elephants are known to eat up to 400 different species of plants (Olivier 1978) and require up to 200 kg of forage a day per animal. Therefore, to restock an area with even a fraction of these species would be a challenging task. Besides, in a given area, different clans use plant species variously depending on their preference (Baskaran 1998 in IUCN 2006).

1.4.3 Artificial Water Sources

Elephant distribution is influenced by the presence of surface water and rivers, and it has been suggested that manipulating water sources could influence elephant presence (Desai & Baskaran 1996). In Kruger National Park (South Africa), Etosha National Park and Khaudum Game Reserve (Namibia), the home range of elephants shrank as the density of waterholes increased (Grainger *et al*. 2005 in van Aarde *et al*. 2008). However, in Kruger (South Africa) where surface water is widely available, bulls used the artificial waterholes while the herds were focused around river systems (Smit *et al*. 2007 in Grant *et al.* 2008). Water provisioning may render previously unused habitat attractive, resulting in redistribution of elephants. It may also lead to an increase in population and density of elephants in that area which may affect the quality of the forest vegetation (Desai & Baskaran 1996, Sukumar 2003, van Aarde *et al.* 2008), and dramatically impact the biodiversity of the surrounding area (Sivaganesan & Sathyanarayana 1995, Smith & Kasiki 2000) by unnaturally increasing herbivore numbers,

compromising system resilience and degrading the herbaceous plants (Walker *et al*. 1987, Grant *et al*. 2008).

1.4.4 Chemicals

Chemicals such as Lithium chloride, quinine sulphate, chloroquine hydrochloride, tannic acid, pheromones, and animal scents have been suggested but more research is needed (Chong & Dayang Norwana 2005). A chemical deterrent tried in the mid-1970s was not effective in the high rainfall areas of northeastern India (Lahiri-Choudhury 1991).

1.4.5 Other Experiments

Playing elephant alarm calls has sometimes elicited aggressive reactions or indifference from small groups of crop eating bulls, but the results are largely inconclusive. They may become inured to frequent usage (Nelson *et al.* 2003). The playback technology is complicated and the equipment expensive (Hoare 2001a).

Playback of tiger calls in a large farm in south India apparently deterred elephants but no further information is available. Neighing of horses, and spraying tiger urine have been tried and the results are inconclusive. Preliminary trials with *musth* secretions were ambiguous (Sukumar 2003). Experiments with tear gas were conducted in north Bengal in 1975 but the evidence was not conclusive (Lahiri-Choudhury 1991). In Valparai, decorative twinkling lights protected one grocery store but was ineffective when replicated in other areas of the plateau. Spraying phenyl on buildings also did not repel elephants (M. Ananda Kumar pers. comm.).

In Nepal, beehives along fences have reportedly been tried (Kulkarni *et al*. 2007), but is of doubtful efficacy as elephants usually raid at night when bees are inactive (Fernando *et al*. 2008).

1.4.6 Satellite Telemetry

There have been attempts to track elephants using satellite collars in northern West Bengal. Based on the direction of the elephants' movements, it is possible to predict if the animals are headed towards a village and to provide the inhabitants with advance information. But to be relevant and timely, data needs to be updated more than once every 24 hours (Venkataraman *et al.* 2005). The high costs of the equipment limits its use to no more than a small number of animals (Fernando *et al.* 2008). Despite its limitations, the West Bengal Forest Department found the information useful in containing elephants inside forest patches during the peak crop raiding seasons of May-June and November-December.

1.4.7 Aversive Conditioning

Use of emetics in unprotected crops has been suggested (Chong & Dayang Norwana 2005) but little is known of such experiments.

1.4.8 Alternate Livelihoods

Providing alternate livelihoods such as bee keeping (Bibhuti Lahkar pers. comm.) have been suggested. While these may not solve conflict they may provide resilience to the affected communities (Daniel *et al*. 2008).

1.4.9 Geo-Fence

Known crop-eating elephants are collared with mobile phone SIM cards and a virtual "geofence" is set up. As soon as the elephant approaches the edge of this virtual fence, a text message is sent to a ranger who rushes to the spot to chase away the elephant. So far only two elephants have been collared for this purpose in Kenya.[97]

1.4.10 Chilli

Trials with chilli based products have been conducted in Africa. Chilli powder or paste is mixed with engine oil or grease and smeared on ropes which are then tied around the perimeter of farms. One farm located in an elephant corridor was protected by a chilli rope for 2 years although elephants made 9 attempts. A nearby farm was raided 7 times and was subsequently abandoned. Chilli ropes are surprisingly successful for being so feeble. It allows some easing of night guarding effort (Sitati & Walpole 2006). Chilli spray has been tested as a repellent and may provide short-term relief (Osborn 1998).

Fig. 10: *Bhut jholokia*, the world's hottest chillies.

Reportedly the world's hottest chillies, the Tezpur chilli (locally called *bhut jholokia*) grows in Assam besides other parts of the Northeast[98]. Fresh chillies cost Rs. 150 to Rs. 200 per kg and it makes better economic sense for villagers to grow them than to buy them from the market to chase elephants (Anupam Sarmah[99] pers. comm.).

[97] http://www.olpejetaconservancy.org Accessed on 13 October 2008

[98] http://www.sciencedaily.com/releases/2007/10/071026162420.htm Accessed on November 6, 2008

[99] WWF, Guwahati

The Assam Haathi Project (AHP) is experimenting with chilli-based deterrents such as smoke, spray, and rope. For the chilli rope to be effective, chilli paste has to be re-applied every fifteen days in the dry season, and every week during the rains. Ropes made of coir were found to be better than jute. However, the chillies are so pungent that grinding the paste is an unpopular task. The AHP has distributed about 5000 Tezpur chilli seedlings to promote chilli cultivation to provide an alternative source of income as well as to be used as a deterrent. Besides *bhut jholokia*, other kinds of chilli used are *jhati jholokia*, a cheaper variety which is good for producing smoke, and *khunkhuni jholokia* or *maim jholokia* which is mixed with *bhut jholokia* to make the paste. In Goalpara, the AHP is conducting trials of chilli spray (mixture of chilli paste and water) on paddy crop (Ecosystems-India pers. comm.).

A comparative study of the efficacy of chilli and tobacco-laced fence in various rainfall regimes was conducted in forest villages of Hosur Forest Division (Tamil Nadu), Wyanad Wildlife Sanctuary (Kerala) and Buxa Tiger Reserve (West Bengal) in 2006. The results indicate that the fence is more effective in low rainfall areas and in deterring elephant herds more than bulls. The study concluded that such chemical deterrents should be used as a novel weapon against elephants just prior to crop harvest (when damage typically peaks) in order to minimize the chances of conditioning; it is also possible that such an olfactory-irritating fence could be a psychological rather than physiological barrier (Chelliah *et al*. 2010). An earlier study in Malaysia had similarly concluded that chilli oil mixed with grease and applied on simple string fences is not suitable for wet climates (Chong & Dayang Norwana 2005).

Burning chilli laced briquettes to create a pungent smoke has limited practical use as it is dependent on the prevailing wind direction and dissipates quickly (Fernando *et al.* 2008).

Elephants are capable of overcoming chilli based deterrents as they have sensors at the tip of their trunks which may be capable of detecting irritants. If they detect the presence of chillies, elephants may be able to seal their trunks, much as humans hold their noses, for short periods of time to prevent inhalation (Hoare 2001a, Rasmussen & Riddle 2004).

There is a lot of variation in the chilli studies being carried out across the country. Different varieties with varying potency are delivered using a range of methods. Usage of chillies low in the Scoville scale may predispose the experiments to failure.

1.4.11 Long Awned Paddy Variety

In 2006, the Central Rice Research Institute in Cuttack developed a long awned paddy cultivar[100] specifically for cultivating in elephant areas of Orissa and Assam. There is no further information on its efficacy and usage.

[100] http://www.crri.nic.in/CRRI_newsletter/crri_nlaprjun06.pdf Accessed August 28, 2010

1.5 Methods Used by Forest Departments

The Forest Departments aid villages by chasing away elephants using scaring squads, driving them across the landscape into forests, and removing those perceived to be dangerous, either by capture, translocation or killing.

1.5.1 Scaring Squads

During the crop raiding season, every division of the Forest Departments of West Bengal and Assam forms a squad to respond to calls from villages seeking help in chasing away elephants from the fields. These operations invariably take place at night (almost every night during peak raiding season), and in immediate response to complaints. They use jeeps, *kumkis*, powerful spotlights, sirens, and in extreme cases, fire blanks to chase the wild elephants from the area. Every division has one unit but when calls come from different areas then the squad is constrained to go to one location at a time. So villagers have to be trained to manage the problem on their own (M.C. Malakkar pers. comm.).

Pros: Elephants recognize the authorities' stronger tactics (Hoare 2001a, Nelson *et al*. 2003); they will not budge at the sound of any vehicle but they move as soon as they hear the sound of the squad's jeep (Gautam Basu pers. comm.). It has some public relations value (Nelson *et al*. 2003).

Cons: The squads provide a few weeks' respite before elephants return, and cannot be considered part of any sound conflict mitigation policy (Nath & Sukumar 1998, Osborn & Parker 2002a). As soon as the squad leaves, the elephants come back, complained one farmer[101] while another said that the squad just chases the elephants to the neighbouring farm so the village has stopped calling them[102]. While the short-distance displacement of elephants provides initial relief, if the same elephants are regularly chased and not prevented from returning, they become habituated (Hoare 2001a, Nelson *et al.* 2003). Elephants became familiarized to the shooting of a shotgun in the air in just four weeks. Thereafter, elephants reacted only when shot at directly (Osborn 1998).

In Assam, Aaranyak provides vehicles and villagers supplement the squad (Bibhuti Lahkar pers. comm.) which are now under increasing political pressure to chase elephants even from encroached areas. Generally the squad gives the elephants some time to eat crops before chasing them, otherwise, they get agitated and refuse to move (Ram pers. comm.).

[101] Coppice Basti, near Chapramari Wildlife Sanctuary, West Bengal

[102] Hidaypur Village, West Bengal

1.5.2 Removal of Elephants

Removal includes killing individuals, driving herds or bulls, and capturing a few select elephants from an area for domestication, and translocation.

Considerations: The biggest stumbling block in removing elephants is identifying the problem animal (Nelson *et al.* 2003), especially at night when raiding occurs (Hoare 2001b). Local villagers' claims of being able to identify problem elephants in the daytime are often unfounded (Hoare 2001a). Whether elephants are killed, or captured for domestication, or translocation, the "problem component" hypothesis indicates that these removed animals will be replaced by others in the population, thereby keeping the conflict alive (Hoare n.d.a). It is, therefore, not a long term solution but it may be necessary in particular cases when elephants have lost their fear of man (Chong & Dayang Norwana 2005). Removal of elephants from the population has limited scope and poses serious consequences for elephant populations (Nath & Sukumar 1998). Removal of bulls leads to loss of genetic contact as they are the dispersing sex (Williams *et al.* 2001). In Bengal, a 40% reduction in the elephant population over a 100 year period did not significantly reduce crop damage (Barua 1995). Neither did the killing of 20 "rogues" and removal of half the herds provide any respite from elephant depredation throughout the 1980s in the same area (Barua & Bist 1995). In Cameroon, shooting a few elephants did not reduce the incidence of crop damage (Tchamba 1995).

a. Drives

The Forest Departments use *kumkis*, several personnel, and a range of noise makers to chase a herd of elephants in a particular direction across relatively long distances and do not cease until the elephants enter their forest destination. Drives may take several days and nights and are conducted in response to several complaints of conflict over a period of time. In India, drives temporarily displace the elephants from a human dominated landscape to the nearest forest.

Pros: In Assam, WWF supports drives by hiring 15 captive elephants at a cost of Rs. 15000/month for 5 months of the year. These are not *kumkis* but captive elephants that are being trained on the job. In Sonitpur District alone, about 200 drives are conducted annually at a cost of Rs. 15 lakhs. WWF has facilitated the formation of village youth groups called ADS (anti-depredation squad) to aid Forest Department during drives and this has led to conflict being minimized (Anupam Sarmah pers. comm.).

Cons: Drives are chaotic, and cause confusion and panic among the animals which results in more damage and even loss of human lives (Nelson *et al*. 2003, Kulkarni *et al*. 2007). Sometimes spectators hinder the *kumki* operations. Herds splinter into groups and run in different directions (Ecosystems-India pers. comm., Barua 1995); they may be chased into new areas (not part of their normal movement route) resulting in more damage (T. R. Shankar Raman, in litt.), thereby spreading and intensifying conflict (Desai 2002). The displaced elephants return in a few weeks (Jayewardene 1995, Nath & Sukumar 1998,

Osborn & Parker 2002a, Kulkarni *et al.* 2007) making drives financially unviable (Datye & Bhagwat 1995d).

Although touted as a public-relations exercise, whether drives reduce conflict, improve public relations or promote positive attitudes towards elephants needs to be assessed. Such events may actually negatively influence peoples' attitudes to elephants since the public begin to view them as 'the other' species which needs to be chased away at all times (T. R. Shankar Raman, in litt.).

Monitoring of drives in Sri Lanka shows that elephants are extremely stressed and some may react with aggression (Fernando *et al.* 2008). Frequent drives without capture may lead to habituation and loss of fear of *kumkis* (Barua 1995). Since elephants adhere to their home ranges even when they extend into human landscapes, they may attempt to turn back on approaching the edge of their ranges resulting in high risks to the wild elephants, *kumkis*, and the people (Fernando *et al.* 2008).

In 1995, a 30 member squad drove an estimated 90 elephants over eight days from Bannerghatta National Park to an adjoining Reserve Forest 100 km away. A survey conducted a month later showed that conflict levels were as high as the month preceding the drive (Nath & Sukumar 1998).

Considerations: Drives are popular among the local people (Anupam Sarmah pers. comm.) but are largely ineffective (Kulkarni *et al*. 2007). To be successful, the elephants must be prevented from returning by deploying a barrier (Hoare 2001a).

b. Translocation

Elephants that are thought to be crop-raiders are captured and released deep inside the same forest or transported long distances to other forests.

Pros: In Kenya, Zimbabwe and South Africa, translocation of elephants to restock tourism areas was successful (Hoare 2001a). Between 1974 and 1995, Malaysia translocated 285 elephants to a distance of up to 400 km from the site of capture and none are known to have returned to their original ranges. Although the animals were not monitored individually using radio telemetry, this assessment was made on the basis of the total absence of complaints from the capture sites. Considering that the elephants caused an estimated loss of 300 million Ringgit since 1969, and the Department of Wildlife spent only 4 million Ringgit on translocations, it was considered a success (Daim 1995)[103]. Kenya translocated 141 elephants between 1996 and 2001, of which 13 died, but this resulted in reducing conflict levels (Omondi *et al*. 2002).

Cons: The cost of translocation is prohibitively expensive and requires specialist skills and equipment (Parker *et al*. 2007). In India, Protected Areas form only a small fraction (22%)

[103] However, the fate of the elephants thus translocated is unknown.

of elephant range and presumably hold elephants at carrying capacities and therefore, there are few suitable release sites. Without a substantial attempt to increase the capacity of the landscape to hold more elephants, large scale translocation to Protected Areas is detrimental to elephant conservation (Fernando *et al.* 2005). In Indonesia, local villagers identified the translocation of about 70 elephants to Way Kambas National Park as the trigger for conflict along its borders (Nyhus *et al*. 2000). In Sri Lanka, translocation efforts have not succeeded in removing elephants entirely from croplands nor did conflict levels diminish (Fernando *et al*. 2006).

A review of 9 case studies where animals (including elephants) were specifically translocated to solve human-animal conflict indicated that it failed to solve the problem (Fischer & Lindenmayer 2000). In individual instances, the identity of culprit animals is hard to determine and may result in unwittingly transporting the conflict with the animal to the new area. The animal is also likely to return to its original home range (Hoare 2001b, Nelson *et al.* 2003, Parker *et al*. 2007, Fernando *et al.* 2008). Three elephants that were translocated in South Africa, to mitigate conflict, continued to cause problems in the release sites (Grobler *et al*. 2008). In 1988, two elephants were translocated 400 km from Dharmapuri Forest Division to Annamalai but within a few weeks they moved to the periphery of the forest and began eating crops (Datye & Bhagwat 1995d). An elephant translocated from the Terai to Buxa Tiger Reserve, a distance of about 250 km, returned in less than 2 months and was found dead within its original home range (Barua 1995). A rogue tusker that was translocated 180 km, returned in 3 weeks. Along the way it killed 2 people, injured another, and it died soon after its return to its former home (Lahiri-Choudhury 1993). Two out of 11 elephants translocated to Nagarhole National Park returned in 9 months covering a distance of 150 km (Appayya 1995).

There is speculation that translocation causes as much stress to the elephants left behind, as culling. The elephants being translocated may communicate their distress by infrasound to the other herds in the area (Slotow *et al.* 2008). Being social kin-based animals, separating a female from its herd can cause tremendous trauma to both (Stüwe *et al.* 1998, Lötter *et al*. 2008). The wrong choice of release site such as inadequate space for the elephant to establish a home range, inadequate access to forage and water through various seasons, unsuitable range of vegetation types, may also cause stress and be detrimental to the survival of these elephants (Lötter *et al.* 2008, Fernando *et al*. 2008).

In Sri Lanka, elephant herds that were translocated by drives and restricted within Protected Areas by electric fences, suffered a decline in body condition, depressed reproduction, and increased mortality of juveniles. While the remaining animals did not attempt to breach the fence, they over-used the resources within their newly-established, abnormally small ranges, thereby reduced the capacity of the habitat to support all the elephants (Fernando *et al.* 2008). Several bull elephants captured and translocated into National Parks were monitored with GPS radio telemetry. All of them left the Parks, some returned to the sites of capture, some wandered over very large areas and others settled

down in new areas but took to raiding crops and destroying houses (Prithviraj Fernando pers. comm.).

Concerns about the welfare of the animals during capture and transit have also been raised. A study in Kenya revealed that adult translocated elephants had a greater probability of dying than resident elephants (Pinter-Wollman *et al*. 2009). In Kenya, five out of 26 elephants died from drug related stress, while in Vietnam two out of six died from injury caused by capture. Translocation is an enormously expensive tool better used for conservation efforts such as restocking than for conflict mitigation (Nelson *et al*. 2003).

The conservation implication of translocating Asian elephants is unknown (IUCN 2006). Detailed guidelines for such translocation efforts has been drafted by the IUCN/SSC/ African Elephant Specialist Group (Dublin & Niskanen 2003).

c. Taking into captivity

A significant number of elephants have to be captured from an area for effective conflict mitigation (Nath & Sukumar 1998). Domestication effectively removes the animal from the gene pool (Fernando 1995) and has little conservation benefit (Chong & Dayang Norwana 2005). Removal of females from the wild is detrimental to the wild population (Fernando *et al.* 2008) while causing tremendous trauma to animals normally found in social herds (see section on Translocation). It is a limited alternative to culling (Desai 2002).

Domestication of large bulls requires skills that are not easily available (Desai 2002). There is little market for domesticated elephants, and maintaining them in captivity is an expensive proposition (Nyhus *et al*. 2000, Desai 2002). Domestication is recommended only as a last resort to tackle animals causing problems repeatedly (Chong & Dayang Norwana 2005). Capacity to look after elephants in captivity needs to be increased while associated infrastructure needs to be set up.

d. Culling

In India, elephants are listed as Schedule I animals under the Wildlife (Protection) Amendment Act 2006. Should any pose a threat to human life, options such as translocation and captivity are to be explored first. If neither of these options is feasible, only then can the Chief Wildlife Warden authorize the animal to be killed.

In India, elephants that are said to have killed several people are the ones marked for culling. There are several instances where problem animals have been missed and uninvolved animals were removed. The effort required to identify the animal is not cost effective (Treves 2007).

Culling is a way of reducing the population temporarily (Nelson *et al*. 2003), but that has not worked in Africa to reduce crop damage (L. Naughton-Treves quoted in Nyhus *et al*.

2000, Hoare 2007). In Asia, a few individuals thought to cause conflict are removed as a conflict mitigation measure. However, the problem component hypothesis indicates that a percentage of the population may be causing the conflict and removal of a few will not solve the problem (Nelson *et al.* 2003). Culling may have a temporary positive effect but in many areas it has no effect at all. It is not a remedy unless the whole herd is killed which has serious conservation consequences for low populations (Chong & Dayang Norwana 2005).

Culling bulls: Some have suggested that killing one may aversively condition the others to stay away from human dominated landscapes. In Zimbabwe, four nights after a group member had been shot, a radio collared bull was found within 1.5 km of the site and on the seventh night he was within 500 m of the cull site (Osborn 1998), indicating that culling of a group or herd member does not deter elephants from entering croplands. Culling of targeted bulls or animals of a particular age may distort the age structure (van Aarde & Jackson 2007), especially in south India which has heavily female-biased sex ratios. However, when minimum intervention is considered essential, and since there is no evidence that crop eating bulls are better breeders, then the selective removal of such bulls may provide short-term relief (Sukumar 2003). In some areas, herds cause more damage than bulls as a result of habitat loss and degradation, so removing bulls would not solve the problem (Balasubramanian *et al*. 1995, Williams *et al*. 2001).

Culling females: Removal of adult females can adversely affect the reproductive success of the population (Hoare 2001a) and may cause elephants to raid other areas (Osborn 1998). In South Africa, when culling of other elephant herds occurred within a radius of 7 km from 10 radio-collared cows, only four responded by moving well away from the area while the other six did not react at all. Within days, the elephants that fled returned to their original sites, indicating that culling does not aversively condition them to avoid certain areas (Whyte 1993). In Malawi, there was no difference in crop loss between fields guarded by hunters where elephants had been killed and fields guarded by unarmed farmers (Bell 1984 in Osborn 1998).

Retaliatory killings of elephants by poisoning or electrocution do occur illegally and threaten to compromise conservation. In 2002-2003, 36% of 53 elephants killed in India was attributed to conflict (IUCN 2006), while it is unknown whether farmers get any relief from crop loss.

e. Contraception

This is a population control measure and has little effect on conflict. It is discussed here as elephant population numbers have been cited as a cause of conflict.

Contraception is considered to be more ethical than culling elephants (Lötter *et al.* 2008) as it relies on natural mortality and reduced reproductive growth to control the size of the population over time. Not only do all contraceptives have side-effects on health and

behaviour, but reducing the reproductive rate may also destabilize the age and social structure of breeding herds. Immuno-contraception is suitable only for small, confined populations (van Aarde & Jackson 2007).

Firstly, scientifically rigorous methods of censusing and estimating ideal densities are required before estimating whether the population needs to be controlled over time using contraception. Then the desired density has to be estimated, and this would then determine the number of elephants to be treated and the number of years that such a program needs to be conducted to achieve the desired result. For instance, it was estimated that 75% of the 3000 adult cow elephants in Kruger National Park (South Africa) would need to be treated continuously for 11 years for the population to stabilize at zero growth rate (Sukumar 2003, van Aarde & Jackson 2007). Contraception conducted on such a scale is expensive and impractical to implement (van Aarde *et al*. 2006).

Until the effects of contraception on elephant physiology and social behaviour are known and the logistics and cost of such an operation calculated, it remains an untested management tool. The consequences of such invasive procedures may take several years to manifest as elephants are a long-lived species. For instance, young female elephants learn to be mothers by allomothering infants born to older females. Contraception of the older females reduces the opportunities available for such learning (Lötter *et al.* 2008) with uncertain consequences for the future behavioural stability of the herd as well as the population.

1.5.3 Compensation

As a conflict mitigation tool, compensation does not interfere with elephant behaviour, biology or movement, but attempts to raise the tolerance threshold of local communities (Tchamba 1995). Since elephants cannot be killed and conflict cannot be altogether stopped, compensation plays an important role in managing conflict. There have been few assessments of the extent of monetary loss and the effectiveness of compensation schemes in offsetting those costs (Madhusudan 2003). In the absence of compensation, farmers feel that the fines and jail terms they face if they hurt elephants to be unjust (Nyhus *et al*. 2000).

Pros: It offers immediate relief to victims (Madhusudan 2003, Chong & Dayang Norwana 2005). Adequate compensation boosts the morale of the local communities suffering from conflict (Nyhus *et al.* 2000). It spreads the costs of conservation more equitably across society while including hostile stakeholders in the discussion, thereby encouraging conservation (Treves 2007). It is most effective for rare species and small populations of charismatic wildlife (Treves *et al*. 2009). Paying compensation provides a framework for the authorities to maintain records which are the only available long-term data on conflict.

Cons: It is widely thought to have failed (Parker *et al.* 2007). Originally farmers were compensated the full monetary value of crops, but the methodology to evaluate loss was complicated and time consuming. Now the authorities provide "token relief," otherwise

called ‘ex-gratia,’ which is only a fraction of the actual loss. The annual loss may be 7 times higher than the compensation. In Kodagu, only 29% of 122 farmers claimed compensation while the rest were not interested as the process was too complicated and time consuming (Nath & Sukumar 1998). A later study of the same area revealed that compensation for crop damage was often delayed by 5 to 6 years whereas the average delay was about 6 months. In case of human mortality, it took up to 2 years for the compensation amount to be received (Kulkarni *et al*. 2007). In Bhadra Tiger Reserve (Karnataka), of 143 cases of crop loss, 63 filed claims (44%), while only 37 (26%) received any compensation. Forest Department records also indicated that successful claimants received 44% of the value of compensation sought, but if the unsuccessful claims were included the average compensation paid amounted to 14% only. Since only a small fraction of loss is compensated, the current compensation policy has not achieved its aim of helping victims of crop loss. Therefore it is not surprising that elephants are injured and sometimes killed by farmers. Despite these failures, 69% (81 households) of the interviewed farmers wanted the compensation program to continue but with faster and less bureaucratic verification system (Madhusudan 2003)

Major problems with compensation schemes include (1) high administration costs, (2) lack of funds which precludes fair payment, (3) inadequate staff and training which impede accurate and prompt verification of damage, (4) lodging of fraudulent claims, (5) disincentives for guarding fields, (6) subsidizing uneconomical agriculture, and (7) no discernable improvement in relations between communities and conservation authorities (Nyhus *et al*. 2005).

Considerations: Sharecroppers and some forest villagers do not possess valid land documents necessary to apply for crop damage compensation. Landowners refuse to give their land documents so tenant farmers are unable to claim compensation. Besides the loss of crop or property, claimants incur additional expenses following up the claims (Madhusudan 2003). Compensation papers are sent to the district headquarters and villagers find it difficult to make several trips to expedite the process (a farmer[104]). Since the state compensates only a fraction of the loss, villagers file several applications (a villager[105]). On the other hand, the Government charges that villagers file false claims and corrupt the system.

An effective compensation program requires that local people are consulted in the overall management of the conflict and the compensation program itself. While compensation provides incentives to farmers to inflate their claims, a participatory approach is essential in making conservation work (Nyhus *et al*. 2005). Some authorities consider the role of compensation for crop loss to be short-term which should be replaced by other strategies such as insurance and alternate sources of income from non-agricultural activities, improved agricultural practices, better marketing, utilization of revenues from tourism and minor forest

[104] Khoribari village, the Duars, West Bengal

[105] Tondu Basti, the Duars, West Bengal

produce. They do acknowledge the necessity of paying compensation for loss of property, human life, and injury as a long-term strategy (IUCN 2006). Some other authorities recommend that compensation be tied to conservation guidelines (Naughton *et al*. 1999), or management best-practices (Bulte & Rondeau 2005). Providing incentives to prevent conflict may be more sustainable than providing compensation as a reaction to conflict (Treves 2007). There is also a suggestion that instead of compensation, local communities could be paid incentives depending on the abundance of wildlife found on their lands (Nyhus *et al*. 2005)

Cash payments can have negative effects by generating conflict within communities, or between communities and conservationists. This is likely if compensation programs are not transparent or perceived to be inequitable (Nyhus *et al*. 2005).

In India, the compensation amount varies from state to state although the Central Government refunds the states at a fixed national rate (Daniel *et al*. 2008).

In Assam, a Rs. 125,000 corpus with funds donated by Wildlife Trust of India, Ecosystems-India and Aaranyak is being managed by Wildlife Areas Development & Welfare Trust (WWT) to make the payments up-front as a humanitarian measure in case of human mortality or injury. When the amount is eventually released by Project Elephant, the corpus is reimbursed. Prior to the setting up of this corpus, the local District Forest Officer or Ranger had to bear the expense personally. Should he be transferred before the money was sanctioned by the Government, he was forced to forfeit the money (Jayanta Das[106], pers. comm.).

[106] WWT, Guwahati

2. LONG TERM METHODS

Most long-term measures require humans to modify their behaviour. Conflict mitigation requires multidisciplinary collaborations (Treves *et al*. 2006) between the Department of Agriculture, insurance companies, land-use planners, and the Forest Department and the latter cannot be solely responsible for mitigating human-wildlife conflict (WWF 2008). The implementation of these methods requires a long timeframe as well as political will (Parker *et al*. 2007).

2.1 Land-Use Planning

Prudent land-use planning should accommodate the needs of both elephants and people (Parker *et al*. 2007). Some of the recommended land-use changes that address the spatial basis of conflict are (1) reduce the conflict interface between elephants and people (restrict and consolidate human settlements and relocate agricultural activity within elephant habitat), (2) make agriculture production more efficient (change location of fields, move to inedible crops, grow a diversity of crops, change cropping patterns), (3) modify movement of problem elephants (secure safe passage of elephants, protect water sources, re-draw forest boundary, expand or create protected areas). Since much of elephant habitat lies outside Protected Areas (78% in India), managing conflict successfully is crucial to conserving many unprotected populations (Hoare 2001a). Other recommendations include: identify priority elephant conservation areas and formulate a land use policy for these areas. To minimize conflict, irrigated agriculture and permanent human settlements should not be permitted on the edges of Protected Areas (Fernando *et al*. 2005). Mosaics of elephant habitat and human use areas need to be restructured to create hard and clear boundaries between the two to minimize conflict (IUCN 2006).

Should any necessary infrastructure development make habitat loss inevitable, the adverse impacts on elephants should be minimized. To this end, an elephant specific Environment Impact Assessment process may even be needed. Obstruction caused by existing infrastructure such as roads, railway lines can be resolved by facilitating elephant movement. Elephant range outside Protected Areas can be managed under the auspices of Elephant Reserves which allow human use of the area while also making this land available to elephants. In India, Project Elephant has established 26 such Reserves which reportedly cover the bulk of elephant habitat (IUCN 2006).

The current and future land use plans need to accommodate elephants. This could be an entry point for much wider conservation action, whose significance goes beyond elephants. To be successful, a national policy, with a budget to implement it, is needed (Hoare 2001a).

Various kinds of land-use planning such as buffer zones, cultivating alternate crops and exclusive zoning have been recommended to minimize conflict.

2.1.1 Buffer Zone

Under certain conditions, farms in close proximity to forests are the most affected by conflict. Therefore in these situations, the best defense against crop loss is having another farm along the forest boundary as a buffer (Naughton *et al*. 1999). However, when the peripheral fields are harvested earlier or abandoned, it opens up the central fields to crop raiding by elephants (Fernando *et al*. 2008, Boominathan *et al*. 2008). For instance, in Tsavo (Kenya), when farmers gave up growing food crops along the border with the National Park, the conflict became intense in other areas further away from the Park (Smith & Kasiki 2000). However, this was considered unfeasible in the developing world where land is at a premium and there is no evidence that such buffer zones have an impact (Sukumar 1989, Osborn 1998).

a. Buffer zone without clearing vegetation

The secondary vegetation around a forest that is allowed to reach late successional forest can act as a buffer (Naughton *et al*. 1999). A study in Assam suggested that since forest cover is negatively correlated to house damage, villages with low forest cover can implement joint forest management to increase cover as well as generate income (Di Fonzo 2007), however, it is likely that elephants may shelter in the area during the day and raid the neighbouring farms at night (Nyhus *et al*. 2000, Desai 2002, Fernando *et al*. 2008).

b. Buffer zone cleared of vegetation

On the other hand, clearing secondary forest to create a distance between the forest and cultivation aids greater visibility of approaching elephants, as well as clearly defines the boundary between the two zones (Osborn & Parker 2002b). A study in Indonesia suggested that this could mitigate conflict as the number of conflict events was greater where the vegetation was denser (Nyhus *et al*. 2000).

c. Buffer zone with inedible crops

Growing unpalatable crops for a 1 km width (Kulkarni *et al*. 2007) along the park boundary can reduce crop raiding (Chiyo *et al*. 2005, Sitati & Walpole 2006).

An effective buffer zone requires hundreds of km^2 to be planted with inedible crops; anything lesser will have little impact as elephants will walk right through them to reach palatable crops (Osborn 1998, Hoare 2001a, Fernando *et al*. 2008). Such zones should also be supported by barriers or active guarding (Chong & Dayang Norwana 2005). Farmers will adopt alternate inedible crops only if they provide greater revenue (Daniel *et al*. 2008). One study that critically evaluated inedible plants as buffer crop showed that it had no deterrence effect (Bell 1984 in Hoare 2003).

Around Bardia National Park (Nepal) menthe was promoted as a replacement for maize (the average annual household loss of maize was $20 whereas the amount of paddy lost

was $110). Reportedly, 75 farmers earned "good income" of $5600 for 750 kg of menthe oil (WWF 2008) but that is only an average earning of $76 per farmer. In Assam, citrus and patchouli as buffer vegetation did not do well (Lahkar *et al*. 2007) nor did chilli or thorny bamboo prevent elephant raids (Bibhuti Lahkar pers. comm.). In some areas of Indonesia, however, oranges appeared to work well and were left undamaged (Desai 2002) whereas in Bengkulu (Sumatra, Indonesia) elephants ate oranges and in the process damaged the trees (Heidi Riddle[107] pers. comm.). With a few exceptions, elephants try out new species of plants and adapt to them. In Africa, exotic tree plantations (such as pines) have suffered debarking by elephants (Hoare 2003). In Sri Lanka, where teak is a non-native species, elephants have taken to eating the bark and have totally destroyed a 10 km^2 plantation (Fernando *et al*. 2008). They are even known to eat the bark of Eucalyptus trees (Sukumar 1985b). Elephants in Kodagu (Karnataka) and Sri Lanka have been known to eat chilli plants (Kulkarni *et al*. 2007, Fernando *et al*. 2008).

In several areas, people are unwilling to give up subsistence crops to grow inedible cash crops (Kulkarni *et al*. 2007, L.A.K. Singh pers. comm., Fernando *et al*. 2008), and in some areas farmers adamantly grow sugarcane and bananas on the edges of forests. One project is experimenting with alternate cash crops with micro-credit facilities in Assam (Ecosystems-India pers. comm.), while another is providing marketing assistance (Bibhuti Lahkar pers. comm.). While these are laudable small efforts, ultimately the Department of Agriculture has to provide marketing and credit assistance, as well as expert advice on farming unfamiliar crops, to give farmers the confidence of switching over.

On the other hand, land converted to inedible crops cannot be used by elephants anymore resulting in loss of habitat and may likely lead to their local extirpation (Fernando *et al*. 2008).

2.1.2 Relocation of Human Settlements and Agricultural Activity

Relocating human settlement and agricultural activity from elephant range and corridors have been recommended by several authorities (Lahiri-Choudhury 1991, Johnsingh & Joshua 1994, Tyagi 1995, Sivaganesan & Johnsingh 1995, Hoare 2001a, Treves *et al*. 2006, IUCN 2006, Treves *et al*. 2009). This expensive exercise has reportedly been tried in some countries (IUCN 2006). In Kodagu, people were unwilling to relocate to other areas (Kulkarni *et al*. 2007). In Assam, attempts to evict forest encroachers have become extremely politicized (Kumar 2002). Relocation of Gujjars from Rajaji-Corbett National Parks was unsuccessful in 1983 (Johnsingh & Joshua 1994). However, China reported that removing people from Protected Areas, resulted in vegetation succession that was unsuitable for elephants (IUCN 2006). Unless the forest is demarcated as a 'critical wildlife habitat', relocation of people from wildlife areas is now being challenged by the Forest Dwellers Act 2008 in India.

[107] International Elephant Foundation

2.1.3 Protection of Corridors

Securing corridors and movement routes (Choudhury 1999, Hoare 2001a, Talukdar *et al*. 2006) allows elephants to use different parts of their home range without intruding into human-use areas. Since corridors appear to be degraded areas between forests, people are not aware of their importance. Loss of corridors would deny access to seasonal ranges resulting in compression and high densities of elephants. It is easier to protect an existing corridor than re-establishing a lost one (Desai 1991, Baskaran *et al.* 1995). In the absence of corridors, elephants come into direct conflict with humans in their attempts to access other parts of their home range.

2.2 Habitat Protection and Forest Management

Since habitat loss, degradation and fragmentation are the root causes of the problem, they need to be addressed to provide long-term solution to conflict (Chong & Dayang Norwana 2005, IUCN 2006). The effectiveness of the short-term mitigation measures depends largely on the availability of natural forage (Chong & Dayang Norwana 2005). Elephants appear to survive in developed environments with increasing levels of conflict, and the possible explanation may lie in the quality of the habitat (Leimgruber *et al*. 2003). While a further increase in conflict can be prevented by habitat protection, there will be some conflict as a result of past land use management decisions. But protection of exploited forests may also change the quality of the forage available to elephants as the canopy closes (Desai 2002).

About 78% of elephant rangelands lie outside Protected Areas (Project Elephant n.d.) and receive little attention (Desai 1991). The boundaries of Protected Areas are configured on the basis of administrative consideration but rarely to meet the ecological needs of elephants (Desai 1991, Baskaran *et al*. 1995). All elephant range lands have to be protected if the population is to be considered protected (Baskaran *et al*. 1995, Joshua & Johnsingh 1995, Chong & Dayang Norwana 2005). At the very least, the home ranges of most of the clans in a population in a Protected Area should be protected (Baskaran *et al*. 1995). When the unprotected part of elephant habitat is mismanaged, it adversely impacts elephants no matter how well managed the Protected Areas may be. Outside Protected Areas and Reserve Forests, forests are owned by the Revenue Department and private individuals or companies. Loss of any of these forests is detrimental to elephant populations and escalates conflict (Desai 1991).

Although wildlife managers have jurisdiction over wildlife wherever they occur, they do not have control over the land in areas outside Protected Areas where the real threat to the elephant population lies. In cases where home ranges of elephants include Reserve Forests, they need to be managed as Elephant Conservation Areas. Revenue Forests that include elephant home ranges need to be acquired and managed as Reserve Forests (Baskaran *et al*. 1995). However to make these decisions, more information on the ranging behaviour of elephants is needed (Desai 1991). The degree of fragmentation of forests should be reduced as it plays a significant factor in the economic loss sustained as a result of conflict (WWF 2008).

In Malaysia, a study showed that the bigger the size of the forest, the fewer the raids (Lee 2002 in Chong & Dayang Norwana 2005). In Nepal, an area with more forest cover and less fragmentation suffered only half the economic loss caused by wildlife conflict compared to two other sites (WWF 2008).

Collection of grass, and cattle grazing in dry deciduous, moist deciduous forests and swamps where elephants occur should be banned. Microhabitats such as streams, valleys, gallery forests need to be protected while a fire control strategy is needed to protect swamps (Sivaganesan & Sathyanarayana 1995, Sivaganesan & Johnsingh 1995). In Orissa, the

intentional use of fire by collectors of non-timber forest produce is thought to be a driver of conflict. In a couple of places, the Forest Department has banned this activity which has led to the successful mitigation of conflict (Rauf Ali pers. comm.).

In the case of herds that are severely affected by habitat loss and seeking new home ranges, different management options may need to be considered (Desai 2002).

2.3 Offsetting the Costs of Conflict

These methods do not seek to reduce conflict but offset the resulting costs through other means (Parker *et al*. 2007) while providing an incentive to maintain habitats for elephants. Direct payments, not necessarily in cash, are a more effective way of restricting exploitation of the habitat than indirect measures such as community-based ecotourism ventures (Ferraro & Simpson 2003). However, indirect ventures are needed where conservation values are already in practice while both, direct and indirect benefits, may be needed in other situations (Thomas Lovejoy quoted in Nicholls 2004). Others argue that direct payments commodifies nature which has limited benefits whereas engagement with the community through debates and education works in the long term (Sjaak Swart quoted in Nicholls 2004, Ferraro & Simpson 2003). The main drawback of the direct payment schemes is that they require long-term financial commitment. Other drawbacks are that the people may shift the exploitation of natural resources to other locations while land ownership is often ambiguous (Ferraro in Nicholls 2004). There is no evaluation to show that direct payment achieves the stated conservation goals (Ferraro & Simpson 2003).

2.3.1 Community-Based Natural Resource Management (CBNRM)

CBNRM is not only a mechanism for coping with losses caused by conflict but it also encourages social integration and empowerment (WWF 2008).

In Nepal, communities, living in the vicinity of forests, are encouraged to form User Groups who are assigned rights and responsibilities over forest resources. They extract fuel, fodder, housing materials, medicine, and food sustainably while they also get a share of revenues from tourism. Communities that benefit from CBNRM are tolerant of conflict losses compared to communities that do not receive these benefits. While CBNRM communities did not want any reduction of elephant numbers to reduce conflict, non-CBNRM communities supported the idea and a majority of them thought that retaliatory killings had increased in their areas (WWF 2008).

However, this may not work under all conditions. In Nepal's Makalu-Barun Conservation Area, an attitudinal survey showed that common-property regimes did not foster tolerance of wildlife depredations. To prevent sabotage of conservation efforts, it was felt that farmers should be allowed to hunt pest species on their farms and provided compensation for their losses (Mehta & Kellert 1998). Similarly, in Namibia, the CBNRM program was in danger of being jeopardized by inadequate compensation or any other effective means of mitigation of elephant damage (Mulonga *et al*. 2003).

Communities need to have governance systems in place (WWF 2008). Many rural communities in developing countries are in transition, experiencing weakened traditional values and institutions, increasing population and social heterogeneity, and increased access to destructive technology. They may not plan for the future when their needs are immediate.

A few powerful individuals may exploit the governance structure for their personal benefit while the community pays the costs (Walpole & Thouless 2005).

2.3.2 Insurance

Villagers must be made to realize they hold some of the responsibility of conflict mitigation, especially since their use of the wild habitat may be a key factor in determining the intensity of conflict. They are generally willing to accept that responsibility; insurance schemes may be a way to compensate losses sustained by communities. Insurance premiums can be divided between three parties: the Forest Department, the farmers and non-governmental organizations (Madhusudan 2003).

An environmental cess, similar to the educational cess being collected by the government, can create a corpus of funds to be utilized not only for crop loss due to elephants but any damage caused by wildlife and other natural catastrophes (M. Ananda Kumar pers. comm.).

2.3.3 Willingness To Pay (WTP)

To urban public, conservationists and biologists, the elephant's ecological value far outweighs any monetary estimate. However, the value of an elephant is no more than the amount of loss caused to farmers living in elephant country. Since one group perceives far greater benefit from the continued existence of elephants than the other (which is usually poor and marginalized), it has to bear the brunt of the expense. In the Biligirirangans, about 250-270 elephants caused damage worth about US $19,000 ($672 per bull and $32 per herd elephant) per year; an annual average of $70 per elephant or $1.58 per person (Sukumar 1989).

A survey of 300 people of various economic strata in Colombo indicated that the people of Sri Lanka were willing to pay Sri Lankan Rupees 8818 million (US $88,180,000) per year for elephant conservation over a period of 5 years. The authors also estimated that elephants caused damage worth about Sri Lankan Rs. 1121 million (US $11,210,000) per year, which could be easily covered by the amount raised from the public (Bandara & Tisdell 2004).

If the community or farmers are paid for the abundance of elephants on their lands rather than compensated for their loss, it furthers the cause of elephant conservation by encouraging the maintenance of habitat. Verification is a major constraint just as with compensation. This is still at an experimental stage and there are too few examples worldwide (Nyhus *et al*. 2005).

2.3.4 Payment for Environmental Services (PES)

Protected Areas form only 1% of the land area of the country and further expansion is impossible without displacing many people. Since conservation outside Protected Areas requires the cooperation of local communities, incentive based mechanisms, such as PES, can encourage land-use practices that retain the integrity of the forest and also lead to the expansion of forest cover (FERAL n.d). The success of PES lies in its ability to bring

previously uninvolved people to conservation and by providing incentives for sustainable landuse practises in inhabited landscapes such as rural areas (Huberman 2008).

PES compensates land owners for the loss of revenue incurred by not converting the land for any commercial land-use (OAS n.d.b). For example, some ecosystem services such as food, fuel, water, flood control, water purification provided by wetlands, and carbon sequestration by forests are perceived to be free for all and taken for granted (WWF 2006). Therefore, these critical life-sustaining services are not taken into consideration during land-use planning and management with the result that the poorest people and ecosystems pay the highest price. PES changes this regime by promoting sustainable land-use practices where the land owner is compensated by people who benefit from the services his land provides (WWF n.d., WWF 2006). For instance, the land owners upstream of a watershed will be paid for not cutting trees or building any infrastructure that affects the quality of the watershed services (OAS n.d.a). Ideally PES makes the most difference when the habitat is under threat and a small payment is likely to tip the decision in favour of ecologically sensitive land-use. When there is no threat, PES makes no difference to the land-use choices (Wunder 2007). This benefits poor land owners as well as biodiversity. This is one way of financing conservation goals, generating revenue for Protected Area management and for other areas designated as forests. But to implement this program, these essential services have to be assessed, service providers and end users identified, land rights clearly established, linkages between ecosystem services, land use and economic benefits documented, market value estimated, and a mechanism of continuous payment designed (WWF n.d., WWF 2006).

A PES program in Costa Rica has invested $14 million since 1997, which has resulted in the reforestation of 65 km^2, sustainable management of 100 km^2 of natural forests and the preservation of 790 km^2 of private natural forests. About 80% of the funding came from a fossil fuel tax and 20% from sale of carbon from Protected Areas (OAS n.d.a). However, there is no evidence that this scheme prevented forests from being cleared (Ferraro & Simpson 2003). In Mexico, current forest and water policy is complemented by paying private forest owners to maintain forests on their lands to ease the severe water problems facing the country. A federal water tax provides funding amounting to US $18 million (OAS n.d.a). It is unclear whether poor local people may be asked to pay for these services which were available freely prior to the setting up of such programs.

A pilot study in the Shencottah gap of the Western Ghats in India seeks to use PES to improve the connectivity between the Agasthyamalai and Periyar-Srivilliputhur hill ranges while also seeking to resolve anthropogenic pressures on wildlife and habitat, such as fire, fuel wood collection and poaching (FERAL n.d.).

There is a lack of institutions creating a market awareness and limited ability to set up such systems in developing countries. Currently there are a whole range of such programs functioning as pilot projects around the world (OAS n.d.a).

One possible solution to the problems of implementation of PES is to tax the industries whose activities cause conflict (WWF 2008).

2.3.5 Avoided Deforestation (AD) or Reduced Emissions from Deforestation and Degradation (REDD)

Roughly 20% of the annual greenhouse gases released into the atmosphere are from deforestation and degradation of forests (Peskett *et al*. 2006). Under the AD scheme developing countries are paid to prevent deforestation while combatting climate change and improving the living standards of some of the poorest people. According to the British Government's Eliasch Review on forestry, deforestation will increase the cost of climate change-induced damages by $1 trillion every year by 2100 (Eliasch 2008). While there is a good case to be made for community managed agroforestry projects earning carbon credits (WWF 2008), a major concern will be how such contracts are signed. Clear land titles are essential for the implementation of AD payments (Stern 2007). There is criticism that AD exacerbates the repression of indigenous communities (Mehta & Kill 2007).

2.4 Education to Raise Awareness

Since politicians impose ill-advised management decisions on the Forest Department, it is imperative that the causes of conflict are communicated to politicians and decision-makers (Walpole *et al*. 2006) as well as local communities. They have to be made to understand that some level of conflict is inevitable and that no single method, including electric fences, is a solution.

Education must also instill a sense of pride and ownership of elephants amongst the local populace. For example, Aaranyak works with self-help groups to produce traditional Assamese scarfs with elephant motif designs (Bibhuti Lahkar pers. comm.). While it is known that conflict is also engendered by the lowering of the tolerance threshold, little has been done to encourage people to tolerate loss caused by elephants. Education programs are one way of altering human attitudes towards conflict and raising tolerance of conflict losses.

Scientists and media should be careful about using negative terms. For instance, "straying" is commonly used to describe any wild animal found outside forest areas. This implies that the animal has wandered beyond its territory when it may actually have lost a part of its home range to human use.

2.5 Conservation Action Plan

In several areas, it is small isolated populations of elephants causing conflict. They are sinks for conservation resources and may provide no long-term benefits for the species. A conservation action plan that prioritises populations based on their long-term viability (IUCN 2006) and recommends management action for small isolated populations is a necessity (Sukumar 2003).

Elephant-human conflict mitigation policy should be an integral part of the national elephant conservation policy (Taylor n.d.). Currently there is an inordinate stress on conflict mitigation measures such as erecting electric fences, while little is done to consolidate elephant habitat or formulate land use plans.

Transborder cooperation is needed to manage elephant populations across India's international borders with Nepal, Bhutan and Bangladesh (IUCN 2006). For example, elephants disturbed by tea estate expansion in Assam are moving into eastern Nepal (WWF 2008).

DISCUSSION

Political Interventions: The State Forest Departments are sometimes unduly pressurized by politicians to undertake ill-advised conflict mitigation actions that serve neither the cause of elephant conservation nor conflict mitigation and human welfare. For example, the Tamil Nadu Forest Department is being forced to construct an electric fence enclosing the 220 km^2 Valparai plateau, creating exclusive zones for people and animals (M. Ananda Kumar pers. comm.). The immediate effect of the fence is to deflect elephants from regular movement routes, depriving them of resources needed for survival. Such long fences are a challenge to maintain, and within the span of a year the fence has already been broken in a number of locations and is a singular waste of public funds and resources allocated for conservation (T.R. Shankar Raman pers. comm.). Besides, the fence will direct the hungry elephants into the plateau through the few gaps that accommodate the inter-state highways (Fernando *et al*. 2008) increasing the likelihood of conflict. Once elephants manage to enter a fenced-in area, they are trapped and if they are chased by humans cause far greater damage in their attempts to break out. While the fencing of the entire Valparai landscape appears populist in agenda, in reality it exacerbates, rather than minimizes conflict (T.R. Shankar Raman pers. comm.).

Disadvantages of the Short-Term Measures: There is no single management solution for all situations (Hoare 2001a, Osborn & Parker 2002a, Fernando *et al*. 2008) and mitigation measures need constant experimentation and innovation (Chong & Dayang Norwana 2005). The effectiveness of the short-term measures is dependent on the temperament of elephants (M. Ananda Kumar pers. comm.), or their response may be based on the herd's cultural knowledge (McComb *et al*. 2001). Since wild animals are neophobic (fear of the new), non-lethal interventions need to be varied and flexible so they can be used in combination or serially to avoid habituation (Treves 2007). However, elephant cognition is complex and they are quick to habituate to any conflict mitigation measure; in some extreme cases, they do not budge even when gunshots are fired at them (Chong & Dayang Norwana 2005). These short-term methods are meant to buy time in which to evolve long-term strategies (Barnes 2002, IUCN 2006).

Impact on Elephants: If elephants are dependent on crops as a result of habitat loss or fragmentation, successful prevention of crop raiding may adversely affect their survival (Fernando *et al*. 2005). Yet, there is little analysis of how short-term mitigation measures being implemented across elephant rangelands have affected their behaviour, foraging patterns, and conservation (Fernando *et al*. 2008).

Evaluation: Interventions to mitigate conflict need to be monitored and evaluated objectively, preferably by an independent reviewer (Chong & Dayang Norwana 2005). Evaluations vary in methodology from assessing farmers' perceptions, treatment-response on trial farms, or post-treatment spatial comparisons between trial and control farms. Time series comparisons between trial and control farms, before and after treatment are needed to identify background changes or existing differences between farms (Sitati & Walpole 2006, Treves

2007). Control farms that are not separated spatially (located in the same area as the experimental farms) and temporally are the best (Treves *et al*. 2006). Frequently, however, the agency implementing the mitigation measure does the assessment thereby biasing the results.

There is evidence that non-lethal mitigation measures do little more than displace elephants to other farms (O'Connell-Rodwell *et al*. 2000) in the short-term while habituating them to these empty threats in the long-term (Sitati & Walpole 2006). By not reducing overall levels of conflict these methods may need to be implemented much more widely before significant reductions are achieved (Sitati & Walpole 2006, Treves 2007). The impact of conflict mitigation should be evaluated on a landscape or population level rather than site level as is the current practice (Fernando *et al*. 2008). Unless evaluation is conducted at this scale, the "success" of these short-term measures, such as electric fences, lies to a large degree on the availability of an alternate resource, either another village's crop lands or natural resources, which usually lie outside the project area.

India has very few evaluations of mitigation measures. Despite the volume of published work, not much is known of the actual effectiveness of these measures.

Minimizing Conflict: As long as humans and elephants share the same landscape, conflict is inevitable and can only be minimized, not eliminated entirely (Hoare 2001a, Madhusudan 2003, Sitati *et al*. 2003, Chong & Dayang Norwana 2005, Taylor n.d.). However, this raises the question - what level of reduction in conflict can be considered a success? What is the benchmark of success and who determines this? Is any reduction of conflict enough to be considered successful? Or should the target of conflict reduction be 75%, 50% or 25%? Also critical to the debate is to decide just how many elephants we can have. Since conflict also reflects the tolerance threshold of the local people, perhaps they should judge the efficacy of the mitigation measure. If local people are the arbiters of conflict mitigation then they need to be involved in decisions from the initial stages. Indeed, their concerns need to be addressed if barriers such as electric fences and trenches are not to be undermined.

Community Participation: Many interventions require changes in human behaviour, and if the local people identify the need for change and identify what change they are willing to make, these measures are likely to be sustainable. However, since the spatial distribution of conflict is uneven, arriving at consensus decisions on interventions is likely to be difficult (Treves *et al*. 2006).

Social science research can contribute the following perspectives to conflict management: economic feasibility and sustainability, conditions under which interventions can not only raise local tolerance but also further conservation goals, processes to change human behaviour and monitoring the results (Treves *et al*. 2006).

CONCLUSION

Every measure appears to work in some areas and fail in others, and there is no single sure-fire way of arresting conflict. The effectiveness of any measure is dependent on the degree of desperation of the concerned elephants. A general rule of thumb appears to be that if they have other crops or forage available, they may not challenge the mitigation measure. However, should they have no other option but target crops for their survival, then they will overcome any challenge in their way sooner or later. Elephants and humans are intelligent and resourceful mammals competing for resources, and mitigation should not only involve minimizing conflict but also compensate the affected people while educating politicians, public and the media.

CHAPTER 3

DECISION MAKING FRAMEWORK

Over the past 2-3 decades a number of conflict mitigation options have been tried out in the field by government agencies as well as conservation NGOs and local farmers. Most of these have achieved only limited success in containing elephant-human conflicts. There has been a lack of a decision-making framework to guide policy makers and field managers as to the type and sequence of mitigation measures that may be implemented in a given region or situation. An important consideration in the choice of a particular measure is an economic cost-benefit analysis for a region and situation. At the same time, one has to take into considerations the perceptions of conflict by the affected people as well as available capacity to deal with conflict. Development of a rigorous decision-making framework would require the participation of social scientists and economists. We do not pretend to provide such a decision-making framework in this report, but merely an outline of the various measures and possible applicability in different situations of elephant-human conflict.

The decision making framework is based on a synthesis of the two preceding chapters. It draws from what we know of the factors influencing conflict and the lessons learnt from various mitigation measures tried across elephant habitat. As more research is undertaken and testing of mitigation methods become more rigorous, this framework (Table 6) would need further adaptation.

Before deciding which method to opt for, an evaluation of the population and habitat needs to be undertaken. Elephant populations in India are found in four situations: large population inhabiting large habitats, large population in fragmented habitats, small populations in large habitats and small populations in fragmented habitats. The nature of conflict is quite different in these populations; for instance, there is only sporadic conflict in the Periyar-Agasthyamalai Elephant Landscape while there is intense conflict over most regions of east-central India (Jharkhand, Orissa and southern West Bengal). Mitigation options would obviously be different in these situations.

Table 6: Decision making matrix

	Large population, large or moderately large habitat	**Large population, fragmented habitat**	**Small population, large or moderately large habitat**	**Small population, fragmented habitat**
Examples	*Nilgiri-Wyanad-Mysore(Nagarhole, Bandipur, Wyanad, Mudumalai)* *Anamalai/ Parambikulam*	*Kodagu district, Brahmagiris (a part of Nilgiri-Wyanad-Mysore)* *Orissa*	*Palamau (Jharkhand)*	*South Bengal* *Parts of Jharkhand* *Dudhwa*
Short-term measures:				
Guarding	X	X	X	X
Trip wire alarm	X	X	X	
Informant	X		X	
Electric fence	XXX	XX	X	X (to contain elephants)
Wall	X		X	
Experimental	X		X	
Chilli based	X		X	
Scaring squads	X	X	X	X
Drives	X		X	
Translocation				
Captivity				X
Culling	X (particular individuals)			X

Contraception			X	X
Compensation	X		X	X
Long-term measures:				
Habitat protection and Forest Management	X		X	X
Protection of corridors	X		X	
Land-use planning	X		X	X
Buffer zone	X		X	X
Removal of people and agricultural activity	X	X	X	
CBNRM	X		X	X
Insurance	X		X	X
Willingness to pay	X		X	X
Payment for Environmental Services	X		X	
Avoided Deforestation	X		X	
Education and Awareness	X	X	X	X

Of these, whichever mitigation measure is chosen, it has to be cost effective, socially acceptable, ethical and take the biology of elephants into consideration.

INSTITUTIONAL FRAMEWORK FOR IMPLEMENTATION

While non-governmental organizations (NGOs) can provide technical inputs and create cohesiveness in community action, local communities have to be persuaded to own some responsibility for the survival of elephants in their areas. Towards this end, NGOs can take the lead in helping people to help themselves by strengthening local initiatives such scaring squads made up of individuals drawn from the community. There are already working examples of such groups in north Bengal and Assam but they need to be implemented in other crop damage prone areas as well. NGOs can also initiate PES, REDD, WTP models to encourage setting aside of habitats for elephants and other wildlife as is happening in Jaldapara, Buxa (West Bengal) and Shencottah Gap (Tamil Nadu). Wherever possible, collaboration between NGO-FD-communities can ensure the implementation of mitigation measures.

In situations such as south Bengal, where there is a small herd of elephants causing disproportionate amount of damage and there is little habitat available for them, the FD has to take them into captivity. Biologists and social scientists can aid the process of enabling positive elephant-human coexistence by providing baseline data which informs the Forest Departments and NGOs on the course of action.

However, since the Forest Departments are the custodians of Protected Areas and protected animals such as elephants, they are pivotal to the implementation of large-scale mitigation measures. It is hoped that under the aegis of Project Elephant, the Department will utilize this action plan in mitigation of elephant-human conflict.

CHOICE OF MITIGATION MEASURE

EPT can be used to protect buildings, guard posts in dry areas, not in medium to high rainfall areas.

Experimental measures need more Research and Development.

Chilli based measures can be used in dry areas and especially in village enclaves within forests. It deters herds but not bulls and should be used seasonally and not as a permanent barrier.

Scaring squads work well where raiding by elephants is predictable. It fails when it is implemented solely by the Forest Department. However, if the authorities provide support to youth groups and local communities, it has a greater degree of success.

Drives should be used to push back small dispersing herds. Post-drive monitoring is needed.

Translocation of bulls to large habitat is recommended.

Small populations that have no major habitat within which they can be contained should be taken into **captivity**.

Culling is recommended only for well identified individuals.

Contraception requires further Research and Development and long-term effects on the population need to be considered.

Compensation for crop loss works best when raiding is sporadic. In such cases, no other state intervention is needed. But communities should be empowered to protect their crops. When lives are lost, people are injured, property is damaged, compensation as ex-gratia should be paid.

Habitat protection is unlikely to work in fragmented habitats while **buffer zones** will not work anywhere as there is no land available.

Alternate forms of land use may reduce conflict such as the tourist resorts around Masinagudi (Tamil Nadu).

Relocation of people and agricultural activity should be implemented in critical corridors. Sufficient incentives should be provided.

Insurance can play a big role in areas with moderate to high levels of conflict.

Willingness to pay is an avenue that NGOs can explore.

PES and **REDD** can be implemented in corridors, community reserves, and reafforestation areas near large habitats.

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