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distribution patterns, people's perceptions and mitigation methods

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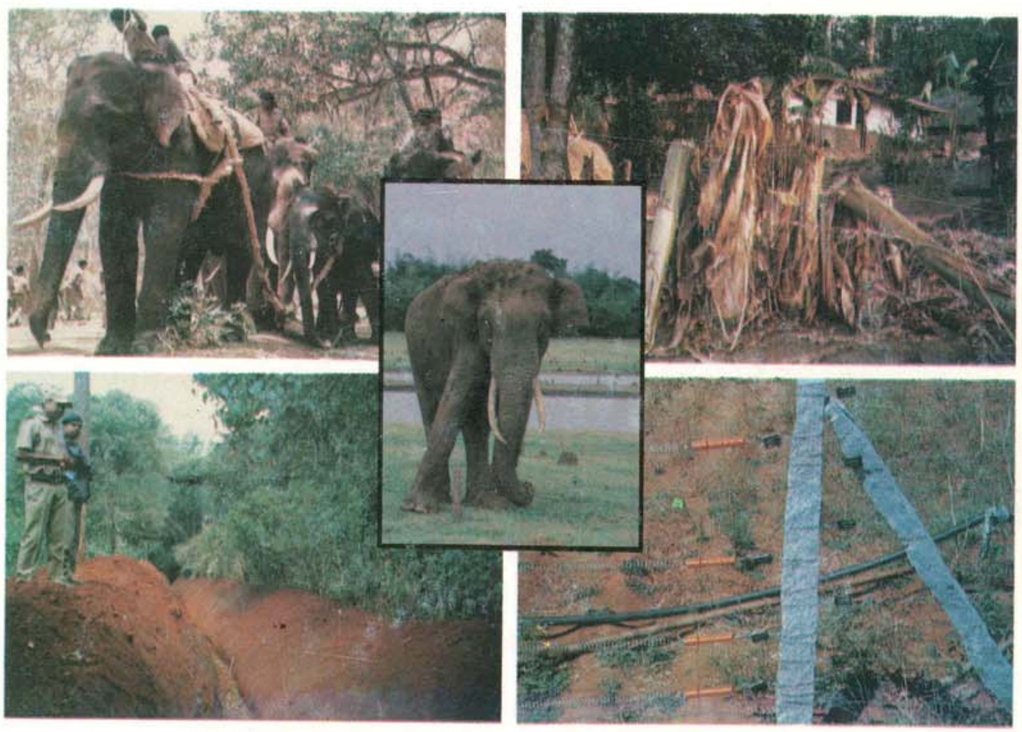

ASIAN ELEPHANT CONSERVATION CENTRE
Centre for Ecological Sciences
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Principal Investigator: Prof. D. K. Lahiri-Choudhury
Co-Investigator: Dr. R. Sukumar
Research Biologist: Cheryl D. Nath
Statistical assistance: Dr. Arun Venkataraman
GIS assistance: N. Venkatesa Kumar

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CONTENTS

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Executive Summary

The term "elephant-human conflict" usually refers to negative interactions between wild elephants and humans, such as crop raiding by elephants, human injuries/deaths caused by elephants and killing of elephants for reasons other than ivory extraction. Selected aspects of elephant-human conflict were studied in Kodagu district of Karnataka State, southern India. The study was carried out between September 1995 and July 1997.

The district of Kodagu lies in the southwestern side of Karnataka, and contains 1588 km^2 of protected forests. The primary occupation of the people is agriculture, and the common crops grown are coffee, paddy, cardamom, pepper, orange, coconut and banana. Approximately 1,730 elephants are present in the forests of this district, either as residents or as migrants. The forests form an almost complete chain around the district, enabling free movement of elephants between the large patches. In the northern region, however, where the habitat is severely fragmented, elephants tend to move between the isolated forest patches at night, often raiding crops along the way.

Methods of data collection

The study area included protected forests of predominantly deciduous and evergreen types, which contain wild elephants, and cultivated lands surrounding them up to a distance of 10 km from the forest boundary. The main aspects studied were the extent of conflict in the district, patterns and economic impacts of crop raiding, attitudes and expectations of local people and methods of prevention and mitigation commonly used.

An overview of crop raiding was obtained from records maintained by the Forest Department, of compensation claims made by farmers against their crop damage losses. Local farmers, whose crops were raided during the study period, were interviewed to obtain detailed information on raiding patterns. Farmers were divided into three socioeconomic groups for sampling in order to ensure adequate representation of the different communities of agriculturists. The major habitat types in the district were also taken into account by dividing the forests into four similar-habitat zones and sampling farmers in all zones approximately equally. Data on people's attitudes towards elephant conservation and crop raiding were also obtained using the above socioeconomic and similar-habitat classifications. In addition, adequate numbers of women were sampled in order to compare their attitudes with those of men. Methods used for reducing or preventing crop raiding were evaluated by carrying out inspections of the relevant elephant-controlling structures or activities, as well as by assessing local people's reactions to the effectiveness of each method in reducing elephant depredations.

Extent of conflict

Between April 1992 and March 1996, the total number of crop depredation cases recorded in the district was 2,146. Of these, 1,889 cases (88%) were compensated by the Forest Department. The average annual number of crop damage cases was, hence, 472, costing an annual average of Rs. 7,51,835 in compensations paid by the Forest Department. Despite the large sums of money spent on compensations by the Government, however, many people appeared to be dissatisfied with this system. There was no clear pattern of increase, decrease, or constancy in the number of crop raiding cases between 1990 and 1996. On average six people were injured or killed by wild elephants every year in Kodagu. Of the 33 cases recorded, 72.7% of the victims were men. Approximately seven elephants were killed every year during conflict encounters in the district. These encounters include conflict over crops and poaching for ivory, and appear to have been higher during 1992-94 in some areas of the district.

Crop raiding patterns and economic impacts

The widespread occurrence of crop raiding throughout Kodagu is probably related to the presence of suitable habitat for elephants (i.e., protected forests) along three sides of the district. Between 1992 and 1996, losses due to crop depredation affected 222 different villages. Analysis of records for this period showed that the highest total number and frequency of crop raiding cases per village occurred in the northeastern part of the district, corresponding with habitat Zone 1. Even after correcting for forest area and elephant densities, the number of raiding incidences was highest in Zone 1. This area has very little protected forest area and a low estimated elephant density, in comparison to the southern and eastern areas of the district. Hence, the proximate causes suggested to explain the significantly higher raiding frequency in the northeastern area are low quality and fragmentation of habitat.

There was high preference by elephants for raiding cultivations that were within 0.5 km from the forest boundary. However, there was no obvious preference for or against human-transformed habitats in the immediate vicinity of raided cultivations. This suggests that elephants may be able to tolerate and use human-transformed landscapes to some extent in Kodagu. Significantly higher numbers of raiding incidences were carried out by single elephants than by groups of two or more. Between habitat zones, the highest percentage of lone raiders occurred in Zone 3 (64%), a hilly region with predominantly evergreen vegetation.

The most commonly raided crops in the district were paddy (48.2%), coffee (17%), cardamom (10.5%), coconut (8.6%) and banana (6.2%). Raiding incidences on three of these crops, calculated as a proportion of their availability, was compared across the three taluks (the highest administrative subdivision within a district). All three crops were raided proportionately higher in the northern taluk (Somwarpet), which encompasses most of the Zone 1 forests. The average economic loss per raid, estimated from on-site inspections, was Rs. 3,253. However, farmers estimated their annual losses to be approximately ten times this amount. Comparisons across the three socioecnmic groups showed that small farmers suffer the highest percentage loss per year (i.e. loss as a percentage of average annual income).

Attitudes and expectations of local people

Surveys of attitudes of local people revealed that most affected farmers believed that elephants have a right to live despite the damage they cause to crops. A higher proportion of people in Group 3 (wealthy farmers) felt that elephants should be protected, in comparison to those in Group 2 (small farmers). Similarly, Group 1 (subsistence farmers) and Group 3 respectively believed that protecting elephants indirectly benefited the habitat. Most of the respondents believed that lack of fodder in the forests, followed by a preference for crops, were the primary causes of crop raiding by elephants. Elephant capture for translocation/taming, and elephant-proof trenches received maximum support from all respondents as the most suitable methods for reducing conflict. Culling (selective killing) of elephants was supported by 19% of the sample group; however, 81% said that elephants should not be killed by man to control crop raiding or manslaughter.

The concept of cooperative efforts between local farmers and the Forest Department to control crop raiding was received with much skepticism and low support in most areas of the district. However, rather than proving that this method is not feasible, it may simply indicate that efforts have to be made first to build trust between the farmers and representatives of the Forest Department. Several problems which reduce trust and cooperation between the two parties were identified, which, if addressed, may facilitate cooperation between them.

Methods of prevention and mitigation of conflict

Methods used by farmers and by the Forest Department to reduce elephant-human conflict were evaluated for suitability and efficacy. Active methods used by the Forest Department are elephant capture and scaring, while passive methods are elephant-proof trenches, electrified fences and rubble walls. It was found that pressure from local people requiring access to the forest was responsible, in large measure, for the high failure rate of physical barriers, such as elephant-proof trenches (EPTs), erected by the Forest Department. Up to 46.3% of points at which elephants could cross the trenches, were created and maintained by local people. The total number of crossing points appeared to increase with increasing age. Hence it appears that in the absence of local cooperation and regular maintenance efforts EPTs are bound to fail as barriers against elephants.

With regard to electrified fences, elephants tended to attack and break fence posts slightly more often than wires. Efficacy of electrified fences was scored subjectively by local people. The average efficacy score for private fences was higher than for fences owned and maintained by the Forest Department. Comparison of three different systems of ownership and maintenance showed that the effectiveness of electrified fences as barriers against elephants was related to maintenance efforts. Fences maintained on a cooperative basis by two or more independent parties appeared to be highly dependent on trust, cooperation and coordination between all the concerned parties.

Other methods used by the Forest Department to control elephants, were rubble-walls as physical barriers, and elephant capturing or chasing. Rubble walls were found to be generally unsatisfactory and unsuitable for use in Kodagu.

However, elephant capture was considered suitable under certain conditions, such as those in Zone 1. Chasing elephants was not recommended by this study as a useful method for reducing elephant depredations in the long-term.

Discussion and management recommendations

This study shed light on several aspects of crop raiding in Kodagu. It appears that small isolated fragments or patches of forest can serve as refuges for elephants during the daytime, from which they can raid nearby crop fields and plantations during the night. This is of special relevance in the northeastern area of the district. In areas where the conflict is extremely high, with resulting antagonism from local people towards elephants and the Forest Department, immediate relief in the form of elephant-controlling and capturing methods are called for. However, it must be borne in mind that no one solution can be applied throughout the district, and that small fragmented patches of elephant habitat require different management strategies from large ones. Management recommendations specific to the different zones of Kodagu are given in the last section of this report. Finally, it is recommended that elephant populations be monitored over the long term to understand their movements and habitat requirements.

1. INTRODUCTION

The Asian elephant, *Elephas maximus*, is often seen as a flagship for conservation in its range states. As the largest land mammal it warrants conservation and as a carrier of valuable ivory, it warrants protection under the strictest enforcement laws. This has been conferred by listing the elephant in Schedule 1 of the Indian Wildlife (Protection) Act, 1972, in the IUCN Red List and in Appendix 1 of CITES. There are, at present, an estimated 35,000 to 50,000 wild Asian elephants (Santiapillai & Jackson 1990, Sukumar & Santiapillai 1996), a low number in comparison with the approximately 573,000 (which includes definite numbers and estimated numbers) of their African counterpart, *Loxodonta africana* (Said, *et al*. 1995).

In order to ensure the continued existence of Asian elephants, it is important to identify and reduce direct and indirect threats to their survival. Habitat loss, fragmentation and degradation are often considered important threats to Asian elephant survival. Closely related to the problem of habitat loss, is the issue of elephant-human conflict. The term "elephant-human conflict" usually refers to negative interactions such as crop raiding by elephants, human injuries and deaths caused by elephants and killing of elephants for reasons other than ivory extraction. Elephant-human conflict interactions have been documented in several Asian (Blair *et al*. 1979, Sukumar 1989, Balasubramanian *et al*. 1995, Datye & Bhagwat 1995, Jayewardene 1995) and African countries (Thouless 1994, Lahm 1996, Hoare 1997). The costs of crop depredation borne by local communities are often very high. Previous crop raiding studies have identified two groups of farmers primarily affected by crop raiding: *subsistence farmers*, commonly affected in countries like India, and *commercial farmers*, commonly affected in countries like Malaysia and Indonesia. In India, many subsistence farmers lose a high proportion of their crops to elephants and face extreme hardship as a result of crop raiding. Simultaneously, wealthy farmers too suffer heavy losses if the crops destroyed are of high cash value. The conflict problem is hence a cause for concern because it threatens to erode local support for conservation in areas where human life and property are at high risk of destruction by wild elephants (Willams & Johnsingh 1997, Thouless 1994, Lahm 1996).

It is commonly reported from many parts of India that crop raiding has increased dramatically in areas surrounding protected elephant habitats. It is likely that the surrounding areas are partly responsible for elephant habitat degradation, fragmentation and pocketing. Some proximate causes of crop raiding suggested by previous studies are: compression of elephant populations (Ratnam 1984, Hoare 1997), rainfall patterns (Hoare 1997), increased cultivated area and human movement in elephant habitats (Blair *et al*. 1979) and natural preference of crops by elephants (Sukumar 1989). A possible ultimate cause of raiding, suggested by Sukumar & Gadgil (1988), relates to social organisation and the "high risk, high gain" strategy thought to be adopted by male elephants to increase their fitness (Sukumar 1991). No single factor may completely explain the phenomenon of crop raiding by elephants, but several of the above factors may play a significant role under particular circumstances.

In response to the need for further information on elephant-human conflict a project was undertaken by the Asian Elephant Conservation Centre, Bangalore, to study the patterns, ecology and social dimensions of crop raiding in India, and to evaluate the efficacy of current management techniques. The overall goals of the project are to identify common conflict issues in different parts of India and to develop effective prevention or mitigation measures for use under different conditions. The current study of elephant-human conflict in Kodagu district of southern India, carried out between September 1995 and July 1997, forms a part of this larger long-term project. In Kodagu, surveys were carried out to assess crop raiding intensities, local people's opinions of the problem, and effectiveness of currently used control methods. Results of the study provide an indication of the extent of conflict in this district and directions for future research to mitigate problems faced by elephants and humans in this region. These findings will be supplemented with further studies in other conflict-prone areas of southern India such as Bandipur National Park, Karnataka, Mudumalai Wildlife Sanctuary, Tamil Nadu and Wynad Wildlife Sanctuary, Kerala, as well as in elephant areas of northern and northeastern India.

1.1 Land use by humans and elephants in Kodagu

Kodagu district, on the southwestern border of Karnataka State (Fig. 1), has a total area of 4,102 km^2, and a human population of c. 500,000 (c. 120 people/km^2). The elevation of the district ranges between 500m and 1500m. The topography is varied: flatter in the east, gently rising westwards with small valleys and isolated hillocks occurring centrally, and the Western Ghats highlands dominating the western and southwestern areas. Rainfall, primarily received from the South-west monsoons, ranges from 6000mm to 1000mm, decreasing roughly from west to east. The primary occupation of the people is agriculture as the geology, topography and climate support a variety of crops almost year-round. The common crops grown are coffee, paddy, cardamom, pepper, orange, coconut and banana.

Four types of land ownership/administration are found in the district: private, cooperative, government non-forest lands and government forest lands. *Privately owned lands* constitute around 1,400 km^2 of land area in the district (34%) and range from 1 acre to over 1000 acres (c. 250 acres = 1 km^2). *Cooperative ownership of lands* by local communities or religious groups is a traditional practice that continues in some areas. These lands generally are left uncultivated and are utilised jointly by the entire community as common property resources. They are referred to by many different names which describe their traditional function for the community. For example, *Baane* refers to a meadowland used for grazing, *Urudve* refers to a village forest used for fuelwood, timber and minor-forest produce collection, and *Devarakadu* refers to a forest used only for maintenance of a local temple or deity. Traditionally, utilisation of common property resources was regulated by the local community, however, the gradual breakdown of community ties and increasing population pressures have led to encroachment and over-utilisation of these resources by local people. This has led to reduced availability of forest-based resources for indigent communities, and as a consequence pressure on government-owned forests for fuelwood, fodder and other forest products has been steadily increasing.

Government non-forest lands are classified under various categories such as cultivable lands, disturbed forests and uncultivable lands. These lands are often subject to encroachment by migratory labour communities and may also be used by the Government for resettlement of displaced communities. *Protected forests* in the district are controlled by the Government, and are of three types: Reserved Forests (RFs), where controlled utilisation (grazing and collection of fallen branches/forest products) by local communities is permitted; Wildlife Sanctuaries (WSs) where higher restrictions are placed on human movement and utilisation of resources, and a National Park (NP) where unauthorised human movement and utilisation of resources is strictly forbidden.

For administration of non-forest lands, the local (civil services) government is centred at the district capital, Madikeri, and is broadly divided into three administrative units called *Taluks* (headquartered at Madikeri, Virajpet and Somwarpet, respectively) which are further sub-divided into *Gramas* and *Hoblis*. However, the administrative units used by the Forest Department to govern protected forests, although centred in Madikeri, have Divisional boundaries which do not coincide with Taluk boundaries. Hence, the Kodagu Circle forest office, situated in Madikeri, supervises two Divisional Forest Offices located in Madikeri and in Virajpet, respectively, which in turn supervise six Range Forest Offices and five Range Forest Offices respectively.

There are two small-scale irrigation dams in the district, the Harangi and the Chiklihole, supplying water to the surrounding crop lands. Both dams were constructed within the boundary of Reserved Forests. This has led to clearing of trees for dam and reservoir construction as well as for resettlement of displaced tribals. Many flumes carrying water from the dams to peripheral cultivations have blocked the movement of animals. As a result, animals may have been forced to stray outside the boundary in moving between different sections of the same forest.

1.2 Protected forests of Kodagu

The lowland farms and plantations of Kodagu district are surrounded on three sides by RFs, WSs and an NP, totaling 1588 km^2 in area (39% of the geographical area) and ranging in type from dry deciduous to wet evergreen. Around 1730 elephants use these forests. This estimate of elephant population has been based on the 1993 Forest Department census (Alva 1994) and on local knowledge of elephant distributions. These forests almost form a complete chain, encircling the district and enabling free movement of elephants between them. As a consequence, all elephants using the district may be considered as belonging to the same population, although the corridor linking forests in the southeastern tip is through Kerala State and is highly endangered at present. In the northern region, where the habitat has been fragmented and exists as a mosaic of forest and cultivations, elephants move between the isolated forest patches at night, often raiding crops on the way. Brief descriptions of the main large forest patches are given below:

1. Kattepura RF and associated forest fragments: These small forest patches in the extreme northeastern tip of the district, covers 2.34 km^2 of moist deciduous and semi-evergreen vegetation. The region supports a transitory herd of about 10 elephants which move between extremely small and isolated forest patches in this and the adjoining district of Hassan. The River Hemavathi, bordering the northern edge of the district separates forests and crop fields of Kodagu from those of Hassan, and may be used to advantage by raiding elephants. It is suspected that the unusually high density of elephants in this region may be largely supported by biannual crop cultivation practised here. The forest is fairly rich in bamboo but faces severe livestock pressure from surrounding villages.
2. Yedavanad-Anekad group: This highly fragmented mosaic of forests consists of 7 interconnected RFs, 125 km^2 in area to the south of Kattepura. This chain of mixed deciduous forests, about 40 km from north to south and 10 km at its widest from east to west, is highly fragmented and disturbed by human activity. There are about 40 elephants, mostly temporary residents, which regularly come into conflict with farmers in the area.
3. Nagarahole NP (NNP) and adjoining reserves: NNP is situated in the southeastern corner of Kodagu, with three small RFs (Mavkal, Devamachi and Dubare) adjoining its northern edge to form a continuous dry and moist deciduous forest belt with many areas of thick bamboo growth. There are also extensive teak plantations within these forests. Together they cover an area of 759 km^2. This is a highly preferred elephant habitat, supporting a population of 1540 elephants (according to the 1993 census, NNP supports 1448 elephants (Alva, 1994). NNP forms a part of the Nilgiri Biosphere Reserve which is a large expanse of protected habitat (5,520 km^2), spreading over three states in southern India, and allowing free movement of wide-ranging mammals such as elephants, across interstate borders. As a result, many of the elephants in the NP may be seasonal migrants from Tamil Nadu and Kerala.
4. Brahmagiri WS and adjoining reserves: The Brahmagiri WS and two small RFs (Kerti and southern Padinalknad RFs) cover about 485 km^2 of mountainous terrain between 1000 and 1500m in altitude. About 80 elephants are estimated to live in these dense evergreen and semi-evergreen forests and grassland slopes.
5. Talacauvery and Pushpagiri WSs: The Talacauvery and Pushpagiri WSs and intervening forests (Padinalknad, Pattighat and Kadamakal RFs) cover 217 km^2 on the western border of the district. A population of about 60 elephants resides on the steep slopes covered with evergreen forests and grasslands.

Fig.1 : Map of Kodagu District showing protected forest areas and major towns. Dotted lines indicate boundaries of the four habitat-similarity zones. Insets show current elephant distributions in India and location of Kodagu district (forest divisions outlined) in relation to nearby elephant distributions in southern India.

2. METHODS OF DATA COLLECTION

Field work was carried out by the first author, at an average of 20 days per month during September - December, '95, February - May, '96, November - December, '96 and February - April, '97. The study areas included protected forests and cultivated lands surrounding them, up to a distance of 10 km from the forest boundaries in Kodagu. Data collection effort was divided to address the following aspects of conflict:

1. Extent of conflict
2. Patterns and economic impacts of crop raiding
3. Attitudes and expectations of local people
4. Assessment of currently used methods of mitigating conflict

The different methods of data collection used are described below:

2.1 Assessment of the extent of conflict

In order to assess the extent of conflict in the district, information on the total number of crop depredation cases, human injuries, manslaughter and elephant deaths was collected from the two Divisional Forest Department offices in the district, at Madikeri, and Virajpet. These records were obtained for the period 1990 - 1996 from the two Divisional offices and consisted of information relating to the numbers of cases compensated in the Division per year during this period, compensation amounts sanctioned and amounts spent on elephant depredation control measures during this time. It has to be borne in mind, when interpreting results of analysis of these data, that the conflict may have been under- or over-represented in a few localities due to local conditions such as inaccessibility of terrain or lack of interest among farmers in receiving compensation.

2.2 Assessment of patterns and economic impacts of crop raiding

For detailed analysis of trends in crop raiding, information was collected from each Division and Range Forest office, relating to crop damage incidences recorded. The data were in the form of individual records detailing the date of filing a crop damage claim, the village where the case occurred, kinds of crops damaged and the estimated value of damages. Only those cases recorded between 1992 and 1996 were used (totally 2146 cases). This is because the southern region of Kodagu was administered by an office outside the district until 1992, after which the Virajpet Division office (within southern Kodagu) became functional. This database was used to obtain an understanding of conflict areas and frequencies of cases recorded throughout the district during this period.

Another kind of data collected was by inspecting recently damaged sites and using questionnaires to interview farmers whose crops had been raided in the recent past (up to 6 months prior to the date of interview). The questionnaire addressed issues such as location of raided crops, kinds and quantities of plants damaged, size and composition of raiding herds and filing of compensation claims. A total of 48 villages were visited and 122 farmers interviewed. Data collection effort was divided to collect information from farmers of the following three ***socioeconomic groups***:

Group 1 (24 respondents) - Tribal and non-tribal subsistence farmers. This group represented subsistence farmers. The average size of land-holdings for this group was 2.5 acres.

Group 2 (48 respondents) - Non-tribal farmers, whose average annual income did not exceed Rs. 50,000. These represented small farmers in the district. The average size of land-holdings was 5.3 acres.

Group 3 (47 respondents) - Non-tribal farmers, whose average annual income was Rs. 50,000 or more. These represented wealthy farmers. Their average land-holding size was 48.3 acres.

(There were 3 more respondents who did not fit into any of the above Groups as they represented large private company estates.)

Study effort was also divided to cover, in roughly equal proportions, four ***similar-habitat zones***. Division of the forested areas of Kodagu into 4 zones was based on their contiguity and similarities in dominant vegetation type, fragmentation and human pressures. It was assumed that elephant movements and crop raiding patterns may be influenced and constrained by similar factors within each of these zones.

Zone 1, Kattepura-Yedavanad-Anekad RFs (35 respondents) - Habitat in this stretch is highly degraded, fragmented and disturbed, and mainly of moist mixed deciduous type. The terrain is mostly flat, resulting in high human population and cultivation pressures in this zone. The total forested area in this zone is 127 km^2 and shelters an estimated 50 elephants (average density = 0.39 elephants/ km^2).

Zone 2, Dubare-Nagarahole NP (30 respondents) - Fairly contiguous and large stretch of dry deciduous forests on flat land with isolated hillocks. Cultivation pressures on the forest boundaries are high. The total forested area is 759 km^2 (including a contiguous area of NNP forest outside Kodagu), and is estimated to shelter 1540 elephants (average density = 2.03 elephants/ km^2).

Zone 3, Brahmagiri-Talacauvery-Pattighat RFs (33 respondents) - A relatively continuous stretch of semi-evergreen and evergreen forest on the slopes of the Western Ghats. Human settlement is high in the bordering areas,. The total forested area in this zone is 603 km^2, and it is estimated to shelter 110 elephants (average density = 0.18 elephants/ km^2).

Zone 4, Kadamakal-Pushpagiri RFs (24 respondents) - A smaller evergreen/semi-evergreen forest in the northwestern region, continuous with deciduous forests of adjoining South Kanara district, to the north. Human pressure is high in isolated locations. The total forested area is 100 km^2, and it is estimated to shelter 30 elephants (average density = 0.3 elephants/ km^2).

2.3 Assessment of attitudes and expectations of local people

Effort was also made to record people's views on the conflict situation and their implications for mitigation measures and conservation of elephants in the district. This information was collected by using questionnaires in which people were asked to provide their opinions on crop damage issues such as causes of conflict, methods of mitigation and voluntary efforts to reduce conflict. Responses were obtained largely by providing multiple choice answer categories. All opinions not covered by the categories provided were noted down.

In total, 22 different communities and 75 villages were represented by 177 respondents, constituting a separate survey from that listed in section 2.2 above. Answers were analysed by comparisons within the following categories:

1. Socioeconomic groups, as described above (Group 1: 45 respondents, Group 2: 73 respondents, Group 3: 59 respondents)
2. Habitat-similarity zones, as described above (Zone 1: 46 respondents, Zone 2: 54 respondents, Zone 3: 39 respondents, Zone 4: 38 respondents)
3. Men and women (Men: 132, Women: 45).

2.4 Assessment of currently used methods of mitigating conflict

Wherever possible, currently used methods of mitigation and control were inspected to evaluate their age, condition, effectiveness and prospects for long-term viability. Inspections of physical barriers were carried out while travelling either by foot or by jeep (esp. for elephant-proof trenches), and all possible points of entry by elephants were noted. If possible, the costs of construction and maintenance of the barriers were obtained, as well as local perceptions of usefulness. In the case of elephant scaring and capture the researcher participated in two sessions of each of these operations, thus enabling practical evaluation of these methods in the field. Costs incurred in carrying out each method of mitigation were obtained from the Forest Department.

Data were analysed using the following non-parametric tests: Mann-Whitney U-test, proportions test, G-test for significance and Spearman rank-correlation test.

3. EXTENT OF ELEPHANT-HUMAN CONFLICT IN KODAGU

3.1 Crop raiding

Between April 1992 and March 1996, the total number of crop depredation cases recorded in the district was 2,146. Of these, 1,889 cases (88%) were compensated by the Forest Department during this period. Compiling lists of compensation payments made per year in each Division is one of the most common methods used by the Forest Department to assess the impact of crop damages by wild animals. Although this is not a very accurate or sensitive method for understanding crop raiding patterns, it is of some use in providing an overview of damages sustained and for comparing the magnitude of damage between different Divisions, if considered over a long period of time. We compiled this information for two Divisions of Kodagu (Table 1) between 1990 and 1996, for these reasons. The annual numbers of crop damage cases compensated in each division ranged from 146 to 483 cases in Madikeri Division and from 53 to 186 cases in Virajpet Division. On average, for the entire district, 472 cases were compensated annually between 1990 and 1996.

Table 1. Number of crop damage cases recorded for which compensations were paid annually by the State Forest Department in Kodagu, 1990-96.

Year	Madikeri Division (A)		Virajpet Division (B)		Kodagu District (A+B)	
	# cases	Compensn. Rs.	# cases	Compensn. Rs.	# cases	Compensn. Rs.
90-91	146		*			
91-92	239		*			
92-93	338	6,03,464	89	1,36,864	427	7,40,328
93-94	260	1,31,150	53	2,66,014	313	3,97,164
94-95	427	4,67,205	186	6,50,808	613	11,18,013
95-96	483	4,89,650	54	**	537	**
Avg/yr	*315*	*4,22,867*	*95*	*3,51,229*	*472*	*7,51,835*
Avg/cs/yr		*1,101*		*3,352*		*2,227*

* No data available for Virajpet Division as it was created in 1992.
** Data were not available at the time of data collection.

Monetary compensation of crop damage losses and human injury/death began in Karnataka State during the mid 1980s. The amount sanctioned is usually much less than the actual value of damage caused, and may be determined rather arbitrarily in some cases by the concerned Forest Department officers. When conceived of originally, the compensation system required the Forest Department to exactly compensate the full monetary value of crops destroyed by wild animals such as elephants in all genuine cases reported. However, the required methodology for evaluating the value of damage caused was found to be too complicated and time-consuming as it involved obtaining assessments of crop values from other Government

Departments and Institutions. In addition, the Department was hard pressed to find the funds required by law if each case was to be compensated exactly according to assessments made independently by agencies such as the Horticulture Department. As a result, the compensation scheme that was originally intended to protect the interests of surrounding villages and raise the tolerance level of local farmers towards the detrimental effects of wildlife, has now evolved into a system of providing "token relief" to farmers.

Several farmers in other parts of the State and country appear to be dissatisfied with the current method of compensation payment (Datye & Bhagwat 1995, P.F. tenVelde unpubl. study in Bandipur Tiger Reserve, 1996; C. Nath pers. observations in H.D. Kote Taluk and Bannerghatta NP, 1997). Dissatisfaction with the compensation system was expressed by farmers in Kodagu as well. The main reasons cited by farmers were the extremely complicated (and sometimes corrupt) procedures involved in claiming and evaluating damages, and the inadequacy of compensatory amounts sanctioned by the Government. Applying for compensation requires the submission of several forms and legal documents by the farmers, providing scope for misinformation and corruption by both sides. Submission of applications sometimes involves traveling to distant towns, followed by a long wait of 2-6 months before compensation sanctioned. This is because compensatory amounts greater than Rs. 2,000 cannot be sanctioned by the local Forest Officer (Deputy Conservator of Forests), and require the approval of higher ranking officials located in distant cities such as Mysore and Bangalore. The award itself is usually equal to a fraction of the actual loss incurred. Despite local dissatisfaction, a lot of money is being spent annually on compensations, as can be seen in Table 1. It must be remembered that the amounts sanctioned compensate only a fraction of the actual losses suffered by all farmers in the district every year. The value of this fraction may lie somewhere between 7%, the figure obtained from local farmers' opinions (ignoring the possibility of exaggeration of losses by affected farmers), and 68%, a figure obtained by our assessment of crop damage losses, i.e. (assuming only one raid per farmer per year and sanctioning of compensation for all cases; ref. section 4.2.1). In addition, an unknown number of cases are not reported and hence not compensated every year.

There is a general perception among farmers and Forest Department officials in Kodagu that crop raiding has increased in the district during the past 4 - 5 years. However, this is not clear in Table 1. More information will have to be collected on crop raiding patterns in previous years before increasing or decreasing trends can be discerned with certainty. However, the following reasons may explain the perception of increased raiding expressed by local people:

1. Increased local awareness of the compensation system and hence increased interest in keeping track of losses, which may not have been done earlier.
2. Until 1992, all claims from southern Kodagu had to be filed at Hunsur, which is outside the district. After 1992, the Forest Department office at Virajpet was put in charge of claims from southern Kodagu, leading to

increased accessibility to the claims office. This may have encouraged increasing numbers of farmers to file claims, and consequently to remember the raids.

3. Increased crop prices, especially in the case of coffee, may have caused larger economic losses per unit area damaged in the last 2-3 years. This could have led to the false perception of increased amounts of damage.
4. As families increase in size and large properties get divided, the losses suffered in comparison with the average land holdings per family may be increasing.
5. Privately owned forest lands which may have been used previously by elephants may now be getting cleared and converted into productive farmlands. This "agricultural creep" may bring humans increasingly into conflict with elephants.
6. Changes in agricultural practices such as intensive cultivation, with increased use of fertilizers and pesticides, may have increased the costs of production as well as the economic value per unit area destroyed.

3.2 Human injury and manslaughter by elephants

Human injury and death at the hands of raiding, disturbed or "rogue" elephants is another aspect of the human-elephant conflict. There are frequent encounters with elephants, but the annual numbers of injuries or manslaughter have tended to remain relatively low and constant during the past six years (Table 2), when compared to numbers of injuries and deaths reported from other parts of the country such as north Bengal. In the case of manslaughter, Rs. 25,000 is usually paid as compensation by the Forest Department to the victim's surviving family members. However, there has been pressure on the Forest Department to increase the compensation amount to Rs. 1,00,000 for loss of life. In the case of survivors of elephant attacks, if permanent disability is sustained the Forest Department compensates expenses incurred up to a maximum of Rs. 10,000. Table 2 shows the numbers of cases of permanent injury and deaths occurring in the district between 1990 and 1996, and the compensations paid to survivors or to families of the deceased. Of the 33 cases recorded, 72.7% of the victims were men.

Table 2. Human injury and manslaughter cases recorded and compensations paid in Kodagu, 1990-96.

Year	Madikeri Division		Virajpet Division		Kodagu District	
	# cases	Compensn. Rs.	# cases	Compensn. Rs.	# cases	Compensn. Rs.
90-91	4	50,000	*		4	50,000
91-92	5	60,500	*		5	60,500
92-93	5	89,000	3	26,000	8	1,15,000
93-94	4	85,000	2	25,000	6	1,10,000
94-95	2	5,000	3	75,000	5	80,000
95-96	4	56,000	1	25,000	5	81,000
Avg/yr	*4*	*57,583*	*2*	*35,200*	*6*	*86,917*

* No data available for Virajpet Division as it was created in 1992.

Most cases of direct conflict took place either within the forest or along its boundary. Some cases were also recorded from coffee estates where workers were often caught unawares and attacked by herds of elephants or solitary bull elephants which were either raiding the estates or merely passing through. As visibility is often poor within coffee estates, chance encounters with elephants remains a constant threat, especially when the fruiting trees, planted to shade coffee bushes, come into season. Such trees include jack fruit, orange and coconut. Often women and elderly workers were not able to escape from such encounters safely. During these seasons, owners of many large estates had no choice but to leave certain "elephant-infested" sections or blocks untended, as the threats to their own and their workers' lives were too great to ignore. This practice of giving up elephant-favoured blocks and corridors was observed in many estates of Zones 1 and 2.

3.3 Elephant deaths due to conflict

Elephant deaths due to conflict are becoming a serious conservation problem in India. In Kodagu, raiding elephants are often counter attacked by farmers with muzzle-loaded guns which spray lead pellets, iron nails, glass pieces or small stones when fired. Most of the wild elephants captured in the district by the Forest Department during April 1996, had numerous bullet injuries all over their bodies, indicating some degree of retaliation from farmers. Often elephants are not killed outright by the projectiles fired on them, but the fragments of metal or glass embedded in their skin may lead to secondary infections, general weakening and death in some cases. Elephant deaths also result from poaching for ivory, poisoning and capture. Another common cause of elephant deaths, often reported from the adjoining district of Mysore, is electrocution by high voltage electrified fences installed illegally around crop fields. This, however, was not reported in Kodagu during this period.

Table 3 lists records maintained by the Forest Department, of all elephant deaths recorded in Kodagu between 1991 and 1996. The table includes deaths listed as due to "Natural causes", because this category often includes cases in which the cause of death could not be ascertained due to age and decomposition of carcasses at the time of inspection.

Table 3. Elephant deaths recorded in Kodagu, 1991-96.

Year	Madikeri Division	Virajpet Division	Kodagu District	# Poached
91-92	3	*		3
92-93	5	10	15	6
93-94	3	7	10	3
94-95	4	0	4	3
95-96	1	1	2	0
Avg./yr	3	4	7	3

* No data available for Virajpet Division as it was created in 1992.

Elephant deaths due to shooting or poisoning in the district, listed under the heading "# Poached", reflect the numbers of deaths directly inflicted by humans either as a result of conflict over crops or poaching for ivory. Poisoning of elephants was recorded only in a few instances, mainly as a retaliatory measure by farmers who had already suffered depredation by elephants. On average, almost half of the elephant deaths recorded every year are due to direct human actions.

A high number of deaths occurred between 1992 and 1994, mainly in the Thithimathi Range forests of Virajpet Division; however, in most of these cases the cause of death was listed as "natural". Four deaths during this period resulted from elephants being shot at during conflict encounters, or for ivory. The threat of ivory poaching, though low in this district until now, cannot be ignored, as elephants are constantly being shot at to discourage crop raiding, and this could very quickly turn into shooting for ivory as well. Raiding elephants were also poisoned in 2 instances, in Madikeri Division, during 1994 - 95.

4. CROP RAIDING PATTERNS AND ECONOMIC IMPACTS

As described in the Methods section, analysis of crop raiding patterns and economic impacts was based on two kinds of data collected:

1. Forest Department records of raiding incidences and compensations paid between April 1992 and March 1996 (totaling 2146 records),
2. Crop damage questionnaires obtained by interviewing farmers in the district between September 1995 and May 1997 (totaling 122 questionnaires).

4.1 Crop raiding patterns

4.1.1 Distribution of crop raiding incidences in Kodagu

A. Distribution throughout the district

The data from Forest Department records were compiled and analysed to provide information on areas with low and high annual intensities of raiding, "hotspots" of raiding, if any, and raiding incidence in relation to habitat factors such as fragmentation and vegetation type. Total numbers of raiding incidences per village over the 4 year period (1992-96) were plotted for 191 villages on a map of Kodagu in order to visualise the occurrence and distribution of crop raiding and to highlight hotspots of conflict in the district (Fig. 2).

Crop damage incidences occurred over a substantial proportion of the cultivated area in Kodagu, although in 48% of villages, raiding occurred at an average rate of 1 case/yr or less. The widespread occurrence of crop raiding is probably related to the presence of suitable habitat for elephants (i.e., protected forests) along 3 sides of the district. The northeastern side of the district, corresponding with Zone 1, shows a high concentration of raided villages. As described in Section 2.2, the forests here are severely fragmented, disturbed and degraded, and incapable of supporting even a small population of elephants throughout the year. One or more of these factors may be responsible for causing the extremely high incidence of raiding here. In terms of distance from the forests, raiding incidences were largely concentrated near the edges of protected forests in Zones 2 and 3, but spread out up to a distance of almost 10km from the forest edge where forests were more fragmented, as in Zones 1 and 4. This probably corresponds with migratory routes used by elephants, as shown in Fig. 2.

The majority of villages plotted (84% or 160 villages) had less than 5 incidences of raiding per year, while 11% (21 villages) had 5–10 incidences per year, 4% (8 villages) had 11–15 incidences per year and 1% (2 villages) had more than 15 incidences per year. Of the villages experiencing more than 5 raiding incidences per year, 68% were in Zone 1. However, the 2 villages experiencing the most severe frequency of raiding (more than 15 incidences/yr) occurred in Zones 3 and 4 respectively. The village of Palangala, in Zone 3, experienced an annual average of 26 raiding incidences, making it the most frequently raided village in the district. From these figures it appears that severe raiding is most commonly found in Zone 1, with isolated hot spots of raiding in Zones 3 and 4. The 10 villages suffering more than 10 raids annually may be studied further to ascertain whether certain attributes of each increases its probability of being raided.

There may be three routes (marked on Fig. 2) by which elephants are able to cross the predominantly cultivated central area of the district in order to move between the eastern deciduous forests and the western evergreen hill slopes. Elephant movements along the northern route (#1) has been confirmed to occur at least once every alternate year. Crop raiding is not widespread and intensive all along the route, but is probably incidental along the way. Along the routes, there are several small forest patches which may provide temporary cover to elephants away from human activity during the day. These patches may be protected (such as *devarakadus* or revenue forests), while others may be privately owned and subject to clearing at any time. However, they probably enable elephants to raid extensive cultivated areas along their route while crossing through at night.

B. Distribution across zones

Data were then analysed to provide information on zone-wise occurrences of crop raiding cases in the district (Table 4).

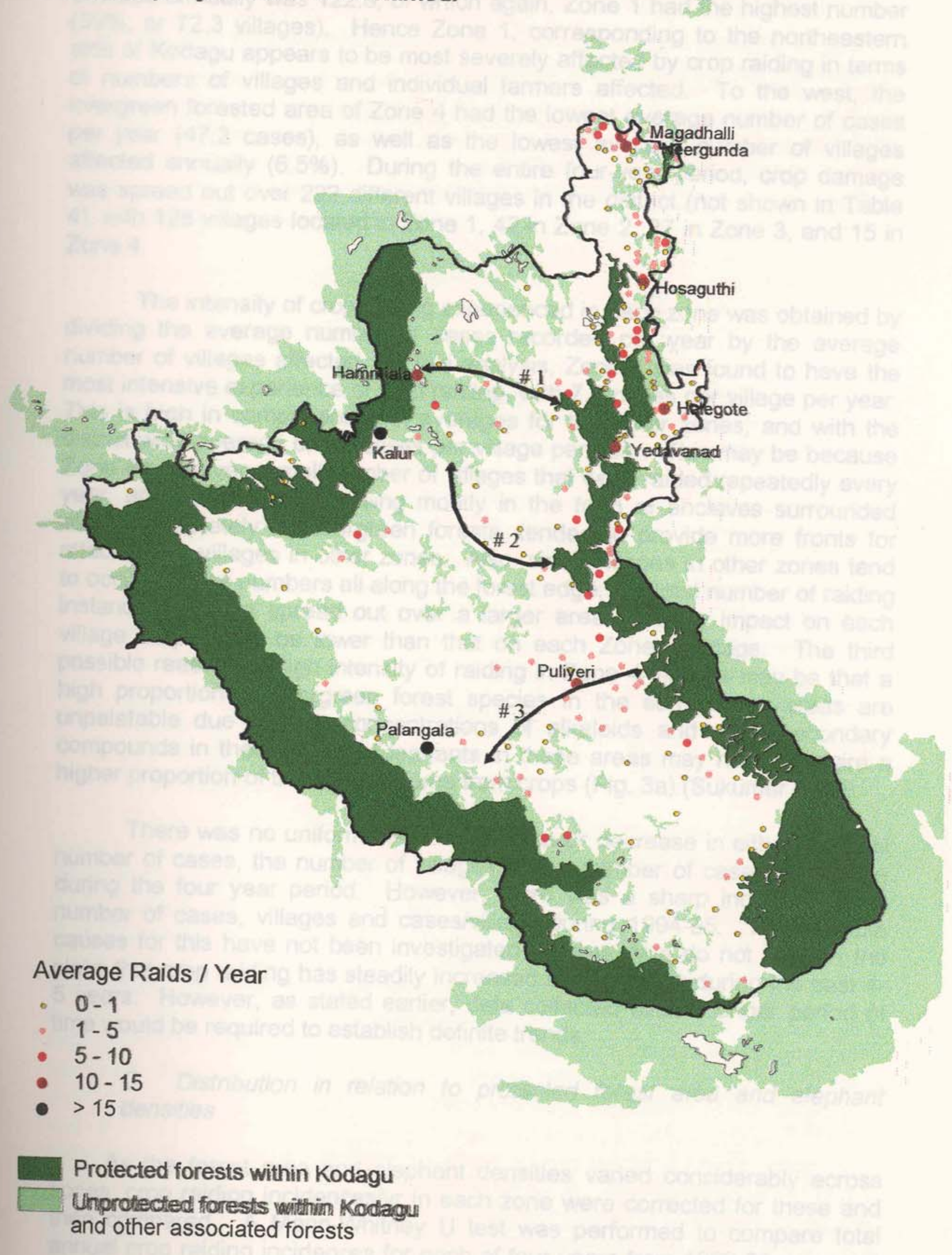
Table 4. Distribution of annual crop raiding cases recorded in the 4 zones of Kodagu between April 1992 and March 1996.

Zone		92-93	93-94	94-95	95-96	Total (4 yrs)	Zone-wise avg /yr	Zone-wise avg /vil/yr
1	# Cases	273	259	424	264	**1220**	**305.0**	**4.2**
	# Vil.	74	74	72	69	289*	72.3	
2	# Cases	102	73	147	65	**387**	**98.8**	**4.0**
	# Vil.	19	23	31	22	95*	24.5	
3	# Cases	93	50	143	65	**350**	**85.5**	**4.5**
	# Vil.	18	18	28	16	80*	19	
4	# Cases	3	4	77	104	**188**	**47.3**	**7.3**
	# Vil.	2	2	11	10	25*	6.5	
Total (4 zones)	*# Cases*	***471***	***386***	***791***	***498***	***2146***	***536.5***	***4.4***
	# Vil.	*113*	*117*	*142*	*117*	*489**	*122.3*	
Year-wise avg. /vil		***4.2***	***3.3***	***5.6***	***4.3***	***4.4***		

* Total does not imply independent villages as many villages experienced raiding during more than 1 year.

On average, 536.5 cases were recorded per year, of which around 57% (305 cases) occurred in Zone 1. The average number of villages

Fig. 2: Map of Kodagu showing annual crop raiding incidences per village and three possible migration routes of elephants (numbered on map). Towns experiencing more than ten raids per year have been named.



affected annually was 122.3, of which again, Zone 1 had the highest number (59%, or 72.3 villages). Hence Zone 1, corresponding to the northeastern side of Kodagu appears to be most severely affected by crop raiding in terms of numbers of villages and individual farmers affected. To the west, the evergreen forested area of Zone 4 had the lowest average number of cases per year (47.2 cases), as well as the lowest average number of villages affected annually (6.5%). During the entire four-year period, crop damage was spread out over 222 different villages in the district (not shown in Table 4), with 128 villages located in Zone 1, 42 in Zone 2, 37 in Zone 3, and 15 in Zone 4.

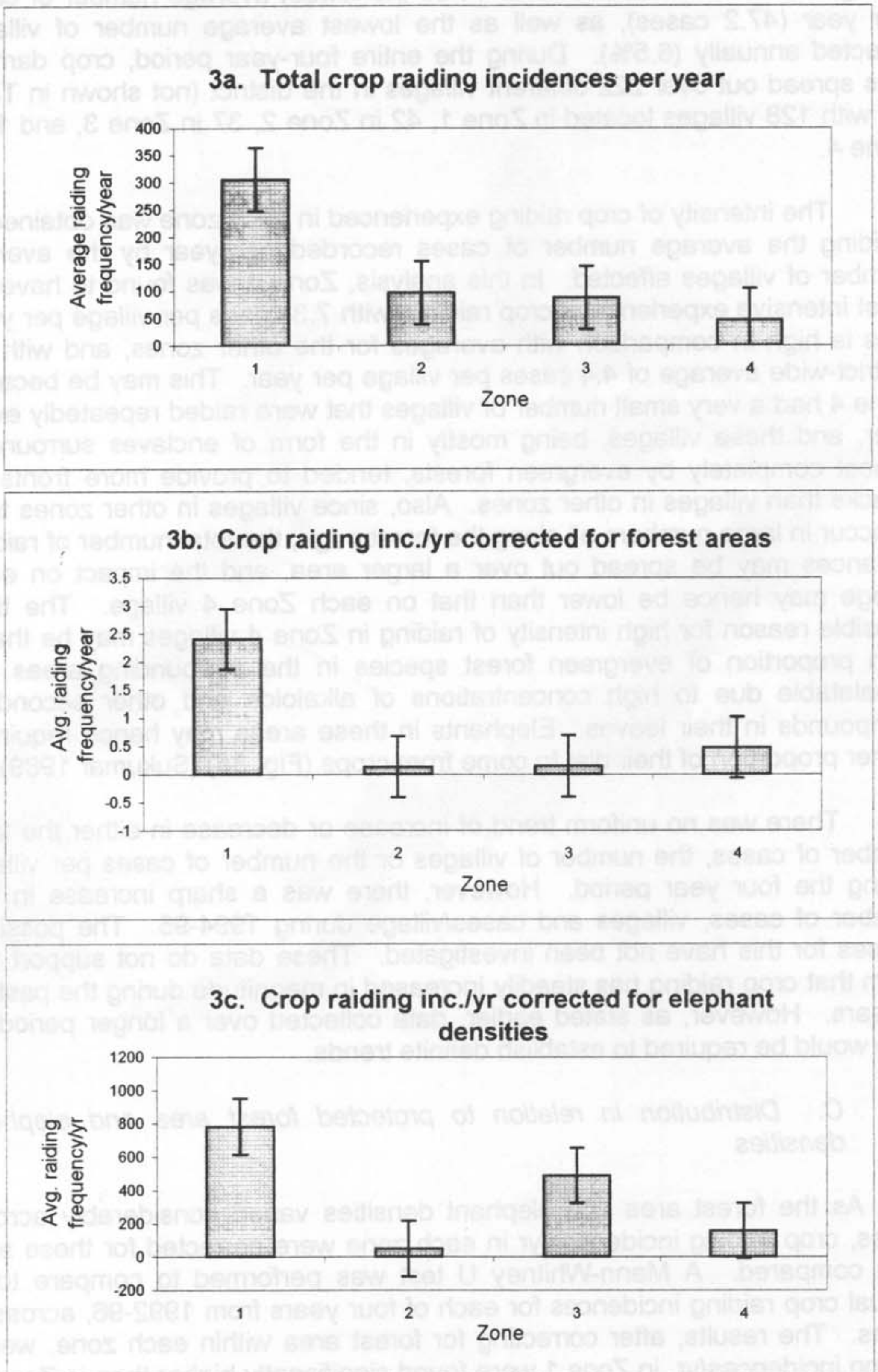
The intensity of crop raiding experienced in each zone was obtained by dividing the average number of cases recorded per year by the average number of villages affected. In this analysis, Zone 4 was found to have the most intensive experience of crop raiding, with 7.3 cases per village per year. This is high in comparison with averages for the other zones, and with the district-wide average of 4.4 cases per village per year. This may be because Zone 4 had a very small number of villages that were raided repeatedly every year, and these villages, being mostly in the form of enclaves surrounded almost completely by evergreen forests, tended to provide more fronts for attacks than villages in other zones. Also, since villages in other zones tend to occur in large numbers all along the forest edge, the total number of raiding instances may be spread out over a larger area, and the impact on each village may hence be lower than that on each Zone 4 village. The third possible reason for high intensity of raiding in Zone 4 villages may be that a high proportion of evergreen forest species in the surrounding areas are unpalatable due to high concentrations of alkaloids and other secondary compounds in their leaves. Elephants in these areas may hence require a higher proportion of their diet to come from crops (Fig. 3a) (Sukumar 1989).

There was no uniform trend of increase or decrease in either the total number of cases, the number of villages or the number of cases per village during the four year period. However, there was a sharp increase in the number of cases, villages and cases/village during 1994-95. The possible causes for this have not been investigated. These data do not support the claim that crop raiding has steadily increased in magnitude during the past 4-5 years. However, as stated earlier, data collected over a longer period of time would be required to establish definite trends.

C. Distribution in relation to protected forest area and elephant densities

As the forest area and elephant densities varied considerably across zones, crop raiding incidences/yr in each zone were corrected for these and then compared. A Mann-Whitney U test was performed to compare total annual crop raiding incidences for each of four years from 1992-96, across 4 zones. The results, after correcting for forest area within each zone, were: raiding incidences/yr in Zone 1 were found significantly higher than in Zone 2 Zone 3 and Zone 4 at (at $p<0.05$) (Fig 3b). Raiding incidences, corrected for

Fig. 3. Average number of crop raiding incidences per year (1992-96) in Kodagu, across four similar-habitat zones.



forest area, between Zones 2, 3, and 4 were not significantly different from each other.

On correcting for elephant densities within each zone, raiding incidences in Zone 1 were found to be significantly higher than those of Zone 2 and Zone 4 (at $p<0.05$), while incidences in Zone 3 were also found to be significantly higher those of Zone 2 and Zone 4 (Fig. 3c). Based on this result, Zones 1 and 3 appear to have the highest crop raiding incidences/elephant/km^2 in the district.

4.1.2 Characteristics of raided sites inspected

A. *Distance of raids from the forest boundary*

Of the 122 raided sites inspected, the farmers' residences were within or adjoining the cultivations in 93% of cases, indicating that the presence of humans nearby did not reduce the probability of raiding. However, human settlements in the form of small villages or towns occurred near only 30% of the cultivations. This suggests that the presence of large numbers of humans in an area may deter elephants.

Proximity of protected forests to raided cultivations was less than 0.5 km in 68% of all cases, indicating a high preference for raiding cultivations closer to forest boundaries, as shown in Fig. 4. Between the different zones, distances from forests to raided sites showed the following patterns:

Zone 1: 74.3% within 0.5 km, and 97.1% within 2 km;
Zone 2: 86.7% within 0.5 km, and 96.7% within 2 km;
Zone 3: 48.5% within 0.5 km, and 63.6% within 2 km, (27.3% beyond 5 km);
Zone 4: 62.5% within 0.5 km, and 78.7% within 2 km, (8.3% beyond 5 km).

Elephants may be able to raid crops further away from protected forests in Zones 3 & 4 because of the availability of fragmented forests interspersed between estates in these hilly regions. Another reason is the high degree of cover provided by cardamom estates (sometimes indistinguishable from natural forests at a distance) which are common in these two zones. Elephants appeared to take several routes towards cultivations and did not raid only those situated on the periphery of the forests. Natural forests and forest fragments occurred just outside and completely surrounded 15% of all sites inspected, enabling elephants to approach these sites from any side. These were most common in Zone 4 (Fig. 5). In 8% of cases, though, there were no forests or forest fragments visible in the vicinity (up to 1 km) of the raided sites, which probably forced elephants to be more cautious in approaching them. These were most common in Zone 2 and did not occur in Zone 4. Interestingly, most of the sites in Zone 1 (94%) were surrounded by a combination of natural forest and cultivations, indicating a high degree of forest fragmentation in this zone. The remaining 77% of inspected sites were surrounded by a combination of natural forest and cultivated or settlement areas.

B. Effect of surrounding vegetation and land use patterns

Next we investigated whether human land use patterns and natural vegetation types had any effect on the frequency of raids. While surveying crop damage in the district, information was collected on vegetation and land use patterns in the area immediately surrounding each raided field or estate inspected. The main kinds of forest types surrounding crop fields included evergreen, deciduous (mainly dry in the southeast and mixed moist in the northeast of the district), fragmented forests and bamboo thickets. Of these, bamboo thickets were commonly found in most zones. Human influenced landscapes were found to be mainly of the following types: estates, crop fields and settlements.

In order to assess the influence, if any, of land transformations (representing different degrees of disturbance from humans) on elephant raiding behaviour, the vegetation/land use combinations were ranked according to the following habitat transformation scale: Among natural vegetation, evergreen forest was considered the least transformed and fragmented forest the most transformed. Hence, human-related transformation was assumed to progress in the following order: evergreen --> deciduous --> bamboo forest --> fragmented forest. Accordingly, evergreen forest was ranked the highest and fragmented forests the lowest. These ranks were then modified by the surrounding land usage types which consisted of combinations of estates, crop fields and/or settlements.

Table 5: Ranks of Vegetation/Land Usage Types

Rank	*Type*	*Rank*	*Type*
1	V	16	DC
2	VB	17	DEC
3	VF	18	DES
4	D	19	DCS
5	DB	20	DECS
6	VE	21	DS
7	VC	22	DBE
8	VEC	23	DBC
9	VDCS	24	DBES
10	VBC	25	DBS
11	VFEC	26	DFE
12	VBECS	27	DFCS
13	VFE	28	FE
14	VFEC	29	E
15	DE	30	ES

KEY:

Natural Vegetation Types:
V = Evergreen
D = Deciduous
B = Bamboo forest
F = Fragmented forests

Transformed Lands:
E = Estate
C = Crop field
S = Settlement

Fig. 4. Distance of inspected sites of crop raiding from the boundary of protected forests.

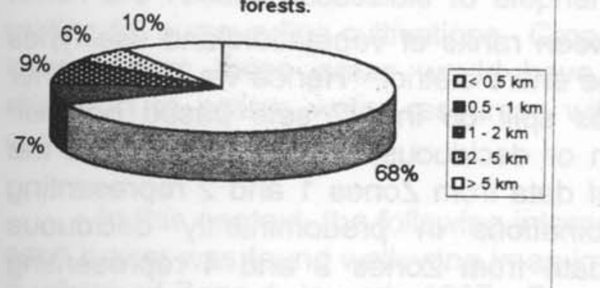


Fig. 5. Percentage occurrence of raided sites which were completely surrounded by forests or by crop fields in Kodagu.

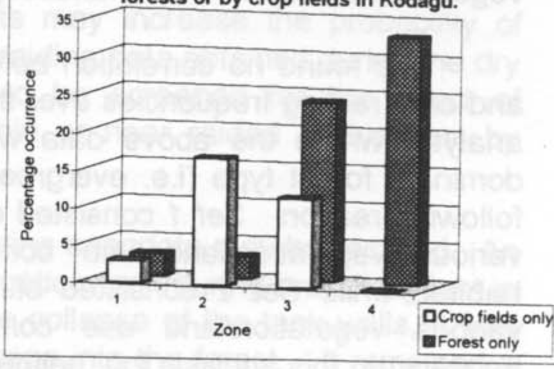
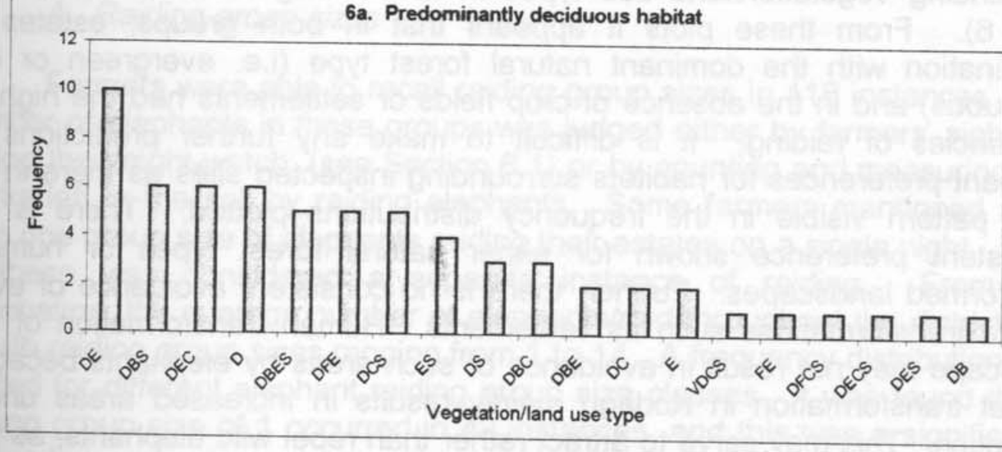
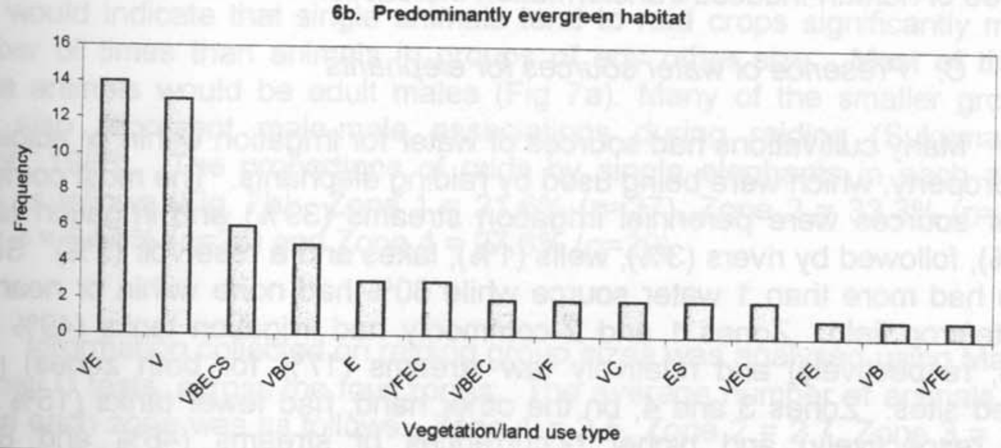


Fig. 6. Influence of surrounding vegetation and human-induced habitat transformations on the frequency of raids by elephants.

6a. Predominantly deciduous habitat



6b. Predominantly evergreen habitat



Estates were assumed to mimic natural forest types the most and settlements the least, and were accordingly assigned ranks. The stage of transformation of the natural vegetation type considered in combination with the extent of resemblance of transformed lands to natural habitat provided the basis for the ranking system used for 30 combinations of natural vegetation and transformed landscapes recorded during the survey (Table 5).

We found no correlation between ranks of vegetation/land use types and crop raiding frequencies over the entire district. Hence we did a further analysis where the above data was split up into 2 sets based on their dominant forest type (i.e. evergreen or deciduous). This was done for the following reason. *Set 1* consisted of data from Zones 1 and 2 representing various vegetation/land use combinations in predominantly deciduous habitat, while *Set 2* consisted of data from Zones 3 and 4 representing various vegetation/land use combinations in predominantly evergreen habitats. In this analysis too, neither Group 1 nor Group 2 ranks showed any correlation with frequency of crop raiding ($r_s = 0.069$, $n = 19$, $df = 17$, $P > 0.05$; and $r_s = 0.1876$, $n = 14$, $df = 12$, $P > 0.05$, Spearman Rank-Correlation, respectively).

The frequency of crop raiding incidents was then plotted against surrounding vegetation/land use types in descending order of occurrence (Fig. 6). From these plots it appears that in both groups, estates in combination with the dominant natural forest type (i.e. evergreen or dry deciduous) and in the absence of crop fields or settlements had the highest frequencies of raiding. It is difficult to make any further predictions of elephant preferences for habitats surrounding inspected sites as there in no clear pattern visible in the frequency distributions plotted. There is no consistent preference shown for either natural forest types or human-transformed landscapes. Further, there is no consistent avoidance of even severe transformations such as settlements. Human transformation of the landscape may not result in avoidance of such areas by elephants because habitat transformation in Kodagu mainly results in increased areas under cultivation. This may serve to attract rather than repel wild elephants, as the degree of human-induced transformation increases.

C. Presence of water sources for elephants

Many cultivations had sources of water for irrigation within or adjoining the property, which were being used by raiding elephants. The most common water sources were perennial irrigation streams (39%) and irrigation tanks (33%), followed by rivers (3%), wells (1%), lakes and a reservoir (2%). Some sites had more than 1 water source while 30% had none within or near the estate/crop field. Zones 1 and 2 commonly had irrigation tanks (49% and 53%, respectively) and relatively few streams (17% for both zones) near raided sites. Zones 3 and 4, on the other hand, had fewer tanks (15% and 8%, respectively) and higher occurrences of streams (46% and 88%, respectively).

In dry areas, such as in most of Zone 1 and northern areas of Zone 2, availability of water to elephants may be an important attraction in addition to crops. This is because during the dry period of the year, (January to May), natural water sources within the forest may dry up causing elephants, which require up to 200 litres of water a day, to enter farms and plantations where water is often available in artificial tanks and wells. Hence, irrigation tanks which are readily accessible to elephants may increase the probability of raiding for surrounding cultivations. Crop raiding data obtained during the dry season from these areas would have to be screened for the effect of attraction to scarce water resources within or near raided cultivations, by using appropriate controls.

In this context, the following interesting anecdote may be recalled: An adult tusker was found wallowing in an irrigation tank during broad daylight in a village of Zone 1, in early 1997. Due to collapse of the tank walls, it was unable to climb the slippery sides and escape into the forest. It remained a grand spectacle for crowds of local villagers for one entire day. Eventually the Forest Department tranquilised and captured it, thus ending what probably once was an illustrious career as a crop raiding bull in Zone 1.

4.1.3 Raiding group sizes and duration of raids

A. Raiding group sizes

Farmers were able to recall raiding group sizes in 118 instances. The number of elephants in these groups was judged either by farmers' sightings during their night-watch (see Section 6.1) or by counting and measuring pad marks left in the soil by raiding elephants. Some farmers mentioned more than one group size of elephants raiding their estates on a single night. Each of these was considered a separate instance of raiding. From this information, the average number of elephants/raid throughout the district was 3, with raiding group sizes ranging from 1 to 14. A frequency distribution was plotted for different elephant raiding group size classes. It was found that a raiding group size of 1 occurred in 42 instances, and this was a significantly higher frequency than all other group size classes ($p<0.05$, Proportions test). This would indicate that single animals tend to raid crops significantly more number of times than animals in groups of any other size. Most of these single animals would be adult males (Fig 7a). Many of the smaller groups may also represent male-male associations during raiding (Sukumar & Gadgil, 1988). The proportions of raids by single elephants in each zone were as follows (Fig. 7b): Zone 1 = 21.6% (n=37), Zone 2 = 33.3% (n=24), Zone 3 = 64.3% (n=28) and Zone 4 = 27.6% (n=29).

Information collected on raiding group sizes was analysed using Mann-Whitney U tests, across the four zones. The average number of animals per raid in each zone was as follows: Zone 1 = 3.5, Zone 2 = 2.7, Zone 3 = 1.7, Zone 4 = 6.1. It was found that between Zones 1 & 3, Zone 1 had significantly larger raiding group sizes than Zone 3 ($U = 256$, $p<0.01$, $n_1=37$, $n_2=28$). Zone 2 was found to have significantly larger raiding group sizes when compared to Zone 3 (U = 219.5, p <0.05, n_1=24, n_2=28). Zone 4 was also found to have significantly larger group sizes than Zone 3 (U = 199.5, p <0.01, n_1=29, n_2=28) (Fig. 7b). It appears that Zones 1, 2 and 4 had raiding group sizes which were not significantly different from each other but which were all significantly larger than the average raiding group size of Zone 3. This is to be expected as Zone 3 had the highest proportion of single elephants raiding crops.

B. Duration of raids

In 20 instances, farmers were able to give estimates of the time spent by elephant groups inside estates or crop fields. The average duration of each raid was 5.1 hours and the total time spent inside cultivations ranged from 1.5 to 11.5 hours. However, reporting bias may be responsible for the lower limit of time spent being 1.5 hours. Farmers may not have noticed or taken note of elephants which stayed for a shorter period of time. Almost all cases of raiding took place between dusk and dawn, with elephant movement into cultivations usually commencing around 7 p.m. and lasting until around 10 p.m., and movement back into the forests or sheltering forest fragments usually occurring between 4 a.m. and 6 a.m. In many areas farmers and their families were afraid to walk inside their estates or fields after dark. Many cases of human injury and manslaughter have occurred during twilight and dawn when workers returning home or leaving for work have suddenly encountered elephants silently moving into or retreating from the estates and fields.

4.1.4 <u>Seasons of raiding and crop preferences</u>

A. Preferred raiding seasons

Crops are available in Kodagu almost all year round, as the district is well irrigated with natural streams that last through most of the year. In the drier eastern and northern areas, large tanks have been constructed for private use, which store rain water from the previous monsoon. As a result, the following crop and fruiting seasons are seen in the district:

Jan - March:	coffee, orange
April - May:	paddy (2nd crop), pepper
June - July:	fruits (mango, papaya, guava, citrus, jack fruit)
August - September:	corn, paddy (early stage)
October - December:	paddy (1st crop), ragi

In addition, coconut and banana are available almost throughout the year.

During the questionnaire survey, raids reported by farmers appeared to have two peaks in a year. These trends were investigated using the data from Forest Department records. Dates of raiding were available for 1553 records, of which 1219 records were from Zone 1. A percentage frequency distribution of raids in the district between 1992 and 1996 (Fig. 8) shows that there are indeed two peak raiding seasons in the district during July-September and November-January, respectively. These patterns appear to be followed in all zones except Zone 2. However, the sample size in Zone 2

Fig. 7. Frequency distribution of group sizes of raiding elephants in inspected sites of Kodagu.

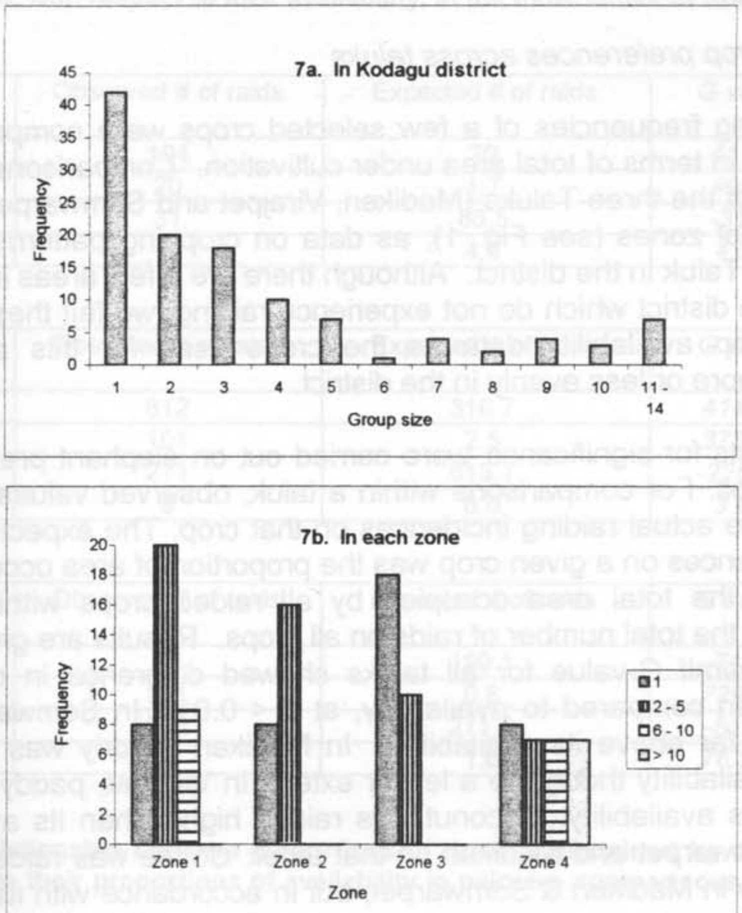
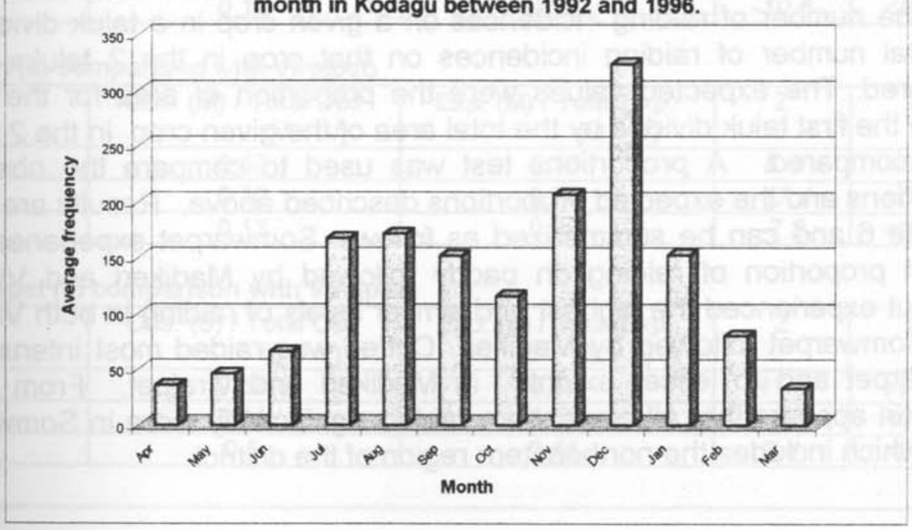


Fig. 8. Frequency distribution of average number of raids per month in Kodagu between 1992 and 1996.



was rather low (n = 38) in comparison with the other zones and hence this result may be an artefact of low sample size.

B. Crop preferences across taluks

Raiding frequencies of a few selected crops were compared to their availabilities in terms of total area under cultivation. Comparisons were made at the level of the three Taluks (Madikeri, Virajpet and Somwarpet) instead of at the level of zones (see Fig. 1), as data on cropping patterns have been compiled by Taluk in the district. Although there are a few areas in the central region of the district which do not experience raiding, we felt these would not bias the crop availability data as the crops used for this analysis are distributed more or less evenly in the district.

G-Tests for significance were carried out on elephant preferences for different crops. For comparisons within a taluk, observed values for a given crop were the actual raiding incidences on that crop. The expected value for raiding incidences on a given crop was the proportion of area occupied by the crop out of the total area occupied by all raided crops within the taluk multiplied by the total number of raids on all crops. Results are given in Table 8a. The overall G-value for all taluks showed difference in crop raiding intensity when compared to availability, at $p < 0.01$. In Somwarpet, paddy was raided far above its availability. In Madikeri paddy was also raided above its availability though to a lesser extent. In Virajpet, paddy was raided lower than its availability. Coconut was raided higher than its availability in Virajpet, Somwarpet and Madikeri, in that order. Coffee was raided less than its availability in Madikeri & Somwarpet, but in accordance with its availability in Virajpet.

The most commonly raided crops in the district were paddy (48.2%), coffee (17%), cardamom (10.5%), coconut (8.6%) and banana (6.2%). Proportions of crop raiding incidences for 3 of these crops (paddy, coconut and coffee) were compared across taluks, pairwise. The observed values were the number of raiding incidences on a given crop in a taluk divided by the total number of raiding incidences on that crop in the 2 taluks being compared. The expected values were the proportion of area for the given crop in the first taluk divided by the total area of the given crop in the 2 taluks being compared. A proportions test was used to compare the observed proportions and the expected proportions described above. Results are given in Table 6 and can be summarized as follows. Somwarpet experienced the highest proportion of raiding on paddy followed by Madikeri and Virapet. Coconut experienced the highest and similar levels of raiding in both Virajpet and Somwarpet followed by Madikeri. Coffee was raided most intensely in Somwarpet and to lesser extents in Madikeri and Virajpet. From these results in appears that all crops were raided significantly more in Somwarpet taluk, which includes the northeastern region of the district.

Table 6a. **Comparison of proportional amounts of damage caused by elephants to different crops, with respect to their availability, in the three taluks of Kodagu**

Madikeri

Crop	Observed # of raids	Expected # of raids	*G value (signif level)*
Paddy	104	70	*41.1 (<0.01)*
Coconut	20	1.7	*49.3 (<0.01)*
Coffee	31	86.5	*-31.8(<0.01)*
Arecanut	8	4.8	*4.0 (>0.05)*

Somwarpet

Crop	Observed # of raids	Expected # of raids	*G value (signif level)*
Paddy	612	310.7	*414.8 (<0.01)*
Coconut	101	2.5	*373.5 (<0.01)*
Coffee	211	613.7	*-225.2 (<0.01)*
Pepper	9	6.0	*3.6 (>0.05)*

Virajpet

Crop	Observed # of raids	Expected # of raids	*G value (signif level)*
Paddy	92	199.1	*-71.0 (<0.01)*
Coconut	141	0.8	*729.2 (<0.01)*
Coffee	213	271.5	*-51.6 (<0.01)*
Pepper	27	1.6	*76.29 (<0.01)*

Table 6b. **Relationship between proportions of damage sustained by different crops with respect to their proportions of availability in pairwise comparisons across taluks of Kodagu.**

Madikeri (in comparison with Somwarpet)

Crop	Obs. (M) / Total Obs (M + S)	Exp. (M) / Total Exp. (M + S)	*Z*	*p*
Paddy	0.14	0.47	*-23.8*	*<0.05*
Coconut	0.17	0.73	*-13.7*	*<0.05*
Coffee	0.13	0.36	*-10.6*	*<0.05*

Madikeri (in comparison with Virajpet)

Crop	Obs. (M) / Total Obs (M + V)	Exp. (M) / Total Exp. (M + V)	*Z*	*p*
Paddy	0.53	0.30	*6.4*	*<0.05*
Coconut	0.12	0.74	*-17.4*	*<0.05*
Coffee	0.13	0.28	*-7.2*	*<0.05*

Somwarpet (in comparison with Virajpet)

Crop	Obs. (S) / Total Obs (S + V)	Exp. (S) / Total Exp. (S + V)	*Z*	*p*
Paddy	0.87	0.32	*41.8*	*<0.05*
Coconut	0.41	0.51	*-1.8*	*<0.05*
Coffee	0.5	0.41	*3.4*	*<0.05*

4.2 Economic impact of crop raiding

4.2.1 Losses perceived by farmers and compensations received

The average economic loss accruing to a farmer during a single raid was estimated to be Rs. 3,253 for the inspected cultivations. Economic values were estimated by obtaining selling prices of different crops from several farmers during interviews. From these an average value for each crop (i.e., immediate loss suffered) was calculated and used to estimate the total economic loss suffered in each case of raiding. This estimation gives a very cursory view of the economic losses borne by farmers, - in order to examine the true extent of losses one would have to consider the inputs provided in expectation of future yield, yields during the current season which were destroyed by elephants, expected yields foregone during years following the raid until the 'replacement' plant begins to yield and all inputs required to bring the replacement plant to maturity and similar yielding potential as the destroyed plant. Such a calculation would apply especially in the case of "long yield-life" crops such as coffee, coconut, cardamom and arecanut, which are common in this district.

The average compensation paid by the Forest Department in the district (Table 1, Section 3.1) was Rs. 2,227 per case, or 68% of the average value estimated by us from inspected sites. However, when farmers were asked to estimate their average annual losses from elephant depredations, the average value obtained was Rs. 32,070/yr, or 14.4 times the average amount paid for each case of crop raiding in the district per year. If we assume that on average each farmer is paid compensation for two separate raids every year (usually a farmer receives compensation only once per year), the loss suffered by the farmer during the whole year still may be as high as 7.2 times greater than the amount compensated by the Forest Department. However, in using these estimations, one must bear in mind that values may have been overestimated by irate farmers. Most farmers had no interest in the compensation system installed by the Forest Department. Only 29% of interviewed farmers claimed compensation for the most recent damage suffered. This may be due to the fact that in the past only 43% of farmers had received compensations for damages suffered, and according to their estimates the amounts paid by the Forest Department compensated only 15.7% of the actual losses suffered per raid. Amounts received ranged from nothing at all to Rs. 50,000. As a result, many had stopped approaching the Forest Department for compensation.

4.2.2. Losses compared across different socioeconomic groups

Losses and compensations were analysed according to socioeconomic groups. The average size of land-holdings of Group 1 farmers was 2.5 acres, Group 2 farmers: 5.3 acres, and Group 3 farmers: 48.3 acres. These were found to be significantly different between the three groups, using the Mann-Whitney U Test. The results were as follows:

Group 1(subsistence) and Group 2 (small farmers): $U = 255.5$, $p < 0.01$, $n_1=24$, $n_2=48$.

Group 1 and Group 3 (large farmers): $U = 14$, $p < 0.01$, $n_1=24$, $n_2=47$.

Group 2 and Group 3: $U = 143$, $p < 0.01$, $n_1=48$, $n_2=47$.

When percentage losses (i.e. losses calculated as a percentage of total income) due to damage were compared across the 3 groups, significant differences were found only between Groups 2 and 3 ($U = 708.5$, $Z = -3.37$, $p < 0.05$, $n_1=47$, $n_2=50$). In other words, losses as a percentage of total annual income were found to be significantly higher for Group 2 farmers than for Group 1 and Group 3 farmers.

5. ATTITUDES AND EXPECTATIONS OF LOCAL PEOPLE

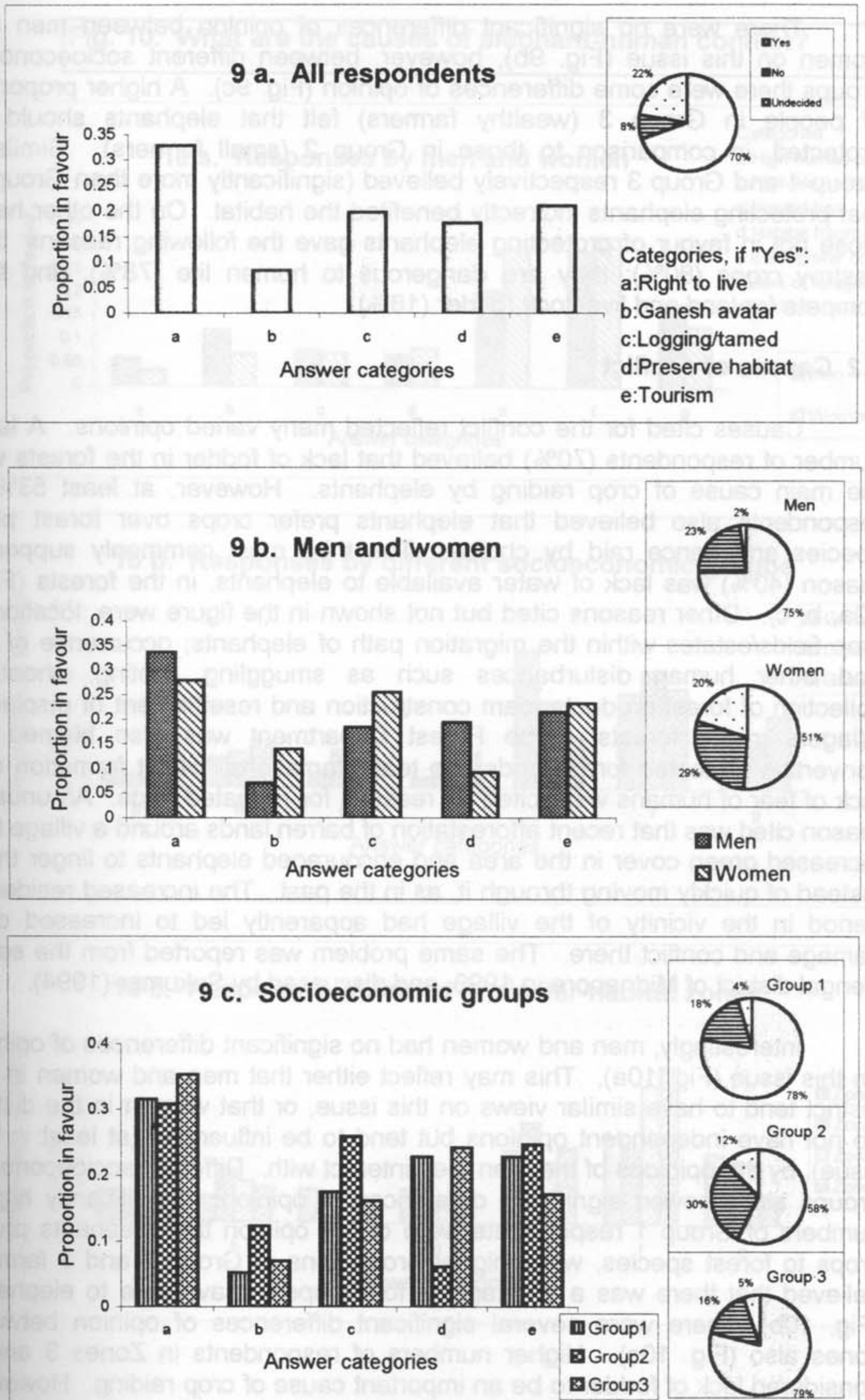
The religious and cultural ties between Indian people and wild animals have had special significance where elephants are concerned. The omniscient and generous elephant-headed God, Ganesha or Vinayaka, worshipped by millions of people throughout the country, may have been significantly responsible for the popular perception of elephants as wise and gentle beings. It is next to impossible to discuss the interaction between Indians and their elephants, whether wild or domesticated, in a purely scientific or economic light. This close and ancient relationship between the two species has given several Indian conservationists hope for the long term survival prospects of elephants in India (Lahiri-Choudhury 1991, Sukumar 1989, Daniel 1995). Similar views linking cultural ties to conservation values have been expressed by researchers in Sri Lanka (Jayewardene 1995) and Myanmar (Ye Htut 1995). How closely cultural values actually influence the daily interactions and views of people facing crop raiding and other forms of elephant-human conflict was hence an interesting topic for study. Do religious sentiments lead to increased tolerance of elephant depredations? Should economic or practical considerations take precedence over cultural values in long-term management strategies? Do people believe that wild elephants have a place in our country in the future? These are some of the issues explored in this aspect of the study.

People of Kodagu District were acutely aware of the conflict between elephants and farmers, although many were initially skeptical of the usefulness of expressing their opinions to us. Some expressed helplessness in the face of the problem which they had accepted as a part of their lives for many years. Others had very strong opinions on the causes and cures of the conflict. The following is a summary of views expressed during the survey. Proportions tests (Z-tests) were used to check for significant differences across groups, at $p<0.05$.

5.1 Attitudes towards elephants

This question probed the feelings of people towards elephants. When asked whether wild elephants should be protected and preserved in protected areas, 69% agreed; 23% disagreed; and the rest did not have a clear opinion. Many respondents in favour of protecting elephants cited more than one reason for doing so. Most commonly, they believed that elephants have a right to live (63%), followed by their use in promoting tourism (42%). Other common reasons for advocating protection of elephants are shown in Fig. 9a. Surprisingly, religious sentiment played a relatively minor role in defending protection of elephants, with only 16% of respondents linking protection of elephants to its religious association as a form (*avatar*) of Lord Ganesh. Some less common, though interesting, reasons cited in favour of preservation were that forests without elephants lose their (intrinsic) value, elephants are a unique natural gift, a form of national wealth, and a legacy for future generations. A small percentage of respondents also believed that the

Fig. 9. Should elephants be protected and preserved?



presence of elephants in the forest deterred smugglers and looters from entering.

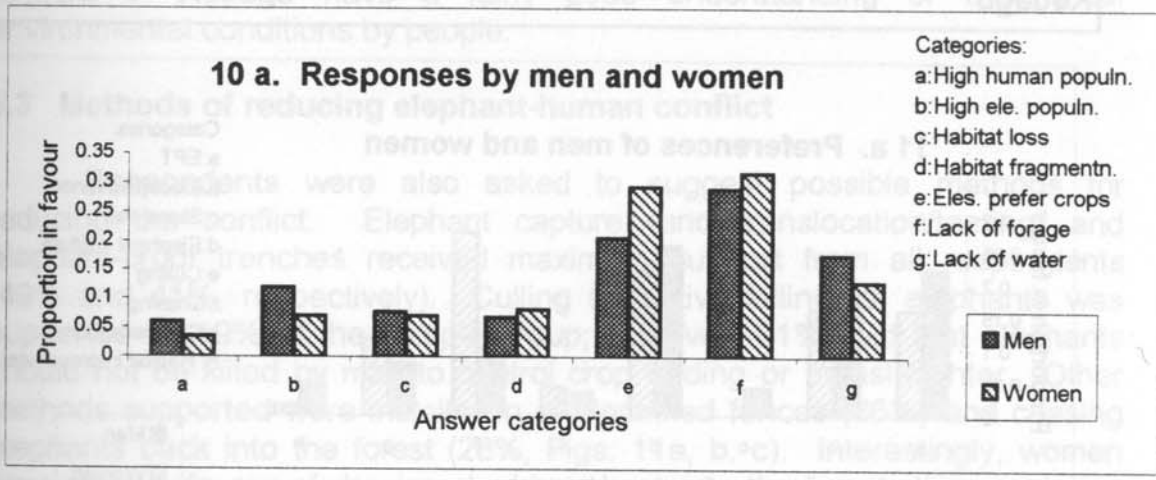
There were no significant differences of opinion between men and women on this issue (Fig. 9b), however, between different socioeconomic groups there were some differences of opinion (Fig. 9c). A higher proportion of people in Group 3 (wealthy farmers) felt that elephants should be protected, in comparison to those in Group 2 (small farmers). Similarly, Group 1 and Group 3 respectively believed (significantly more than Group 2) that protecting elephants indirectly benefited the habitat. On the other hand, those not in favour of protecting elephants gave the following reasons: they destroy crops (80%); they are dangerous to human life (78%); and they compete for land and livestock fodder (18%).

5.2 Causes of conflict

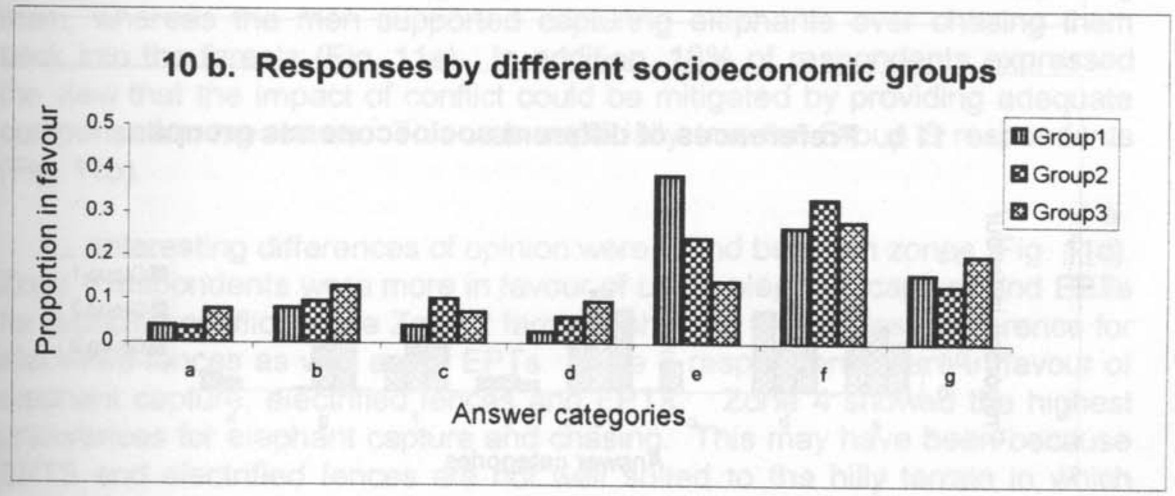
Causes cited for the conflict reflected many varied opinions. A large number of respondents (70%) believed that lack of fodder in the forests was the main cause of crop raiding by elephants. However, at least 53% of respondents also believed that elephants prefer crops over forest plant species and hence raid by choice. The third most commonly supported reason (40%) was lack of water available to elephants, in the forests (Figs. 10a, b, c). Other reasons cited but not shown in the figure were: location of crop fields/estates within the migration path of elephants; occurrence of fire and other human disturbances such as smuggling, looting, shooting, collection of forest products, dam construction and resettlement of displaced villagers inside forests. The Forest Department was also blamed for converting protected forest lands into teak plantations. Habit formation and lack of fear of humans were cited as reasons for repeated raids. An unusual reason cited was that recent afforestation of barren lands around a village had increased green cover in the area and encouraged elephants to linger there instead of quickly moving through it, as in the past. The increased residence period in the vicinity of the village had apparently led to increased crop damage and conflict there. The same problem was reported from the south Bengal district of Midnapore in 1993, and discussed by Sukumar (1994).

Interestingly, men and women had no significant differences of opinion on this issue (Fig. 10a). This may reflect either that men and women in the district tend to have similar views on this issue, or that women in the district do not have independent opinions but tend to be influenced (at least in this issue), by the opinions of the men they interact with. Different socioeconomic groups also showed significant differences of opinion. Significantly higher numbers of Group 1 respondents were of the opinion that elephants prefer crops to forest species, while higher proportions of Group 2 and 3 farmers believed that there was a shortage of forest species available to elephants (Fig. 10b). There were several significant differences of opinion between zones also (Fig. 10c). Higher numbers of respondents in Zones 3 and 4 considered lack of fodder to be an important cause of crop raiding. However, respondents in Zones 1, 2 and 3 (in that order) believed that lack of water is an important cause. These opinions reflect the vegetation and climatic

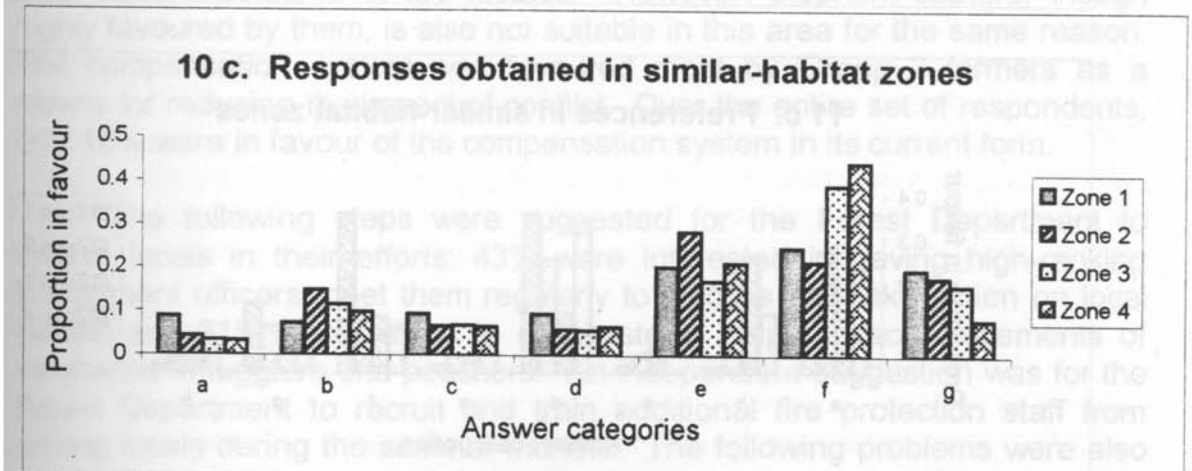
Fig. 10. What are the causes of elephant-human conflict?



10 a. Responses by men and women

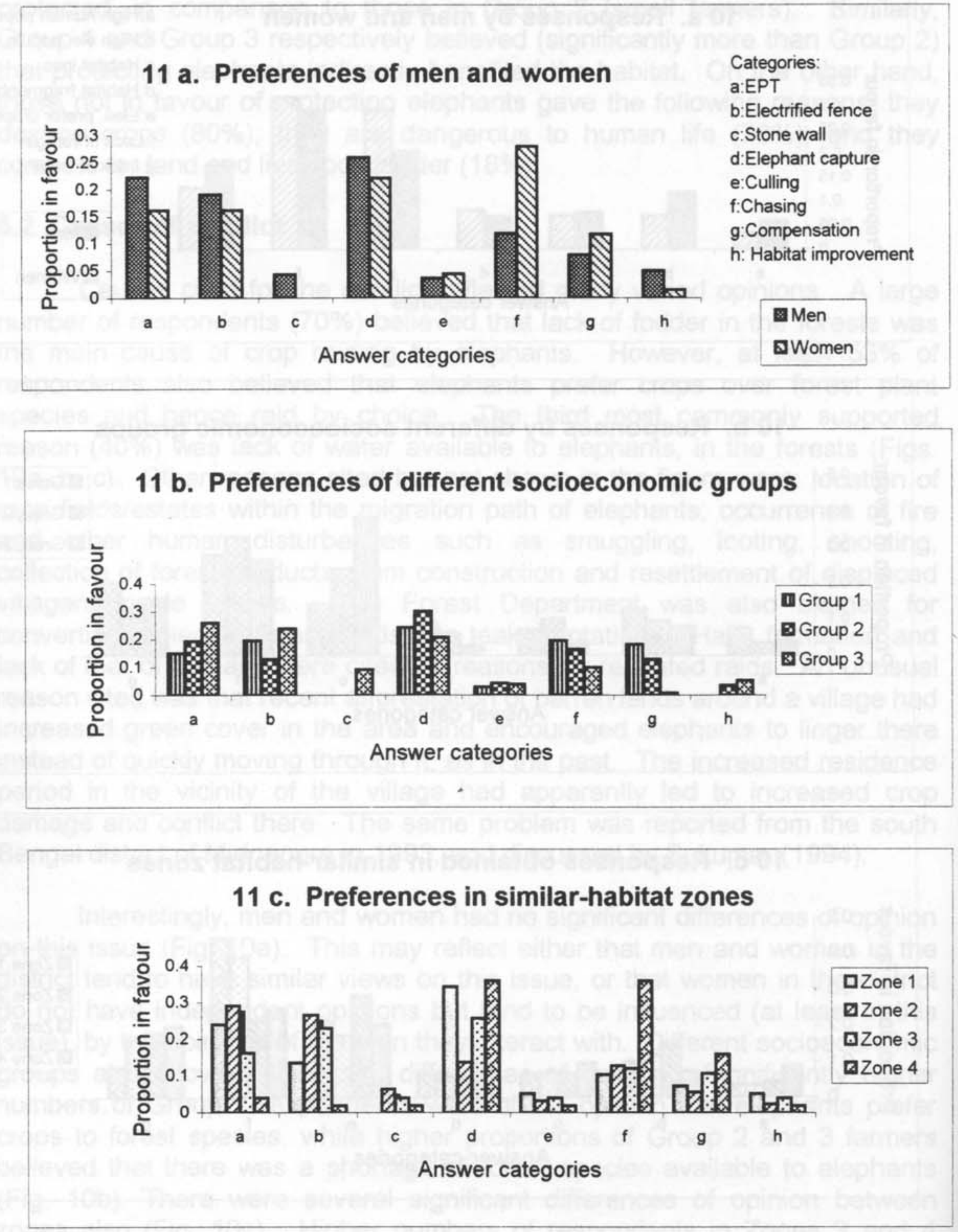


10 b. Responses by different socioeconomic groups



10 c. Responses obtained in similar-habitat zones

Fig. 11. Methods considered suitable to reduce elephant-human conflict in Kodagu



conditions of the 4 zones quite closely. The zones with predominantly evergreen/semi-evergreen vegetation types (Zones 3 and 4) would be expected to contain fewer edible plant species for elephants, while the predominantly dry deciduous zones (Zones 1 and 2) would be expected to contain less water, especially during the summer. These views reveal that farmers in Kodagu have a fairly good understanding of their local environmental conditions by people.

5.3 Methods of reducing elephant-human conflict

Respondents were also asked to suggest possible methods for reducing the conflict. Elephant capture (and translocation/taming) and elephant-proof trenches received maximum support from all respondents (49% and 41%, respectively). Culling (selective killing) of elephants was supported by 19% of the sample group; however, 81% said that elephants should not be killed by man to control crop raiding or manslaughter. Other methods supported were installation of electrified fences (36%) and chasing elephants back into the forest (28%, Figs. 11a, b, c). Interestingly, women were more in favour of chasing elephants back into the forests than capturing them, whereas the men supported capturing elephants over chasing them back into the forests (Fig. 11a). In addition, 18% of respondents expressed the view that the impact of conflict could be mitigated by providing adequate compensation measures. This was especially true for Group 3 respondents (Fig. 11b).

Interesting differences of opinion were found between zones (Fig. 11c). Zone 1 respondents were more in favour of using elephant capture and EPTs for reducing conflict, while Zone 2 farmers showed the highest preference for electrified fences as well as for EPTs. Zone 3 respondents were in favour of elephant capture, electrified fences and EPTs. Zone 4 showed the highest preferences for elephant capture and chasing. This may have been because EPTS and electrified fences are not well suited to the hilly terrain in which most Zone 4 settlements are located. However, elephant capture, though highly favoured by them, is also not suitable in this area for the same reason. The compensation system was favoured most by Group 3 farmers as a means for reducing the impact of conflict. Over the entire set of respondents, only 18% were in favour of the compensation system in its current form.

The following steps were suggested for the Forest Department to involve locals in their efforts: 43% were interested in having high-ranking Department officers meet them regularly to discuss and take action on local issues; and 31% were willing to cooperate in helping track movements of elephants, smugglers and poachers. An independent suggestion was for the Forest Department to recruit and train additional fire protection staff from among locals during the summer months. The following problems were also cited, which reduce trust and cooperation between local farmers and the Forest Department:

- lack of sufficient staff and forest outposts to deal with crop raiding during the peak months

• lack of commitment by the Forest Department to complete projects undertaken by them (such as EPT construction)

• lack of interest and promptness, when called to assess crop damage or chase elephants, unless provided with incentives

• scope for corruption and red-tape in the compensation payment system.

It was felt that if these problems are addressed, cooperation between the two sides could be improved.

5.4 Voluntary and cooperative efforts

The respondents were also asked what kinds of lifestyle changes they were willing to make to reduce the conflict. Less than a quarter of the entire sample group were willing to make changes involving cropping patterns, occupation and/or location of residence and crop lands. The overall interest in providing support for community efforts in the form of local action groups was also surprisingly low: 38%. Among women alone, 20% voiced support for such efforts. Farmers were willing to help in the following ways: 29% were willing to take part in regular meetings and participate in developing strategies to reduce conflict, 28% were willing to provide labour for repair of EPTs and electrified fences; and 20% were willing to make monetary contributions only.

Support for community-initiated efforts to reduce conflict received support from Group 2 and Group 3 farmers in Zones 1, 2 and 3. However, the idea of community participation was not received with enthusiasm by farmers in all Groups of Zone 4, and by Group 1 farmers in the other zones. The main reason for lack of support for community action among most Group 1 (tribal) farmers was that they are not able to afford the loss of time or income entailed by voluntary work, regardless of the expected benefits. In Zone 4, however, most farmers felt that local efforts would be insufficient to tackle the problem as farmers live several kilometers away from each other and do not have the required means for protecting themselves against raiding elephants.

Respondents willing to accept a leadership role in organising community action were available from Groups 2 and 3 of Zones 1, 2 and 3. However, the majority of farmers preferred to get involved in community action only in a supporting capacity. Most commonly, farmers were willing to provide 1 - 2 family members or workers towards the effort on a monthly basis, while monetary contributions offered were generally between Rs. 100 - 1000, to be paid annually.

Overall, the support for community-driven action was relatively low in the district. However, this is a relatively new concept in India in the field of wildlife management, and has not been aggressively promoted by the Government or by any other agency. As a result, it is not very surprising that most farmers greeted the idea with a level of skepticism. In the few areas where local leaders can be identified, the concept of cooperative elephant-management schemes may be introduced and explored further. In fact, one such locality was identified on the basis of high local enthusiasm and availability of local leaders: the town of Maldare, in eastern Kodagu (Zone 2). In this town, meetings were held during early 1997 to explore the possibility of developing a "Joint Elephant Management Scheme" involving local farmers and the Forest Department. The system of cooperation envisaged was to be based initially on the principles of Joint Forest Management practised in several localities throughout India since the mid 1980s. At present the project has suffered from lack of adequate funds and long-term commitment from both sides. It is hoped that funding may be obtained from external sources in the future, to further develop ideas which were enthusiastically discussed at the town meetings held previously.

5.1 Methods used by farmers

In Kodagu district, farmers use various methods to protect their fields from raiding elephants. These may be classified as active and passive methods. Active methods are used to chase away elephants after they have reached the fields. These include noise-making activities such as shouting, beating drums and tins, bursting fire crackers and firing gunshots into the air. The drawbacks of these methods are risks to farmers' lives and increased damage due to trampling when elephants are chased. Passive methods are more expensive and have been installed only by a few farmers who could afford them. These include installing electrified fences, changing the type of crop grown, selective removal of the plants which attract elephants and illuminating the entire estate with flood lights at night.

5.2 Methods commonly used by the Forest Department

Installation of long term methods of control has been attempted by the Forest Department in many areas within and outside Kodagu district since the mid 1980s. Active methods used by the Forest Department are elephant capture and scaring, while passive methods are elephant-proof trenches, electrified fences and rubble walls. The usefulness of each method in minimising crop raiding, the costs involved in their maintenance and the general opinion of local people regarding effectiveness was sought during this study. Inspections of these measures and assessments of their usefulness as long term management strategies are detailed below. Elephant-proof trenches and electrified fences were evaluated in greater detail than the other 3 methods. This is because the former are most commonly used throughout India, often incurring large expenditure without much attention paid to suitability or effectiveness.

5.2.1. Elephant Proof Trenches (EPTs)

Elephant proof trenching (EPT) is the most commonly used preventive measure as it was considered the best long term solution in terms of effectiveness and ease of maintenance when first introduced in the mid 1980s. Since then, almost 150 km of trenching have been excavated in the district, with almost no maintenance carried out subsequently. Given the lack of regular maintenance efforts, it was important to verify whether EPTs

6. METHODS OF PREVENTION AND MITIGATION OF CONFLICT

In this section, methods currently used by independent farmers and the Forest Department are described and evaluated for cost-effectiveness and overall efficacy. Methods used by the Forest Department were inspected in Kodagu, Bannerghatta National Park, Bangalore, Bandipur National Park, Mysore (all in Karnataka), Wynad Wildlife Sanctuary, Kerala and Mudumalai Wildlife Sanctuary, Tamil Nadu.

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6.2.1 <u>Elephant-Proof Trenches (EPTs)</u>

Elephant-proof trenching (EPT) is the most commonly used preventive measure as it was considered the best long term solution in terms of effectiveness and ease of maintenance when first introduced in the mid 1980s. Since then, almost 150 km of trenching have been excavated in the district, with almost no maintenance carried out subsequently. Given the lack of regular maintenance efforts, it was important to verify whether EPTs actually remain effective for many years after excavation, and whether they are considered adequate for controlling elephant depredations by local people. With this objective in view, 23 stretches of trenching, of several different lengths covering a total distance of 63.5 km, were visited during the study period. Twenty one stretches were in Zones 1 & 2 of Kodagu and two were outside the district. The lengths inspected varied from 0.5 km to 8 km, depending on their continuity and accessibility. Officially prescribed dimensions for EPTs are 3m x 2m x 1m (top width x depth x bottom width), however, the average dimensions recorded during this study were 2.29 m x 1.82 m x 1.02 m respectively. Excavation of EPTs is sometimes carried out by using a mechanical excavator, but more often by hiring labour on contract. Weak points in a trench, such as crumbling sides and points where streams cross, require construction of stone walls or culverts. Most often this construction work had not been carried out, thus leaving openings which are used by elephants to get cross easily. The trenches had cost an average of Rs. 85,000/km to excavate. The range of costs varied depending on the type of soil, topographic features and other local factors. A few trenches had not been completed at one go, and hence had older sections adjoining more recently excavated sections. In these cases, deterioration of older sections was clearly visible in comparison to the newer ones.

None of the EPTs inspected was intact or completely elephant-proof, as there were several points at which elephants could cross each of them. All such potential crossing points were recorded and quantified to obtain a measure of the effectiveness of each stretch inspected. Crossing points were mainly of the following types:

- Roads maintained by the Forest Department, or footpaths maintained by local people who needed to cross the trenches,
- Sections filled in with earth by humans or by elephants, subsequent to trench completion (recorded as "earth fills"),
- Openings created over time by collapse/caving in of EPT walls, erosion by wind or water, and steps cut into the walls by humans or animals.
- Sections left uncut due to the presence of boulders, logs/trees, or for other reasons,
- Stream beds cutting across the trenches,

On average the number of potential crossing points was 7.1 points/km inspected, and ranged from 2 points/km to 28 points/km. The most common pathways for elephants to cross were footpaths (34.5%), earth fills (23.7%), erosion/steps (11.7%) and cave-ins (9.4%). Paths created due to Forest Department roads, boulders, logs/stumps and uncut sections were of relatively lower proportions in comparison to the total number of crossing points available. From the above data, footpaths and earth fills together accounted for over half of the openings created in the trenches. Footpaths were generally created and maintained by local people living outside the forest who require access to the forest for fuel wood, fodder and other purposes, or by communities living inside the forest who require points of exit from the forest. Earth fills were also created by local people for the same reasons, but reflected individual needs rather than common needs. Some earth fills were created by elephants who kick soil into the trenches with their forefeet. If we consider that up to half the earth fills were created by elephants, the overall contribution towards creation and maintenance of crossing points by local people remains high: up to 46.3%.

Paths created by environmental effects such as erosion by water run-off or wind, or caving in of trench walls accounted for 16.8% of all points recorded. The Forest Department was also responsible for crossing points in the form of public roads maintained by them, boulders/logs/stumps not removed from the trenches, streams for which culverts had not been constructed and sections left uncut for various reasons. Together, these paths accounted for 20.6% of the total number of crossing points. Trenches were also rated subjectively by the researcher to obtain *a general condition* score which reflected appearance in terms of uniformity of depth, steepness of sides, soil packing on the walls, presence of undergrowth inside the trench and overall extent of degradation by various factors. The scoring was as follows: 0 = EPT not functional, 1 = poor, 2 = fair, 3 = good. The average general condition score for 23 stretches of EPT was 1.7 (fair to poor). Similarly, local people were asked to rate the efficacy of trenches according to their experiences of reduction (if any) in elephant depredations after excavation of a trench in their area. The scoring scale was as follows: 0 = nil, 1 = low, 2 = medium, 3 = high. The average efficacy score for 21 trenches was 1.7 (medium to low). The range of variations in these scores are viewed in relation to trench parameters below.

In order to gain a better understanding of trench effectiveness, data collected on all EPTs were categorised according to the number of crossing points per km (3 groups: 0-5 pts./km, 5.1-10 pts./km and >10 pts./km) and then analysed for differences. Similarly, data collected from 15 stretches which occurred on the boundary of the Nagarahole National Park were categorised according to the side of the National Park on which they occurred (3 groups: NNP-East, NNP-West and NNP-North) (Table 7).

Table 7. Summary data of elephant-proof trench (EPT) parameters quantified for comparison across trenches.

GRP.	KM INSP	AVG. AGE	DIMENSIONS			CROSSING POINTS PER KM							TOTAL CROSSING PTS. PER KM		GEN. CND. SC.	EFF. SC.
			TW	HGT	BW	FP	EA	ER	C	PR	B/L	S	(-) [FP + EA]	ALL PTS.		
1. Categorisation by average number of crossing points per km inspected:																
0-5 pts.	33.8	3.5	2.1	1.8	1.0	1.0	1.0	0.2	0.1	0.3	0.3	0.1	1.0	3.0	2.0	1.7
5.1-10 pts.	25.8	6.3	2.4	1.8	1.0	2.0	2.5	0.9	0.3	0.0	0.3	0.6	2.1	6.6	1.6	1.5
>10 pts.	4.0	9.0	2.3	1.9	1.2	4.1	4.2	2.3	4.4	2.7	0.4	0.2	10.0	18.3	0.8	1.3
2. Categorisation by location along Nagarahole National Park:																
East	17.0	12.5	2.6	2.1	1.0	4.6	1.2	0.5	0.9	1.7	0.3	0.4	3.8	9.6	1.7	1.3
West	20.0	4.6	2.4	1.7	1.1	0.9	2.9	0.7	0.2	0.2	0.2	0.3	1.6	5.4	1.8	1.8
North	7.5	1.0	2.0	1.6	1.0	1.2	0.8	0.3	0.1	0.0	0.0	0.0	0.4	2.4	2.0	1.0

Dimensions: TW = top width, HGT = height, BW = bottom width
Crossing points per km: FP = footpaths, EA = earth fills, ER = erosion, C = cave-ins, PR = public roads, B/L = boulders/logs/stumps, S = streams
GEN. CND. SC. = general condition score (by researcher): 0 = EPT defunct, 1 = poor, 2 = fair, 3 = good
EFF. SC. = efficacy score (by local people): 0 = nil, 1 = low, 2 = medium, 3 = high.

The following observations may be made from the table above:

1. There appears to be no meaningful relationship between the average dimensions of trenches and age, number of paths or subjective evaluation scores.
2. The total number of crossing points increases with increasing age.
3. The proportion of points due to factors other than local people (see column 14, total number of cr. pts. per km (-) [FP+EA]) increases with increasing age. This indicates that environmental factors causing deterioration in fence condition may have increasing effect as trenches get older. This is also indicated by the increasing numbers of crossing points/km caused by erosion and caving in alone as age increases. The proportion of crossing points created by local people (footpaths and earth fills alone, not shown), and hence their contribution towards reducing trench effectiveness may be greatest during the initial years, and have progressively smaller incremental effects later on.
4. The general condition score (by the researcher) appears negatively correlated with age and/or number of crossing points/km in both sets of categories.
5. Similarly, the efficacy scores appear to decrease as age and/or number of crossing points/km increase indicating reduced satisfaction with increasing age. This is true for both sets of categories. However, this score is unusually low for the northern side of the Park, despite this stretch having the lowest age and number of crossing points per km, as well as the highest general condition index in comparison with the other two sides. This is an interesting case as it may reflect local dissatisfaction with EPTs as a preventive measure due to reasons unrelated to its effectiveness in controlling elephants.
6. The following differences in kinds of crossing points may be inferred between the eastern and western sides of the National Park.

   A. On the eastern side, crossing points caused by local people (footpaths and earth fills) account for 5.8 points/km, with a greater proportion coming from commonly used footpaths. On the western side, however, crossing points by local people account for 3.8 points/km, with a greater proportion coming from earth fills. Public roads leading into the forest are also in greater numbers on the eastern side (1.7 points/km) than on the western side (0.2 points/km), indicating a greater overall magnitude of human movement across trenches on the eastern side.

   B. Differences between the two sides due to environmental conditions are also visible in the table above: the number of crossing points caused by erosion is slightly higher on the western side than on the eastern side. This may be due to the higher annual rainfall received on the western side, leading to higher water run-off and subsequently higher erosion effects on that side. Effects due to caving in of soil, however, appear higher on the eastern side. This could either be due to drier soil conditions on the eastern side or due to differences in soil types between the two sides.

C. Overall, the effects due to environmental conditions appear higher on the eastern side, but this may be merely a reflection of the higher average age of trenches on that side.

EPTs may be effective during the first few years after excavation, provided that continuity is maintained over several kilometres initially. Several local farmers in Kodagu expressed satisfaction with EPT effectiveness in areas where the number of crossing points was relatively low, and provided that it did not restrict their own access to the forests. It may take several years of dedicated effort to arrive at a solution that satisfies both these conditions without compromising the effectiveness of the EPT. Based on the above analysis, the following general recommendations may be made to improve EPT effectiveness, bearing in mind that differences in local forest use practices, topography, climatic patterns, and elephant movements also should be accounted for on a case-by case basis:

1. At the time of excavation, continuity of the trench without any crossing points must be ensured for at least 5-10 km. The total length of a trench is of no consequence if its integrity cannot be maintained for several km at a stretch.
2. In order to achieve the above, agreements between the Forest Department and local people may have to be drawn up regarding joint management of trenches, including agreements not to create multiple footpaths across trenches where one path or foot bridge could serve the needs of many. In the absence of local cooperation, EPTs are bound to fail as barriers against elephants.
3. After the first year, EPTs may require monthly inspection, especially during the rainy season, to ensure that new points of exit have not been created for elephants. Areas that get silted up during the monsoon should be re-dug at least annually.
4. A minimum depth of 2m should be excavated and maintained for the entire length of the EPT.
5. Crumbling EPT sides should be reinforced with brick or stonework, and culverts constructed where necessary at the time of excavation. Trees or boulders in the line of the trench should be removed if possible, rather than having the trench curve around them or using rubble walls to block elephant movements at such points.
6. EPTs are generally unsuitable and impractical in areas of loose sandy or rocky soil, severely undulating topography, high rainfall and high human use of forests. In these areas other methods should be used.

6.2.2 Electrified fences

A method of deterring elephants which has been used by private individuals successfully is the electrified fence (also referred to as the power or shock fence). It usually consists of 3 to 4 wires fixed 1 ft. apart, to a height of around 5 ft. and delivers a pulsed 4000-8000V electric shock if touched. The pulses of current are insufficient to kill animals or humans as they usually last for 0.0003 of a second and are spaced 1 second apart. However, if functioning optimally, they can act as a psychological deterrent to elephants, preventing their entry into estates and crop fields. In areas of moist, non-rocky soil and high rainfall, electrified fences are highly effective and can prevent stray livestock as well as wild animals (elephants, gaur, wild pig, deer) from entering estates without harming the animals. In remote and hilly terrain this may be the only effective means of protecting property and crops. The main drawback generally associated with electrified fences is the need for constant and regular maintenance in the form of clearing of undergrowth and fallen branches, or replacement of old and broken parts. The effective use of electrified fences also assumes a certain degree of technical sophistication on the part of the owner and the person(s) responsible for regular maintenance. In addition, technical support from the company which supplied the fence parts should be forthcoming when called for service.

Electrified fences installed privately and by the Government were inspected in Karnataka, Kerala and Tamil Nadu to assess effectiveness and suitability for long term use against elephants. A total of 37 fences were inspected during the study period. Ownership of the fences was as follows: private individuals: 13; private companies: 5; Tibetan community (cooperatively owned and managed): 1; and State Forest Departments of Karnataka and Kerala: 18 (4 and 14 respectively). Many fences installed by the Kerala Forest Department completely enclosed forest settlements in the Wynad Wildlife Sanctuary. These had been installed after reaching informal agreements with local communities regarding their maintenance.

The inspected fences were being used to protect estates, farms and settlements with areas ranging from 8 acres to 3000 acres. The fences ranged in length from 0.75 km to 15 km and the average area to be protected per km of fencing (not necessarily completely enclosed by fences) was 124.5 acres (n = 17). Installation costs per km averaged Rs. 32,904 (n = 22), but was found to be quite variable depending on the topography, soil, and local material costs. This figure indicates that most tribal and subsistence farmers may not be able to afford electrified fencing. Many individuals had found ways of reducing costs by substituting brand-name parts with cheaper alternatives. Some alternatives used were short lengths of rubber hosing instead of breakable ceramic insulators, existing trees instead of wood or stone fence posts and recycled automobile batteries and chargers instead of expensive Company-supplied battery packs. Other methods of cutting costs included reducing the number of wires used, and installing fencing only in areas of the property where elephants enter most frequently.

The number of electrified strands and fence designs used were more variable among privately owned fences than among Forest Department fences. This may be because all but one of the Department fences had been supplied by the same company, while privately owned fences had been supplied by six different companies. Overall, the average dimensions were found to be the following: number of strands = 3.7, height = 1.5 m and distance between posts = 5.5 m. Often different materials were used in the same fence; for example, some fences used combinations of stone pillars, wooden poles and existing trees for posts. These were the most commonly used types of posts, with percentage occurrences of 59%, 34% and 31%

respectively (n = 32). Bamboo poles, iron anglers and cement or concrete posts had been used to a negligible extent. The most commonly used insulator materials were ceramic or porcelain (74%), rubber hose sections (23%) and plastic (16%, n = 31). In one case pieces of wood had been used to mount the plastic insulators and improve their effectiveness.

In order for fences to be effective proper annual maintenance was required in terms of clearing undergrowth and fallen branches of trees, mending or replacing broken wires, posts and insulators, and ensuring that the battery and energizer were working optimally. Regular replacement of broken or disfunctional parts such as battery, energizer, solar panels, posts and wires were equally important to ensure continuous functioning of the fence. In economic terms, these investments of time and labour amounted to Rs. 6,083/km/yr, in the study area. Fence posts had been replaced after being broken in 52% of fences (n = 25), of which 62% were stone posts and 31% were wooden poles. Other parts which commonly needed replacement were batteries (48%), energisers (32%) and wires (32%). Some farmers continued to run current in the fences during the day as they believed that elephants lose their fear of the fence if they are able to negotiate it even once. The ratio of broken fence posts to wires was 1.2 : 1; in other words, elephants tended to attack and break fence posts slightly more often than wires. A recently adopted method of reducing attacks on fence posts is to provide a few loops of electrified wire around the posts as well, an arrangement referred to as a 'toupee'. However, toupees had been installed in only two inspected fences and hence could not be assessed for effectiveness.

Efficacy of electrified fences was scored subjectively by local people as in the case of EPTs: 0 = nil, 1 = low, 2 = medium, 3 = high. The overall average score for electrified fencing was 2.0, corresponding to a rating of medium effectiveness. General condition scores were not assigned for fences as visual cues were considered to be of relatively negligible significance and did little to deter elephants as long as there was no current in the wires.

It was found that the percentage of fences in working condition was much higher when owned by private individuals or companies (84%) than when owned by State Forest Departments (17%). Correspondingly, the average efficacy score for private fences was higher (2.6) than for Department fences (1.4). Table 8 below summarizes average values obtained for several parameters of private and government-owned fences.

The use of solar panels in a high percentage of Department fences may have contributed to their high failure rates. However, this cannot be stated with certainty for the following reasons: (1) There is no direct relationship evident between the use of solar panels and failure rate if all inspected fences are considered: only 1 out of 4 private fences using solar panels was dysfunctional, while 14 out of 17 Forest Department fences using solar panels were dysfunctional at the time of inspection. (2) Replacement of solar panels (when not functioning properly) was reported in the case of 3 private fences, while this was not reported for any of the government fences.

It seems unlikely that this is due to better quality of solar panels used by the Forest Department. It is more likely that sub-optimally functioning solar panels were not replaced by the Department, thereby leading to lower effectiveness of their fences. This may be further related to lack of adequately trained personnel for regular monitoring of the fences and lower investment in maintenance costs by the Forest Department (Table 8).

Table 8. Electrified fence features quantified for comparison by ownership.

Feature	Privately owned (n)		Forest Dept. owned (n)	
% functioning	84%	(19)	17%	(18)
% using solar panels	21%	(19)	94%	(18)
Length (km)	1.8	(17)	3.4	(17)
# acres/km	24.1	(12)	32.1	(17)
Age (yrs)	4.7	(15)	3.2	(16)
Height (m)	1.6	(15)	1.5	(16)
# strands	3.7	(18)	3.7	(16)
Distance between posts (m)	5.1	(14)	6.0	(14)
Installation cost/km (Rs.)	23,325	(12)	45,357	(10)
Maintenance cost/km/yr (Rs.)	8,269	(13)	2,531	(8)
Efficacy score	2.6	(16)	1.4	(15)

Another possible reason for failure of Forest Department fences is cutting of wires by local people who require access to the forest. During the study it was difficult to differentiate between and hence to quantify the number of places where wires had been cut by humans and by elephants (elephants may be able to cut wires with their tusks, by stepping on wires or by pushing trees over on top of them). However, when local people were asked which part of the fence was usually broken there was a difference in answers received from private farmers and those from people in areas with Forest Department fences. Although fence posts and wires were cited as the most frequent points of attack, the ratio of broken posts to broken wires cited by private farmers was 2.3:1, whereas the ratio cited by local farmers regarding Forest Department fences was 1:1.1 (posts : wires). If we assume that human pressure on electrified fences installed by the Forest Department is similar to that on EPTs, the higher ratio of broken wires in the case of Forest Department fences may be a reflection of higher human pressure on the fences rather than damage due to elephants alone. Mutual agreements between the Department and local people may be the best means of resolving this problem. The use of such agreements in Kerala is discussed later in this section.

Most of the above difficulties were overcome by private farmers who had sufficient resources and took an active interest in maintaining their fences well. More than 70% of them were satisfied with the reduction in wildlife incursions achieved after installing an electrified fence, indicating that it may indeed be an effective means of controlling elephant depredations if used with proper care and maintenance. Three separate models of electrified fences are discussed below, to compare aspects of fence design and maintenance by different kinds of owners. The first is owned and maintained by an individual farmer (the best maintained and most successful fence inspected), a small well-knit community, and a cooperative system established between a State Forest Department and several forest dwelling communities.

1. Private fence owned *by Mr. Wiedemann, (Bokkapuram, Tamil Nadu)*

This 1.2 km long fence was installed in 1983, at a total cost of Rs. 18,370 (Rs. 15,308/km), to protect 20 acres of farming and grazing lands. The battery was charged by 4 solar panels which provided sufficient electric charge to keep the fence active throughout the day and night. As the fence was activated 24 hours a day, and completely surrounded the property there was no way for elephants to enter the property except by breaking through. When installed, the fence consisted of 5 strands up to a height of 1.7 m. However, during the last few years, the owner had been replacing all broken or fallen stone posts with mild steel "L-anglers" which were basically thin steel posts with a short angled arm at the top, reaching a total height of around 6 m. A sixth wire was added to the fence at that height, at the tip of the short arm of the L-angler posts. This wire was hence projected by at least 1 ft. in front of the fence and acted as a first line of defense against elephants.

All materials used were of high quality. The energizer and solar panels were imported from Germany while the battery and fence components such as posts, wires, insulators and gates were locally manufactured. Maintenance costs per year were significantly lower than for most other private fences: Rs. 3,667/km/yr. Yet this was the best maintained fence and possibly the most successful at absolutely eliminating elephant (and other animals) incursions into the property. How was this possible? There are several reasons:

1. The owner had taken the trouble of reading literature on electrified fences from various sources, in order to understand the theory behind its working. As a result he was able to solve many problems on his own, without having to consult technical experts who charged for their services. He also regularly made improvements in the fence design when he judged that elephants were becoming accustomed to the previous design and were capable of identifying weak spots such as stone pillars.
2. Use of high quality materials played an important role in reducing maintenance costs. The solar panels had not been replaced since installation, while the energizer and wires had been replaced once during the past 14 years, and the battery was replaced once every 4 years. The steel L-anglers used as posts did not break if pushed over, and could be straightened physically if necessary. Use of toupees on every alternate post may have further reduced the possibility of post damage. Insulators rarely needed replacement as the posts were not being attacked by wild animals and hence the insulators (ceramic and plastic) remained largely intact.
3. Labour was not hired specifically for daily maintenance of the fence. Much of this work was carried out by a supervisor who had other duties to perform during the day. As the fence was kept functioning throughout the day and night, maintenance involved checking the voltage across the

wires daily and removing fallen or dead vegetation, if any, that touched the fence.

4. Four times a year, the current was switched off, and ten workers were employed to clear undergrowth at the base of the fence. This was found to be the most efficient and economical way of keeping the fence clear of undergrowth that would otherwise cause drainage of current.

This fence was highly successful due to the combination of high quality components, high quality and consistency of maintenance efforts, and constant innovation with its design. At the time when visited, the owner of the fence was planning to add a single strand of live wire at a height of 2.5 m and at a distance of 1 – 2 m in front of the fence with suspended short lengths of wire (10 – 20 cm long) dangling from it at regular intervals along the main strand. This was expected to transmit pulses of current to the forehead and back of adult animals. According to him, wild animals, especially elephants were capable of learning to identify and avoid a good electrified fence within a few months. However, after a longer period of time, such as a few years, certain persistent animals (usually bulls) were able to find the weak spots in a fence where it could be crossed. This necessitated further innovations in fence design and construction every few years, in order to keep one step ahead of the elephants.

2. *Cooperative fence, Tibetan Settlement (Gurupura, Karnataka)*

A 15 km long fence was jointly owned by members of a Tibetan community living on the border of the Nagarahole National Park, Karnataka. The fence had been installed at a cost of Rs. 550,000 (Rs. 36,667/km) in 1995 and was being maintained at an annual cost of Rs. 31,600 (Rs. 2107/km/yr). The design was very common: stone posts without toupees and 5 strands of wire reaching a maximum height of 1.3 m. This fence had several public roads crossing it with electrified gates used at night (6 p.m. to 6 a.m.) to eliminate the possibility of elephants entering at these points. The rest of the fence was left functioning 24 hrs a day. 7 km of the fence ran alongside an old EPT dug by the Forest Department several years previously. In the opinion of settlement inhabitants, the EPT had failed to reduce elephant damage to their fields and hence they opted to install their own electrified fence. The fence had reduced elephant depredations significantly.

At the time of inspection the fence was functioning but the shock delivered was too weak to deter elephants effectively. This was due to malfunctioning of the solar panels which had not been replaced due to lack of funds. Another problem faced by the settlement was that people from surrounding villages sometimes cut the wires to graze their cattle on settlement lands during summer. This cutting of wires by people necessitated repairs more often than incursions by wild elephants. Elephants sometimes entered crop fields by moving around to the side of the settlement away from the forest, which had not yet been fenced. Some elephants subsequently got trapped inside the fence. This problem could probably be overcome by extending the length of the fence to encompass the entire settlement boundary. More often, elephants crossed the fence by breaking the stone posts. However, the frequency of such occurrences was low: around 6 - 7 times/yr. The community leaders were hoping to further reduce this frequency by installing an additional (6th) wire at a distance of 2 - 3 m in front of the fence, at a height of 2 m by installing steel L-anglers (as described for the private fence above). In addition, it is hoped that the use of toupees to protect the posts may further reduce fence damage and increase its efficacy.

The most interesting aspect of this fence was the cooperative method of installation and maintenance adopted by the community. This was possible in the settlement of 500 families, probably because of their cultural ties and social organization. All families had contributed similar amounts of time, labour and money towards installation of the fence, as families owned almost equal shares of land and benefited almost equally from the existence of an effective elephant-proof barrier. Maintenance was also shared between the 15 villages of the settlement. Two people from each village were given the (paid) responsibility of maintaining the length of fence which abutted their village. This involved clearing undergrowth, ensuring proper functioning of the battery/energizer/solar panels (if applicable) and making minor repairs such as wire/post/insulator replacement. All families shared the costs of maintenance.

Communication between village inhabitants was extremely good. Every day almost all adults of a village sat together in prayer and meditation. Such gatherings probably provided opportunities to discuss other issues such as elephant break-ins and fence repairs/improvements. In addition, village leaders met almost weekly with the Representative (the leader of the entire community) and hence were able to discuss issues related to crop depredations. A register had been maintained of crop raiding cases in all villages before and after fence installation. According to this record, the number of cases had been reduced by 80% during the year 1996, following installation of the fence. It remained to be seen whether elephants would become habituated quickly and learn to avoid the fence in the future, or instead, would learn to break stone posts more frequently and resume crop raiding at previous levels. Despite the very average design and condition of this fence, it had a higher than average success rate in blocking elephants because of its well organized system of maintenance. The degree of cooperation exhibited by the community in joint management of the fence was probably a crucial factor affecting its success.

3. Cooperatively managed fences, Kerala Forest Department (Wynad Wildlife Sanctuary, Kerala)

The Wynad Wildlife Sanctuary in northern Kerala adjoins Nagarahole National Park of Karnataka and Mudumalai Wildlife Sanctuary of Tamil Nadu. It consists of 4 separate ranges joined by narrow corridors, and contains several small settlements of people within its boundaries. Elephant-human conflict has been severe in this area for several years and since the habitat is highly fragmented, the use of EPTs thought to be impractical here. Hence the Kerala Forest Department decided to install electrified fences around the most severely affected villages, targeting especially those villages which were remote from others and completely surrounded by forests.

Between 1985 and 1997, 38 electrified fences were installed by the Forest Department around different settlements in the Sanctuary. Long-term maintenance was being carried out jointly by the Forest Department and local farmers, under several informal agreements. Whereas the earlier agreements had been achieved by mutual understanding, the later agreements involved undertakings on signed documents by farmers to ensure proper maintenance of the fence after installation.

Fourteen fences were inspected to evaluate them for effectiveness, and, in a broader perspective, to study whether the cooperative model of management could be applied to reduce crop damages in other parts of the country as well. All of the fences had been supplied and installed by the same company and hence very similar components were used in all of them: stone/wooden posts and existing trees for supporting the wires, ceramic insulators, and solar panels for charging batteries. The average cost of installation was Rs. 55,334/km (n = 7). Only 2 fences were working when inspected, while 4 had been switched off to save current during the day. The remaining 8 fences (57%) were discontinuous, either due to broken posts or wires (or both). According to the Forest Department, these would be replaced at the start of the crop season, when elephant problems were highest. Unfortunately these fences were not inspected during the crop raiding season.

The overall efficacy rating by local people for the fences inspected was 1.7 (medium - low, n = 11). There were several reasons for this score:

1. As stated above, more than half of the fences had broken posts and/or wires which the Forest Department intended to fix before the main wet crop season beginning in August. This meant that plantation crops (such as coconut, banana and arecanut) which were grown year round, were prone to raiding during the rest of the year, as long as the fence was not repaired.
2. The average height (1.5 m) and number of wires (3.6) were very similar to the averages obtained for all fences inspected. However, the average distance between posts (6.4 m) was larger than the average for all fences (5.5). As mentioned earlier, this could have led to sagging of wires over time and draining of current by undergrowth.
3. According to local people, the wires were broken as often as the posts. This may be an indicator of human pressures on the fence, especially when viewed in comparison with the ratio of 1:2.3 (broken wires : posts) for privately owned fences.
4. The investment on maintenance costs appeared to be extremely low in terms of replacement of parts and engaging watchmen to oversee the fences. According to Departmental records, Rs. 4,900/km/yr was spent on one fence and no maintenance costs were invested in 4 other fences. Data on maintenance for the remaining 9 fences were not available. A watchman was hired by the Department in one case, but despite this, the fence had been broken and not repaired. In all other cases local people

were expected to inspect the fences regularly and report all elephant incursions to the Forest Department as part of their cooperative fence management duties. This system had, however, failed in almost all cases due to lack of adequate communication when the fences needed fixing, and lack of promptness by the Department in fixing fences.

From this preliminary study, it appears that the cooperative system of fence maintenance in Kerala may have suffered from inadequate fence design and lack of coordinated maintenance. As many of the settlements are completely surrounded by forests, the pressure from elephants is possibly very high. Under such conditions, the height of the fences and number of wires used may have to be increased. Steel L-anglers, described earlier, may be have to be used in conjunction with toupees and an additional strand of wire at 2-2.5m height. In addition, the system of cooperative maintenance will require more effective communication between the parties concerned. Both parties will also have to be more responsive to break-ins and break-downs. In many of the newer fences, narrow and low gateways (about 1 m width x 1.5m height) had been provided at regular intervals for human/cattle movement. This was not noticed in the older fences, and may have been responsible for humans cutting the fence wires to gain access to the forest.

It seems contrary to reason for local farmers to cut the fence wires if this means lower protection from elephants for their respective settlements. However there are many possible explanations for this occurring. Often the wires are cut by farmers who don't own crop fields within the settlement, but may require access to the forest for fuel wood and fodder. Other farmers may cut the wires during summer, in anticipation of the Forest Department fixing it before the main crop season. Another possible explanation is that the fence wires may have been broken by elephants previously, but not fixed promptly by the Forest Department. This may have given farmers the impression that even an intact fence is not an impenetrable barrier, and hence justified their act of cutting the wires later.

Despite its flaws, the cooperative system of fence maintenance is not without merit. It demands a high degree of cooperation within and among local communities, and between local communities and the Forest Department. In a few villages where Departmental officers had maintained regular contact with people, a lot of trust had been built up on both sides and people were forthright with their problems and concerns. This system is much cheaper to install than the EPT, however, it requires higher maintenance effort, trained personnel to carry out well-defined maintenance duties and a high degree of trust and effective communication between the cooperating parties. In this manner the cooperative fence system has a more specific set of requirements in order to be successful. It may not be suitable for large and diverse communities in which local cooperation may be difficult to sustain over long periods of time, or in cases where people are not willing/able take on the long term responsibility of providing high quality maintenance.

6.2.3 Rubble walls

The rubble wall consists of rough cut rocks and stones piled up, without cementing, to form a physical barrier of dimensions: 1.5 m x 2 m x 2 m (top width x height x bottom width). A short wall, 1km in length, was inspected in Kattepura RF. This was considered the most economical and feasible barrier as rocks were locally available and the soil was not considered suitable for EPT construction. It cost approximately Rs. 5,00,000 to construct a few years prior to inspection, and the dimensions were about 1 m x 1.5 m x 2 m (top width x height x bottom width). Since no cement was used to hold the stones together, the wall was later dismantled by local people in 3 places, for livestock grazing and, possibly, timber smuggling as well.

Another rubble wall constructed at Bannerghatta National Park was also inspected. This had been constructed in the form of several segments with several short sections of EPT intervening at intervals where the soil was considered suitable for the latter. A total of 7.5 km of rubble walls had been constructed in this discontinuous fashion, at an average cost of Rs. 7,50,000/km. Constructions had begun in 1984-85, and increments in length were being added until the time of inspection in 1996. Rocks from quarries within and around the park were used in construction of the wall segments. Around 7 km of barriers (rubble wall and EPT) were inspected on the northwestern boundary of the park where maximum crop raiding took place during the preceding crop season. The combination of rubble walls and EPTs had obviously failed to protect local farmers.

Reasons for failure of the rubble wall-EPT combination barrier are surmised to be the following:

1. Discontinuities in the barrier, especially at junction points of rubble walls and EPTs, where local people had made paths.
2. Lack of consistency in wall height at different points.
3. Loose packing of rubble leading to crumbling and removal by people, especially at the ends.
4. High pressure on the barrier from local people requiring access to the forests.
5. Other problems associated with EPTs, such as crumbling, erosion and streams. These have been discussed in Section 6.2.1.

There was also a single case recorded, of elephants successfully scaling the rubble wall inspected. At the time of entry, the group of nine elephants was being chased by a Forest Department squad from surrounding crop fields, back into the park. The squad used firecrackers, gunfire and loud shouting to chase the elephants. Under such conditions of stress, the elephants scaled the wall at a point where its height was almost 2m. An EPT running parallel to the wall had a 2m gap at this crossing points, and this enabled the elephants to approach the wall close enough to be able to climb over it. This seems to indicate that an EPT, if deep enough, may be a more effective barrier against elephants than the rubble wall.

6.2.4 Elephant Capture

Capturing wild elephants is a method employed in some areas of Kodagu to reduce crop raiding. Usually male elephants suspected to be habitual raiders are captured. Capture is done by tranquilizing the elephant using a dart gun, securing the animal using ropes, chains and the help of tamed elephants (kumkies), and subsequently transferring the sedated animal to a local training camp. At the camp the captive elephant is gradually trained to accept commands from a mahout. If the Department is successful in training the captured elephant within a few months, it may be sold to private individuals, temples or zoos for up to Rs. 4,00,000.

In 1996, eight elephants were captured in the Madikeri Division of Kodagu. The entire operation took about 20 days in April, and cost about Rs. 6,00,000. All 8 animals were males, and had numerous bullet wounds and other injuries on their bodies, indicating high conflict levels in the district. However, despite their wounds, all eight animals were generally healthy. The average cost of capture/day was Rs. 30,000; or Rs. 75,000/elephant. During the training period of 3-6 months, one trainer was appointed to look after and become familiar with each animal. Food for the elephants was obtained from the surrounding forests, and supplementary nutrition in the form of jaggery (unrefined sugarcane concentrate), hay, rice and millets was also given.

The estimated cost of capture and training for a single animal was estimated to be around Rs. 1,00,000, or Rs. 8,00,000 for 8 elephants. Hence the Department expected that the sale of at least three newly tamed elephants for a minimum of Rs. 3,00,000 each, would have enabled the operation to pay for itself. However, as of one year later, not a single captured elephant had been sold, thus reducing the potential for using this method on a larger scale for controlling problem elephants. Some reasons responsible for the difficulty in selling tamed elephants are reduced demand due to the high cost of maintaining a captive elephant, declining use of elephants in the timber industry and objections raised by animal rights groups to the capture and taming of wild elephants.

Elephant capture may be suitable and satisfactory as a method of reducing elephant-human conflict under certain conditions. It cannot be employed in very hilly terrain as the risk of the tranquilized elephant falling down a steep slope and succumbing to injuries is very high. The method is safer where the land is mush flatter and the forest more open. Capturing elephants in dense evergreen forests is also difficult as tracking the darted elephant in a dense forest is problematic. It is also not suitable for areas of high elephant density, as replacement of one habitual raider by another is highly likely. In addition, elephant capture is most safely carried out during the cool dry season, between November and March. During other months, the weather is either too hot, wet or otherwise inconvenient.

According to the opinions of local people, this method was useful in reducing crop damage, but was most effective only if a significant number of raiding elephants were captured simultaneously from a given area. This would help purge the area of raiders for a reasonable period of time before fresh raiders moved in. However, despite local opinion in support of elephant captures, the overall raiding frequency had not reduced substantially in areas where elephants have been captured in the past. This is primarily because these areas are not isolated, but adjacent to other elephant habitats. Hence replacement of captured raiders by fresh ones had occurred almost within the same year. It must be added that it is probably not ecologically or economically feasible to remove substantial numbers of suspected crop raiders from a small area. The high cost involved cannot be justified in view of the short-term nature of the expected benefits. In addition, capturing large numbers of males could lead to depletion of the local genetic pool and to skewing of sex ratios in the local population. In summary, elephant capture is probably a method with limited geographical scope and which, if used indiscriminately, could have serious consequences for the elephant population.

6.2.5 Elephant Scaring Squads

This is probably the second most commonly used method, after EPT construction, in Kodagu. The inputs required are Forest Department watchers or guards with guns and firecrackers, and a few unskilled labourers, in groups of 20 - 25. Temporary workers are often employed during the crop raiding season for this purpose. The main job of a squad is to drive herds of crop raiding elephants back into the forest, using gun shots, firecrackers and shouting. The squad may work as one unit or split up into smaller groups inside the forest. Communication is vital to the safety of the different squad groups once they enter the forest, and this is accomplished by either shouting to one another or by using walkie-talkies. This is the easiest and cheapest method of providing immediate, though temporary, relief to farmers. Squads are usually mobilized in response to a raid and rarely arrive in time to prevent one.

In Dec. 1995, an eight day operation was organized at the Bannerghatta National Park, using a 30 member squad, to chase as many elephants as possible from Bannerghatta National Park, south into a larger Reserved Forest in the State. The distance covered was almost 100 km. At the end of 8 days of chasing, an estimated total of 90 elephants had been driven south into the adjoining Reserved Forest. The estimated cost of the 8-day operation was around Rs. 28,000, inclusive of wages, fire crackers, ammunition and fuel. However, upon visiting the surrounding villages during the following month, it was found that raiding frequencies were almost as high as during the weeks preceding the elephant drive. The most likely reason was that the chased elephants had returned within a few weeks to the areas where they were habituated to raiding crops. Hence this method was found to have only temporary effectiveness of a few days to a few weeks, and would have to be carried out at regular intervals during the crop season in order to provide consistent effectiveness.

This method brings quick and temporary relief to farmers and requires no sophisticated technology or skills. It usually achieves short-term success of a few weeks' respite before the elephants return to the fields again. However, most often, by the time the squad is assembled and sent to the affected village, the elephants have already left the area. Hence the system has limitations in terms of the time lag between crop raiding and the arrival of the squad. This may be avoided by stationing a forest watcher on duty in areas of high conflict during the raiding season and equipping him with a walkie-talkie for fast communication of problems in his area. However, regular harassment of elephants with firecrackers, gunshots or shouting may lead to increased aggression from them towards humans in the long run.

7. DISCUSSION

This study of crop raiding in Kodagu, has provided several interesting results with respect to elephant movements and crop raiding patterns in the district. There appear to be significant differences in raiding between different zones, for which several reasons such as habitat fragmentation, long distance movement and habitat quality may be responsible. Until this study was carried out there was little understanding of elephant movement and crop raiding preferences in this district. It now appears that the presence of even isolated or fragmented patches of forest may serve as refuges for elephants to avoid contact with humans during the daytime, and a base from which to raid crops at night. There are many isolated patches of forest such as *devarakadus* which could serve this purpose for elephants. Mapping of locations where crop raiding occurred between 1992 and 1996 shows that there may be three routes by which elephants cross (possibly infrequently) the predominantly cultivated central area of the district, in moving between the eastern deciduous forests and the western evergreen hill slopes. Elephant movements along the northern route has been confirmed to occur at least once every alternate year. Interestingly, crop raiding is not widespread and intensive throughout this route, but is concentrated at the edges of forest patches which provide cover to elephants during the daytime. This may indicate that elephants prefer to spend more time in larger undisturbed forests and less time in the relatively more exposed cultivated areas, although, where accessible they do stop to raid extensively cultivated areas while crossing through them at night. The existence of small patches of closed canopy forest probably plays an important part in supporting this type of raiding in central areas of the district.

The highest raiding frequency was in Zone 1 between April 1992 and March 1996 in terms of total number of cases and villages raided. This is significant as Zone 1 does not contain the highest area of forest nor the highest elephant density. Other characteristics of this Zone are probably responsible for the high intensity of raiding in this area. These are the high degree of habitat fragmentation by cultivations, high forest boundary to area ratio, low habitat quality and high human disturbance. These characteristics were not investigated, but may be of relevance, when considered in relation to the sparse habitat available and elephant density, to explain the unusually high raiding intensity in Zone 1. From visual inspection of the zones, Zone 1 appears to have the highest level of fragmentation in the district. Higher incidences of crop raiding may be related to this factor, as found by Hoare (1997) in Zimbabwe, and referred to by Ratnam (1984) in Malaysia.

The routes thought to be used by elephants in moving between the eastern and western sides of the district indicate that at least some elephants use habitats ranging from dry deciduous to wet evergreen, even if it entails moving through cultivated areas in close proximity to humans. The regularity of elephant movement between these habitats and the proportion of time spent in each area needs to be established before a realistic projection can be made about the habitat requirements of elephants in these areas.

The absence of any obvious relationship between the degree of habitat transformation and crop raiding indicates that the influence of habitat transformation on elephant movement patterns and habitat use may be more complex than was initially expected. Regardless of the degree of transformation, elephants may continue to use a habitat due to the benefits gained from it. The relatively high number of cases occurring in habitats where estates adjoin forests, in the absence of other transformations, may indicate a preference for environments which mimic forests to a high degree, have minimal human disturbance and yet provide high returns in terms of forage. In some areas elephants were thought to enter coffee estates mainly for the high quality of grass available. Coffee estates are watered by sprinklers and hence the grass may be more tender and nutritious especially during the dry season (January-April), inside the estate boundaries when compared with that growing in the adjoining forests. Sukumar (1989) had found a relationship between forage quality and proportions of different kinds of vegetation in the diet of elephants in BRT Sanctuary, Karnataka. Similarly, higher forage quality of grasses inside coffee estates may encourage elephants to enter the estates and "raid" the grass, leading to accidental trampling of several valuable coffee bushes while grazing. Elephants also may be straying into estates adjoining the forest boundaries without realising that they have crossed from forests into private lands. This would be true especially in the case of cardamom estates, which usually undergo little transformation in the upper-storey vegetation, and whose boundaries are usually not demarcated by hedges or wire fences.

When economic losses were converted into percentage of annual income for comparison across the three socioeconomic groups, small farmers (Group 2) appeared to be more badly affected by crop raiding than subsistence (Group 1) or wealthy farmers (Group 3). This may be because tribal communities usually have alternate sources of income such as daily wage labour, basket-weaving, serving as mahouts and MFP collection. The large farmers also do not appear to suffer high percentage losses, possibly because they have incomes which are much larger than the amount of losses suffered by them. For small farmers, on the other hand, farming may be their main source of income. Hence, elephant depredations on their crops could have devastating consequences for small farmers who are wholly dependent on agriculture for their livelihood. When the percentage losses suffered by the different groups was compared against attitudes towards crop raiding, however, it was interesting to note that the large farmers, rather than small or subsistence farmers, were significantly more in favour of culling elephants to reduce conflict.

In spite of being affected, most farmers seem to be aware of the need for conservation and believe that elephants have a right to live in their habitats. However, subsistence and small farmers suffer greatly throughout the crop season, often having to maintain vigil every night until the crops are harvested. The raiding elephants face continual harassment from farmers and Forest Department squads when chased. In most areas, driving elephants out of fields with noise and fire is the only option available. Although temporarily effective, chasing elephants cannot be considered part of any sound long-term policy to deal with the problem. Local perception of increases in crop damage, habituation of elephants to being chased, as well as informed speculations about increasing elephant populations strongly suggest that the conflict may indeed be escalating. If this trend continues, control by intimidation and other currently used methods will not be sufficient to contain the problem.

The possible proximate or ultimate causes of crop raiding were not rigorously investigated as part of this project. However, several factors studied may be considered possible proximate causes, and investigated future studies of crop raiding. Lack of adequate forage for elephants in the forests and increased elephant populations, as suggested by local farmers, may be common causes affecting several elephant subpopulations in this district and elsewhere. Other possible causes which may not be discernible to individual farmers, such as increased encroachment of forest habitat by people and habitat degradation due to human activity, may play an equally important role. Elephants also may have developed a natural preference for crops over forest vegetation due to higher palatability and nutrient content of cultivated plants, as suggested earlier by Sukumar (1989, 1990). This is indicated by the occurrence of two crop raiding peaks during the first and second monsoons (July-Sept., Nov-Jan), when forest vegetation is expected to be of high quality. Small groups of elephants have sometimes stayed in an area for several days, repeatedly feeding on the same fields. In almost all cases when the elephants were not disturbed or chased, the point of return was close to, if not the same as the point of entry into the fields, suggesting purposeful raiding.

With regard to methods of reducing conflict, there is evidence that people living near or within protected forests do not appreciate Departmental efforts to control the elephant problem which entail reducing or withdrawing previously implicit rights of locals to use the forests for daily requirements. As shown in our study, human impact appears to be a severe problem during the first few years after installing an elephant-proof barrier. The main method used by local people to fight against such an imposed system appears to be to disregard it and carry on as if it did not exist, or to modify it to suit their purposes, subsequent to its installation. Their apparent non-cooperation with systems set up by the Forest Department may indicate that their views have not been solicited or incorporated into the solutions developed to solve the problems. Since they are not consulted or taken into confidence during the decision-making process, they appear to revolt (usually through various forms of passive resistance) by simply not falling into step with the program, as expected by the Forest Department. The findings of our efforts to evaluate Department-installed control methods highlight the importance of trust-building activities *prior to* installation of any elephant controlling device or system. Reaching mutually agreed-upon solutions which address the problems of both, local farmers and the Forest Department, may increase the probability of long term success of future efforts.

8. MANAGEMENT RECOMMENDATIONS

Management strategies in Kodagu should be aimed at reducing and mitigating the effects of conflict between elephants and humans, based on the severity of damage experienced in different areas. Immediate relief in the form of elephant-controlling and capturing methods may be called for in areas where damages are extremely high, and where local people show severe antagonism towards elephants and the Forest Department as a result of conflict. However, the cost-effectiveness and practicality of mitigation methods implemented by the Government should be borne in mind before huge sums of money are sanctioned and large projects undertaken. It must be stressed here that small fragmented patches of forest require considerably different management strategies from large contiguous forest areas. Methods of controlling elephant movement, such as elephant-proof trenches and electrified fences are not practical for use in small habitat patches as this results in confining elephants to areas which cannot adequately support them in the long run. In such areas other methods will have to be used.

The following recommendations have been made keeping in mind that the four habitat-similarity zones may require mitigation and control measures which are different from those required by the other zones. Zones 3 & 4 may require similar methods for controlling the problem, and hence are clubbed together in this section. Some long-term measures of controlling conflict in the district are also suggested.

Zone 1:

For the highly fragmented areas in Zone 1, no management recommendations can substantially reduce the problem immediately, without causing a serious ecological backlash. The use of rubble walls, EPT or electrified fences in this region would be extremely impractical and unreasonable. The only alternatives available to the Forest Department in the Zone 1 area of Kodagu appear to be the following:

1. Capture and tame habituated raiders at least every alternate year in the area, and hence to reduce the pressure on the habitat from elephants.
2. Engage elephant-scaring squads during the crop season. Local people (non-farmers) in these areas could be hired to scare elephants. Areas particularly prone to elephant depredations could have permanent squads organized from among local people who communicate with the Forest Department regularly to obtain funding and support. However, this is not recommended as a long term or permanent solution in this region.
3. As no method appears suitable for reducing elephant incursions in a very highly fragmented forest area, the Forest Department should provide adequate compensation and extend other forms of support to farmers living there.
4. In the short term, farmers in the area who can afford an expensive solution may be encouraged to install electrified fences around their

properties. Small groups of farmers may be provided with monetary support by the Forest Department, by the local Panchayat government or by local cooperative banks to allow them to consider this option.

In the long term, the Department may have to seriously consider removing all the elephants from this area, as the habitat is clearly declining here. Zone 1 also supports the 2 irrigation dams of the district, which have been substantially responsible for habitat fragmentation. Forests in Zone 1 once supported large numbers of spotted deer, gaur, wild pig and possibly leopards, in addition to elephant. Now all that is left are elephants which may be supported largely by crops. A possible alternative use envisaged for this area, if devoid of elephants is a *forest-for-forest swap program*, aimed at providing a reasonably wooded surrounding for resettled forest-dwelling communities who would be willing to consider moving out of larger protected forests in the future. This area may be suitable for forest-swapping with tribals/non-tribals who currently live in large, relatively undisturbed habitats such as Nagarahole NP or the western evergreen highlands, which are possibly crucial biodiversity areas, and may benefit immensely by protection from over-use and fragmentation.

Zone 2:

For the areas classified as Zone 2, the following immediate suggestions are possible:

1. Improvement of the existing EPTs with the help of local people,
2. Construction of a permanent mechanical fence or barrier along the N-S length of the park and its adjoining reserves, up to R. Cauvery . This would probably be successful in restricting human and elephant movement across it, if local people are taken into confidence and involved from the planning stages of barrier installation. Agreements would have to be made explicit with local people, regarding crossing of the barrier, and by no means should elephants be allowed to move across R. Cauvery, to enter the fragmented forests of Zone 1. There is a long-term benefit to elephants and local people in this, because the Nagarahole NP would simultaneously receive protection from other threats such as encroachment, fire and poaching.
3. As farmers in this Zone are generally wealthy, they may be encouraged to use electrified fences around their properties.

As a long term plan, consolidation of habitat is a serious concern in Nagarahole, and may have to be taken up in conjunction with resettlement of tribals in Zone 1 forests.

Zones 3 & 4:

Few efforts appear to be required, to control most of the problems in Zones 3 & 4. There are only a few villages experiencing more than five cases of crop raiding per year in these hilly areas. The following management methods are suggested for these areas:

1. Local trained and well supported elephant protection squads supplied with fireworks (as described for Zone 1) are probably the best method of protection.
2. Village or site-specific management measures need to be applied in the following villages where raiding is very high. These areas may require further studies, initially, to address specific causes of conflict in each case.
   Zone 3: Palangala, Kuttandi, V. Badaga, Bettathur
   Zone 4: Kalur, Hachinad, Hammiala
3. Enclaves in the forest may respond well to electrified fencing. However, the lessons learnt from the Wynad WS experiences must be borne in mind regarding good communication and coordination between the Forest Department and local people.
4. Increase payment of compensation and encourage alternative environment-friendly income generating vocations such as bee-keeping, medicinal plant gathering and farming.

Sealing off boundaries of selected high-conflict villages in Zones 3 & 4 may lead to increased raiding in nearby villages; this will have to be monitored. Where people are willing to move, resettlement of forest-dwelling communities should be carried out without delay. The highly contiguous nature of forests here, especially in Zone 3, makes the area an ideal candidate for protected status in the form of a large, unfragmented *Western Ghats Sanctuary or Biosphere Reserve*. This would ensure free movement of elephants along the Ghat ridges as well as protect the evergreen forests from illegal felling and poaching. However, any increase in protected status would have to be coupled with direct talks with tribal and other communities currently living inside or otherwise dependent on the forests, as it may mean changes in their rights to use these areas.

In addition to the recommendations made above, the local governing bodies may like to consider introducing *crop insurance schemes* in the district. These may be available through various governmental schemes and programs such as the Jawahar Rojgar Yojana (JRY) and the Integrated Rural Development Program (IRDP). In addition, the National Bank for Agriculture and Rural Development (NABARD) may have crop insurance schemes suited to the needs of farmers in the district. Other development programs undertaken with the help of international funding agencies such as the World Bank-funded Ecodevelopment Program and schemes funded by the Global Environment Fund (GEF) also may be used to implement solutions involving local people.

Finally, elephant populations should be monitored over the long term to understand their movements and habitat requirements. The above management recommendations may provide immediate relief to both, people and animals, in these areas. However, it is likely that, in the long run, conflicts would resurface because of the need of both species to range widely, explore and colonize suitable habitats.

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Appendixes

A1. Common and scientific names of crops mentioned in this report:

Common name	Scientific name
Arecanut	*Areca catechu* L.
Banana	*Musa paradisiaca* L.
Cardamom	*Elettaria cardamomum* Maton
Coconut	*Cocos nucifera* L.
Coffee	*Coffea arabica* L.
Corn/maize	*Zea mays* L.
Guava	*Psidium guajava* L.
Jack fruit	*Artocarpus integrifolia* L.
Mango	*Mangifera indica* L.
Orange/Mandarin orange	*Citrus reticulata* Blanco
Papaya	*Carica papaya* L.
Pepper/Black pepper	*Piper nigrum* L.
Ragi (finger millet)	*Eleusine coracana* Gaertn.
Rice (paddy)	*Oryza sativa* L.
Sugar cane	*Saccharum officinarum* L.
Sweet potato	*Ipomoea batatas* Lam.
Tamarind	*Tamarindus indica*

(From Handbook of Agriculture, Indian Council of Agricultural Research, New Delhi, 1969)

A2. Areas (in hectares*) under cultivation of crops in the three Taluks of Kodagu, used in this report:

Crop	Madikeri	Somwarpet	Virajpet
Paddy	10,012	11,319	23,266
Coconut	250	92	89
Coffee	12,423	22,353	31,721
Arecanut	691	-	-
Pepper	696	220	190

* 100 hectares = 1km^2

(From Kodagu District Working Plans, 1985-95, Karnataka Forest Department)

A3. Standardised crop yields & economic values used in this study to estimate economic losses of individual farmers:

Crop	Yield/acre*	Cost /quintal** or cost/plant	Value/acre
Arecanut		Rs. 200/pl.	
Banana		Rs. 70/pl.	
Cardamom	7.5 q./a	Rs. 15,000/q.	Rs. 1,12,500/a
	0.75 kg/pl.	Rs. 112.5/pl.	
Coconut	15,000 nuts/a	Rs. 3/nut	Rs. 45,000/a
	100 nuts/pl.	Rs. 300/pl.	
Coffee	7.5 q./a	Rs. 3,000/q.	Rs. 22,500/a
	10 kg/pl.	Rs. 300/pl.	
Corn	20 q./a	Rs. 350/q.	Rs. 7,000/a
Guava		Rs. 500/q.	
Orange	250 or./pl.	Rs. 250/pl.	
Pepper		Rs. 100/pl.	
Ragi	20 q./a	Rs. 400/q.	Rs. 8,000/a
Rice (paddy)	20 q./a	Rs. 500/q.	Rs. 10,000/a
Sw. Potato		Rs. 1,300/q.	
Tamarind		Rs. 1,500/q.	

* 1 Acre = approx. 0.4 hectares
** 1 Quintal (q.)= 100 Kilograms (kg)

A4. Exchange rate of Indian Rupees for US dollars, 1990-97:

Year	Value of US $
1990-91*	17.94
1991-92*	24.47
1992-93*	28.96
1993-94*	31.37
1994-95**	31.43
1995-96**	33.65
1996-97**	35.43

* Official rate
** Average of buying and selling rates
(Adapted from Statistical Outline of India, 1997-98, Tata Services Limited, Mumbai, Dec. 1997)

For copies of publication please contact

ASIAN ELEPHANT CONSERVATION CENTRE

Centre for Ecological Sciences

Indian Institute of Science

Bangalore - 560 012, INDIA.

Tel +91-80-3092786 Fax +91-80-3311280

E-mail : aecc@ces.iisc.ernet.in