DRIVERS OF HUMAN ELEPHANT INTERACTIONS IN COFFEE AGRO-FORESTERY LANDSCAPES
IN
KODAGU (WESTERN GHATS), INDIA

An approach to understand the Human-Elephant Conflict

By

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CAVEAT

This is a scientific report. Reference to the word *forest* is according to FAO's definition (Global Forest Resources Assessment Update 2005):

"Land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds *in situ*. It does not include land that is predominantly under agricultural or urban land use.

Explanatory notes

1. Forest is determined both by the presence of trees and the absence of other predominant land uses. The trees should be able to reach a minimum height of 5 meters *in situ*. Areas under reforestation that have not yet reached but are expected to reach a canopy cover of 10 percent and a tree height of 5 m are included, as are temporarily unstocked areas, resulting from human intervention or natural causes, which are expected to regenerate.
2. Includes areas with bamboo and palms provided that height and canopy cover criteria are met.
3. Includes forest roads, firebreaks and other small open areas; forest in national parks, nature reserves and other protected areas such as those of specific scientific, historical, cultural or spiritual interest.
4. Includes windbreaks, shelterbelts and corridors of trees with an area of more than 0.5 ha and width of more than 20 m.
5. Includes plantations primarily used for forestry or protection purposes, such as rubberwood plantations and cork oak stands.
6. Excludes tree stands in agricultural production systems, for example in fruit plantations and agro-forestry systems. The term also excludes trees in urban parks and gardens."

We therefore use the word *forest* without considering the actual land tenures or management systems, which are of no concern to us in this work.

INTRODUCTION

The **Asian Elephant, *Elephas maximus***, an integral part of many tropical landscapes, is considered a flagship species for conservation throughout its worldwide range in Asian countries. Ecologically vulnerable and threatened by the high market value of its ivory, the species has been listed in Schedule 1 of the Indian Wildlife (Protection) Act, 1972; and the International Union for Conservation of Nature (IUCN) Red list and Appendix 1 of Convention on International Trade in Endangered Species (CITES).

Human elephant conflict (HEC) is not a new phenomenon. Humans and elephants have shaped each others' distribution over the years through a combination of crop-raiding and exploitation (Nelson *et al.* 2003). In pre-colonial times elephants played a major role in the distribution of arable farming (Parker & Graham 1989, Ville 1995, Barnes 1996). In the early 19th century 'slash and burn' subsistence farmers cultivating crops in central African forests lost entire crops to elephants, while in other areas elephant crop-raiding caused food shortages and displaced settlements (Barnes 1996; Graham 1973; Parker & Graham 1989; Ville 1995).

HEC has been a two sided equation but more recently conflict has generally led to the exclusion of elephants (Parker & Graham 1989, Hoare & Du Toit 1999). Now it is mostly taken to mean direct conflict but it is part of a complex interaction between people and elephants which in most countries has been going on *in some form* for centuries (Hoare 2001).

The broad definition of HEC adopted by the IUCN/SSC African Elephant Specialist Group (AfESG) is *"any human-elephant interaction which results in negative effects on human social, economic or cultural life, on elephant conservation or on the environment"* (Hoare, 2001). Studies on human elephant conflict in Asia (Sukumar and Gadgil 1988, Santiapillai and Widodo 1993, Balasubramanian *et al.* 1995, De Silva 1998, Amirtharaj *et al.* 2001) and Africa (Thouless 1994, Barnes *et al.* 1995, Tchamba 1996) identify crop raiding as the main form of conflict. Nath & Sukumar (1998) define HEC as 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. Such interactions have also led to animosity and fear among those sharing their land with elephants (Naughton *et al.* 1999), decrease in human appreciation of wildlife and potentially severe detrimental effects for conservation (De Boer & Baquete 1998; Nyhus *et al.* 2000).

THE INTERFACE

The most serious issues now facing African and Asian elephants are habitat loss (through land-use change), habitat fragmentation, ivory poaching and persecution as crop raiders (Parker & Graham 1989, Sukumar 1991, Armbruster & Lande 1993, Barnes 1999, Nyhus, Tilson & Sumianto 2000, FFI 2002). Associated with increasing habitat loss and fragmentation is a concomitant increase in the human-elephant interface, and by extension an increase in conflict (Nelson *et al.* 2003).

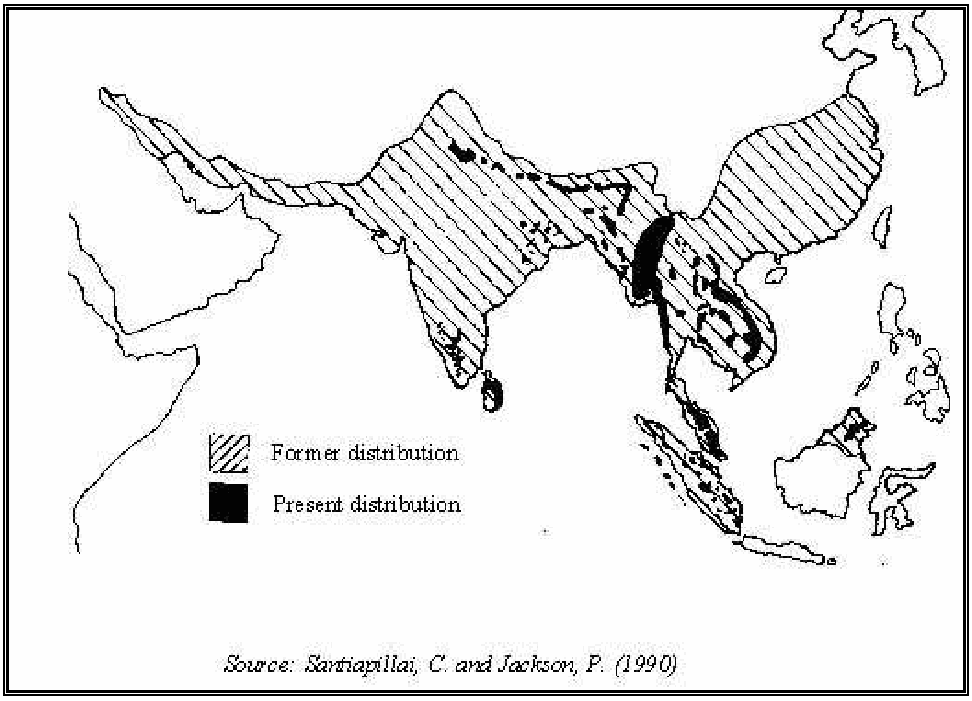

Figure 1: Former and Present Distribution of the Asian Elephant (*Elephas maximus)*

In the African continent, HEC is reported from most of the 37 elephant range states (Hoare 2001). In Asia it is prevalent throughout the 13 countries where the Asian elephant is distributed. However present distribution of the Asian elephant covers only a fraction of its former extensive range stretching from the Indian subcontinent in the west to Indochina in the east (WWF Species Status Report 2000) (see Figure 1). Today, in southern India, the Asian elephant occurs in the hill forests of the Western Ghats and adjacent Eastern Ghats in the states of Karnataka, Kerala, and Tamil Nadu (Nair and Gadgil 1978; Nair *et al.* 1980; Sukumar 1986, 1989). The protected areas within these states are estimated to have densities in the range of 1 to 3 elephant per km^2 (WWF Species Status Report, 2000).

India has a human population density of 311 inhabitants per square kilometre (Census of India, 2001) and houses the largest Asian elephant population, approx. 25,000 (Amirtharaj *et al.* 2001). As human and animal habitats overlap the friction results in the loss of life and property. It is estimated that every year elephants damage 10,000 to 15,000 houses and 8,00,000 to 10,00,000 ha of crops (Kulkarni *et al.* 2007). The Central and State Government spend up to 10 to 15crores of rupees every year on ex-gratia payment to victims and on protection and control measures (Kulkarni *et al.* 2007). The increasing number of crop raiding incidences has led to increasing people's resentment towards the elephant and in some cases led to retaliatory killing of elephants. It is estimated that every year 200 elephants are killed in the country due to poaching, poisoning, electrocution and accidents. Human losses are estimated to 150 to 200 annually (Bist, 2002).

The case of the Asian elephant provides an example of ecological, economical, sociological and religious factors merging to create a complex, emotive and potentially harmful combination for all involved parties. There is a very strong tradition of elephant worship in most Asian countries which forms the foundation of elephant conservation initiatives in the continent. However, the observed levels of HEC pose a major obstacle to elephant conservation efforts in India. Conservationists must therefore find ways to raise public tolerance of elephants and this requires a better understanding of their ecology. (Naughton *et al.* 1999).

A WICKED PROBLEM: KODAGU CASE STUDY

Kodagu is part of the Western Ghats of India, which are described as **one of the 34 global biodiversity hotspots** (Myers *et* al. 2000, Gunawardene *et al.* 2007) due to its high level of endemism. Situated mainly on the eastern slopes of the Western Ghats, Kodagu is a **major coffee-growing region** (Figure 2) in India. It produces nearly one-third of Indian coffee, mostly in agro-forestry systems under native tree cover. Forest is represented on 46% of the land area of the district (Elouard 2000). Kodagu is dominated by agricultural land including protected areas, sacred forests and patches under private tenures. Coffee estates cover 29% of the total area of the district (Elouard 2000). The other crops that are associated with coffee are pepper, cardamom, oranges and rice in the paddy fields. Altogether, forests and agro-forests account for approximately 75% of the district.

Kodagu district with its surrounding protected forest belt totalling 1588km^2 (39% of the geographical area) is reported to have 1252 elephants according to the 2005 elephant census of Karnataka Forest Department (as analysed by Asian Elephant Research and Conservation Centre (AERCC), Kulkarni et al 2007).

Major **landscape transformations** in Kodagu during 1977-97 reduced the forest cover from 2566 km^2 to 1841 km^2 (Elouard & Guilmoto, 2000). This deforestation has occurred in private lands, converted for coffee cultivation, whereas the reserve forests managed by the Forest Department of Karnataka remained relatively untouched.

Studies on HEC in Kodagu (Nath and Sukumar 1998, Kulkarni *et al.* 2007, Bhoominathan *et al.* 2008) have described the regional pattern of the conflicts and the coping strategies developed by coffee planters and institutions (including the Karnataka Forest Department) to tackle HEC. However, HEC relationship differs significantly across sites of human-elephant conflict. The basis of the conflict is spatial (i.e. the distribution of and interface between people and elephants) and temporal (i.e. seasonal), as opposed to numerical or density dependent (i.e. how many people and elephants live together) (Barnes *et al.*, 1995; Hoare, 1999c; Hoare & Du Toit, 1999; Smith & Kasiki, 1999). Irregular and unpredictable nature of HEC incidents in the study area may also depend on the behavioural ecology of individual elephant bulls (Sukumar 1991, Hoare 1996).

In this study we try to understand the specificity of the conflict in Kodagu by updating previous studies and exploring the probable causes for elephant intrusion into coffee agro-forestry systems. By understanding the current status of conflict, stakeholders' perceptions about the conflict, drivers of HEC and elephant dietary preferences to certain crops we hope to be able to draw specific management implications for the study area. HEC calls for adaptive management working with a combination of possible solutions since no single method can work in isolation towards conflict alleviation (Nelson *et al.* 2003).

OBJECTIVES OF THE STUDY

The main objective of the study was to understand HEC in Kodagu through a multidisciplinary approach. There were two phases to this study.

PHASE I: Assessing the spatial and temporal patterns of human/elephant conflicts at the division level. We also identified the perceptions of the different stakeholders affected by the HEC problem at the village level.

PHASE II: The study aims to identify the environmental factors that drive the elephants into coffee agro-forestry systems (CAFs) at the level of the individual coffee plantation. The question asked here is 'Why are the elephants coming into coffee estates?' Additionally, we also worked on a corollary, 'Are the elephants eating coffee?'

STUDY AREA

The study was conducted in southern part of Kodagu district (75°25' – 76°14' E, 12°15' – 12°45' N), Karnataka (Figure 2). The district has a total area of 410,200 ha and a human population of c. 500,000. The elevation of the district ranges from 850 to 1745m (Elouard, C. 2000). 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 south-western areas. The yearly rainfall ranges from less than 800 to more than 5000 mm (Elouard 2000). Much of this rainfall is primarily received from the South-west monsoons (6000mm to 1000mm) from June to end of September. The North-east monsoons bring rains from October to December but these showers are not comparable to those in the summer. As we move eastwards, rainfall decreases and the forest type changes correspondingly from wet evergreen to dry deciduous.

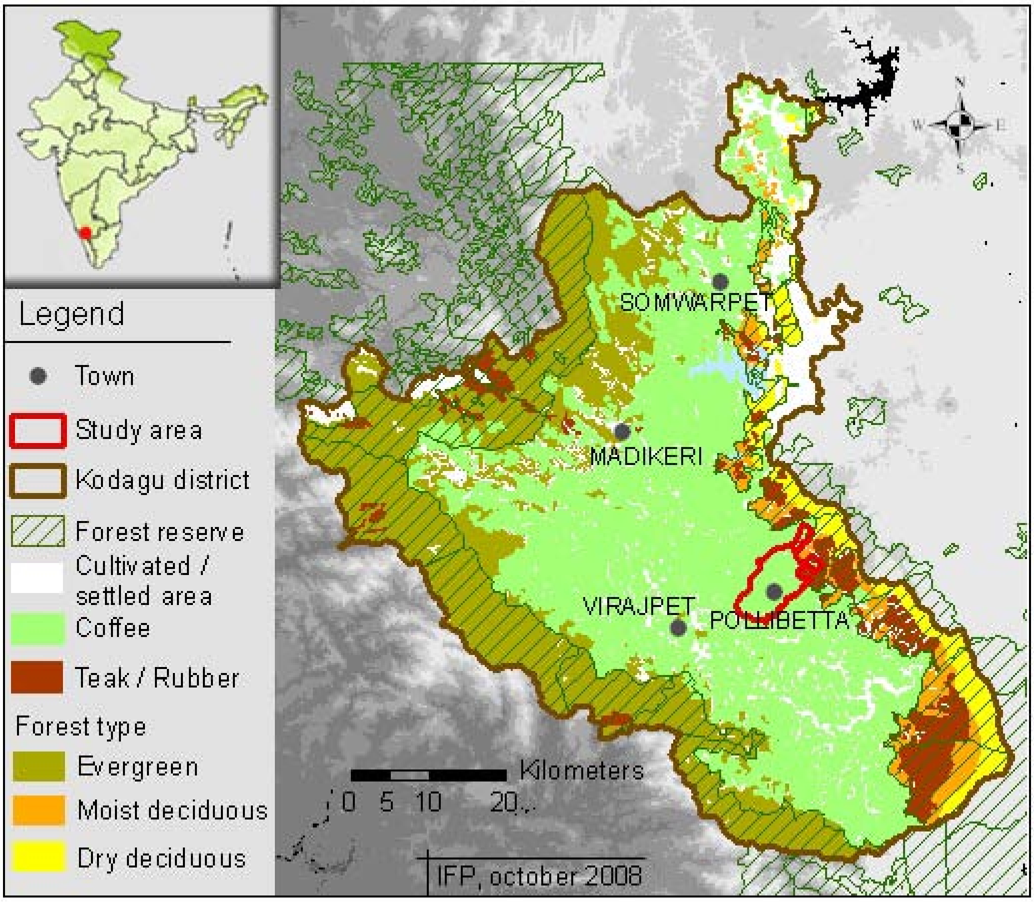

Figure 2: Location of study area and the surrounding reserve forests in Kodagu

The district is divided into three *taluks* or administrative units (Figure 2) headquartered at Madikeri, Virajpet and Somwarpet. However administrative units used by the Forest Department do not coincide with the taluk boundaries since they divide the district into two divisions i.e. Madikeri, the northern half of the district inclusive of Somwarpet *taluk* and Virajpet constituting the southern half. Divisions are further divided into *ranges* (six in Madikeri and five in Virajpet) and ranges are broken up into *sections*.

METHODS OF DATA COLLECTION

PHASE I – Spatial pattern of conflict and Stakeholders' Perceptions

SITE SELECTION: Based on discussions with key informants, we identified Virajpet taluk[1] in south Kodagu for the purpose of HEC data collection, partly because of its high level of conflict and because the results of the study would feed into existing projects of the French Institute of Pondicherry. Two villages in Virajpet division, Chennangi and Channayanakote (see Figure 3), lying next to the Reserve Forest (RF) were selected for the purpose of interviews. This work was carried out from May to July 2007.

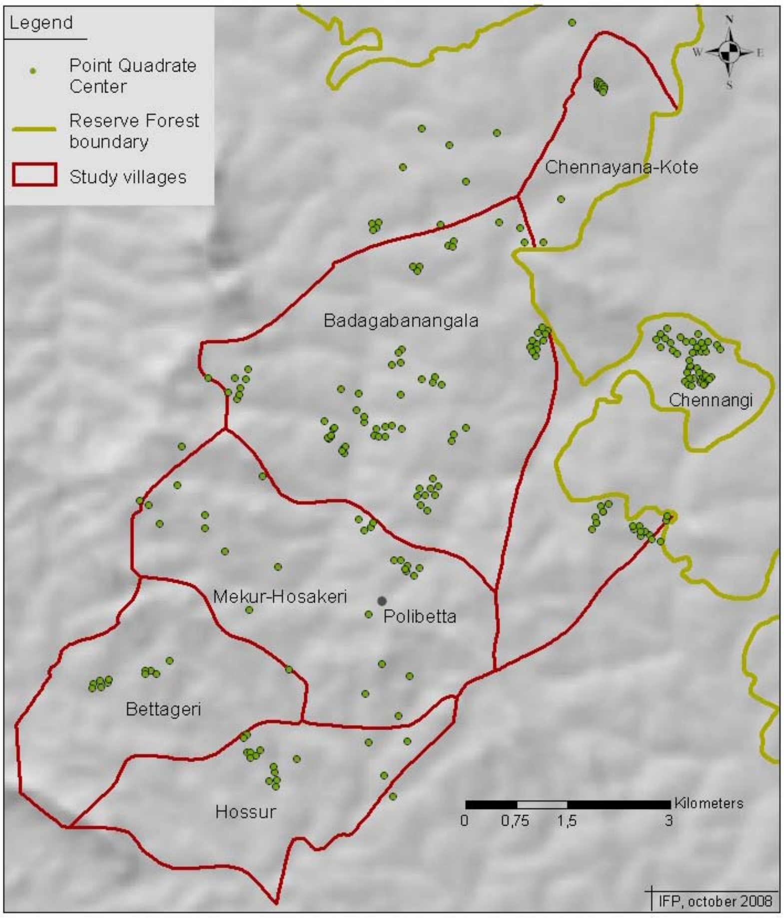

Figure 3: Location of study villages

[1] Known as the *Virajpet Forest Division* under jurisdiction of the Forest Department.

ASSESSMENT OF CURRENT STATUS OF CONFLICT

Records of HEC from 1997-2007 for Virajpet division villages were obtained from the Virajpet Division Forest Department (FD) headquarters, following permission from the Deputy Conservator of Forest. However for some villages falling within Nagarahole, Anechowkur and Kalhalla ranges of the Rajiv Gandhi (Nagarahole) National Park (NNP), cases have been registered at the Wildlife Division of Hunsur Forest Department. Some villages of Coorg in the Anechowkoor and Periyapatna ranges register their HEC cases at the office of the Territorial Division of Hunsur Forest Department. Further, there also are cases from Srimangala Range (bordering Brahmagiri Wildlife Sanctuary) that continue to be registered at the Madikeri Wildlife Division office.

The records were then translated and entered into a database. We also gathered additional data from regional corporate coffee estates. The data provided information on crop compensation and human death and injury cases. For all the cases, location and year of occurrence were noted. Unlike for previous years, data from 2006-2007 contained details of the month of damage and the crops damaged. We then cross-referenced our data with the results on levels of conflict in Virajpet Division presented by Kulkarni et al, 2007.

Additional data are being gathered on crop raiding cases for Virajpet villages bordering NNP, registered at the offices of the Wildlife and Territorial Divisions of the Hunsur Forest Department and for those bordering Brahmagiri Wildlife Sanctuary (BWS) registered at the office of the Madikeri Wildlife Division.

ASSESSMENT OF STAKEHOLDERS' PERCEPTIONS

Qualitative data regarding HEC was obtained through semi-structured interviews with local stakeholders. Our sample included private estate owners, forest watchers, Eco-Development Committee (EDC) and Village Forest Committee (VFC) members, estate workers, tribal inhabitants and local experts (total 20 interviews coded I.1, I.2 …. I.20; see Appendix 1 for details). Four of the interviews were not recorded and therefore could not be used for statistical analysis. We asked open ended questions on details of crop damage, stakeholders' perception on the HEC and the coping strategies developed locally. The discussions were carried out in English wherever possible, otherwise in Kannada or Kodava with the assistance of a translator. The first five interviewees were identified from FD records of crop compensation for the selected villages. We expanded the sample size to 20 through snowballing. Interviews lasted for one to two hours and were systematically followed by a survey of the plantation with the interviewee for elephant damage.

PHASE II – Environmental Factors and Feeding Patterns in CAFs

SITE SELECTION: Based on the preliminary survey of the conflict situation in Virajpet Division from phase I of the study, we selected six villages, Chennangi, Channayanakote, Mekur Hosakeri, Badaga Banangala, Hosur and Bettageri (Figure 3). The villages extend from the RF boundary up to the middle of the district (10-11 km), along a transect perpendicular to the boundary of the RF.

Coffee estates were randomly selected within these villages, using the contact details corresponding to randomly selected survey numbers obtained from the respective revenue offices. We thus covered 20 estates coded E.1, E.2 …. E.20 (see Appendix 2 for details) between January to March 2008.

ASSESSMENT OF HABITAT VARIABLES IN COFFEE ESTATES (Estate Characterisation Study)

We identified 10 habitat variables to characterise each of the study estates based on the interviews conducted in phase I:

1. Area of the estate
2. Distance to Reserve Forest
3. Area under paddy cultivation
4. Number of water bodies
5. Tree density
6. Percentage of canopy cover
7. Percentage of fruit trees
8. Percentage of *preferred* trees[2]
9. Percentage of *Erythrina subumbrans* trees
10. Percentage of Jackfruit (*Artocarpus heterophyllus*) trees

Estate area, distance to RF, area under paddy cultivation and the number of water bodies were estimated using Geographic Information System (GIS) software (ArcGis 9.1). To measure tree species, abundance, density and canopy cover, 10 sampling points coded *PQC*

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[2] Trees that were repeatedly damaged by elephants (according to FD data and interviewees) were considered to be *preferred* by the elephant while they were foraging in coffee estates.

(Point Quadrat Centre) were laid within each estate, after randomly generating angles for direction and number of steps from a starting location within the estate. For large estates, 10 random points were selected using a Global Positioning System (GPS) unit (Trimble: Geoxm, 2005 series). The coordinates for each sampling point were recorded using a GPS (see Figure 3).

At each sampling point, 5 measure points were laid, one on the same location, and four additional, each 10m away from the centre in the north, south, east, and west directions, coded PQ1, PQ2, PQ3 and PQ4, respectively. Figure 4 illustrates the sampling protocol. Each set of five points per PQC (inclusive of the PQC itself) thereby made one *plot*.

Information about the study estates, its management, frequency of elephant visitation in 2007 and type of damage caused was also obtained by means of questionnaires handed out to the study estate owners (see Appendix 2).

Estate area: Due to missing information in three of the questionnaires, estate area was estimated using GIS. For small estates this was done based on GPS marked boundaries. For large corporate estates, the boundary was estimated by drawing a polygon whose edges were at an average of 50 m from the outermost PQCs. GIS estimates were used for all the estates for analysis, as the correlation between this estimator and the data recovered through questionnaires is high ($R^2 = 0.85$).

Distance from RF: The distance between the closest PQC to the RF and the closest edge of the RF boundary was measured using GIS software. RF boundaries were identified using satellite images and previously generated maps at the FIP.

Area under paddy cultivation and number of water bodies: A 500m buffer from the boundary of the study estates was created using GIS. Area under paddy and number of water bodies falling within the boundary of the buffer were identified by means of Remote Sensing (RS) images and GPS locations.

Tree density: The distance between a PQC and the 10th closest tree (>30cm gbh) to the PQC was measured and tree density was calculated using the following formula:
Tree density = $10/\pi r^2$, where 'r' is the distance to the furthest tree (out of the 10 recorded trees) from the PQC. Figure 5 illustrates the method of measurement and tree density calculation.

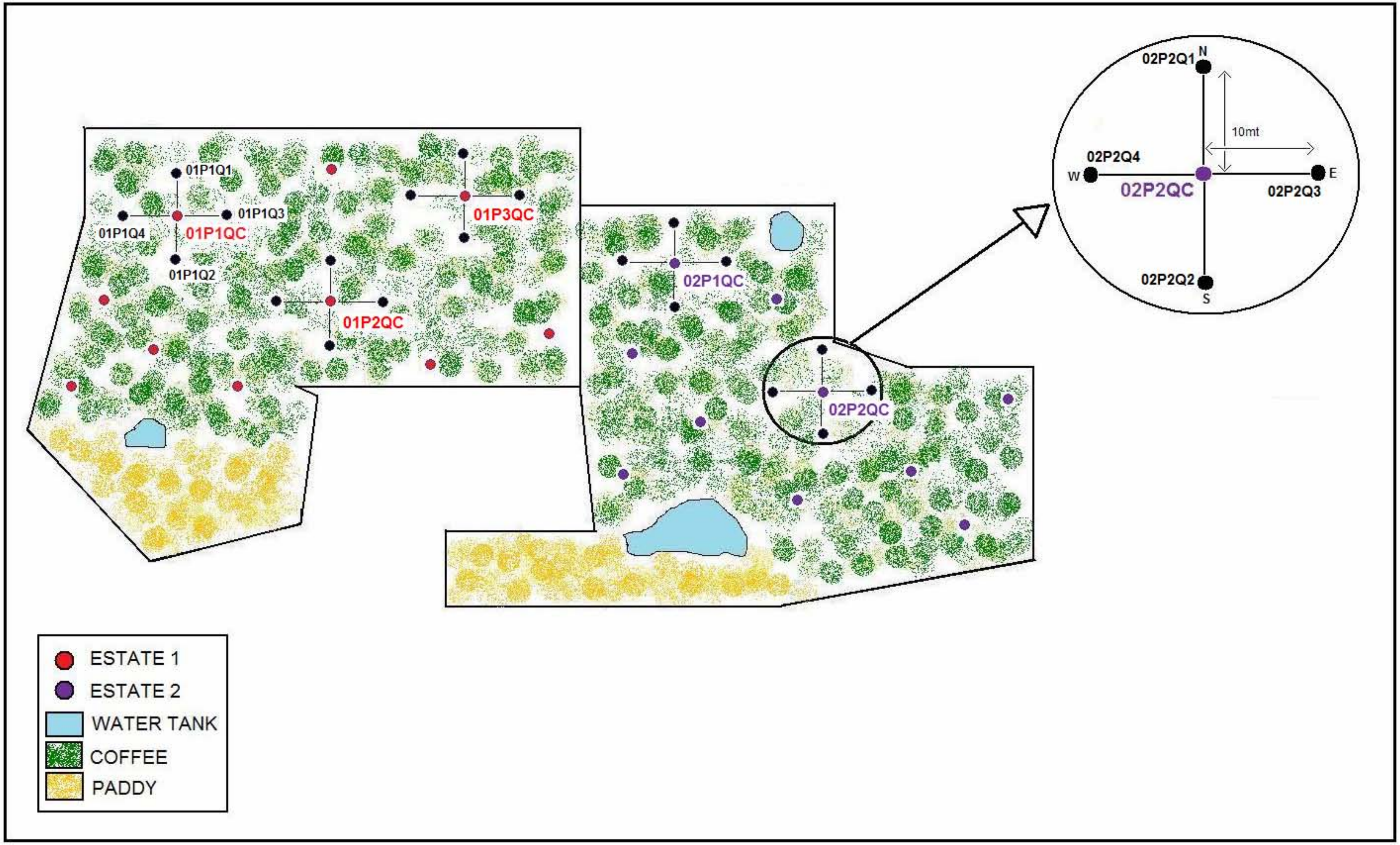

Figure 4: Sampling protocol for measurement of some of the habitat variables and a generalised depiction of layout of PQCs across study estates

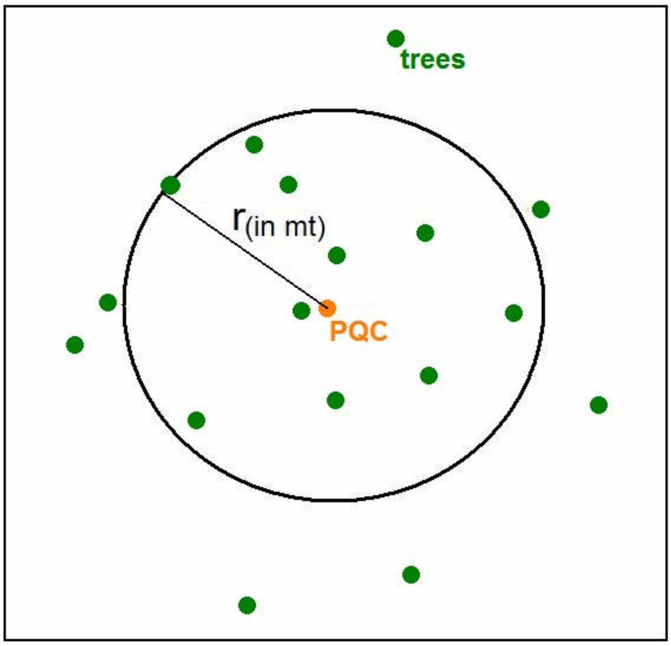

Figure 5: Tree density measurement within the coffee estate

Canopy cover: A convex spherical densiometer (Figure 6) was used to estimate canopy cover at each of the five points per plot. Each reading of the densiometer comprised of four readings, N/S/E/W at the point of measurement. Coffee and pepper leaves were not considered while taking measurements for canopy. The measure was then converted to percentage.

(Photo credit: Decroix, M. & Chretien F.)

Figure 6: Convex spherical densiometer

Percentage of fruit trees, *preferred* trees, Erythrina trees and Jackfruit trees: At each PQC, species of the 10 closest trees to the PQC with >30 cm girth at breast height (gbh) were noted according to the following basic classification:

a. Arecanut (*Areca catechu*)
b. Banana (*Musa paradisiaca*)
c. Coconut (*Cocos nucifera*)
d. Jackfruit (*Artocarpus heterophyllus*)
e. Orange (*Citrus reticulata*)
f. Wild mango (*Mangifera indica*)
g. Dadup (*Erythrina subumbrans*)
h. Silver Oak (*Grevillea robusta*)
i. Other species

10 *trees/ plot*	x	10 PQC *plots/estate*	=	100 *trees/estate*

Percentage of fruit trees was calculated by pooling together arecanut, banana, coconut, jackfruit, orange and mango. Percentage of trees *preferred* by elephants was calculated by pooling arecanut, banana and coconut based on the FD crop damage data, along with jackfruit and *Erythrina* based on field notes and interviews.

Elephant visitation: Information regarding frequency of elephant visitation was obtained from FD crop compensation data for the last year (2006-07) for Virajpet Division (80 villages) and from the questionnaires handed to estate owners. The two data sets vary greatly in scale (5 villages).

Questionnaire data provided the following information on elephant visitation to study estates: (1) which months in 2007 did the elephants visit the estate? (2) dichotomous data categorized as more than or less than four elephant visits to the estate on average per month.

ASSESSMENT OF COFFEE CONSUMPTION BY ELEPHANTS

The location of all dung piles encountered during the study was recorded with a GPS. In addition, dung bolus[3] diameter was measured and the presence of coffee seeds was noted. A total of 209 dung piles were observed during the study period of January 2008 - March 2008. 62 of these could not be measured for size due to excessive damage to the boli and in these cases only the number of coffee seeds and GPS coordinates were noted. After sampling, the dung pile was destroyed to prevent double counts. The following parameters were considered for this part of the study:

1. Age of the elephants based on measurement of bolus diameter (Sample size = 147)
2. Presence/Absence of coffee seeds in dung piles (Sample size = 209)

Age of the elephants: Bolus diameter was used as an indicator of age as these are known to be positively correlated (Jachmann & Bell 1984, Vidya 2000, Reilly 2002, Morgan & Lee 2003, Morrisson *et al.* 2005). Boli were considered 'intact' if there were no apparent deformations due to impact with the ground (Morrison *et al.* 2005) or trampling. The long and short axes of the cross section of a cylindrical bolus were measured, and then the mean of these 2 measures was taken as the diameter for a bolus. Three such readings were obtained per dung pile and averaged.

We grouped the elephant dung piles into two age classes based on bolus diameter, juveniles and adults. Ten centimeters was used as the bolus diameter cut off for juvenile elephants, as in previous studies (Jachmann & Bell 1984, Morgan & Lee 2003) that related this size to Asian or African elephants aged five to six years. Below this age elephants may be considered as juvenile (Sukumar 1992). In addition, the proportions of dung piles in the two age classes achieved with this size classification was in accordance with the population proportions of juvenile and adult elephants in the 2005 census by the KFD (χ^2= 0.8622, N=147, df=1, p=0.3531) (see Appendix 3).

Bolus diameter $\leq$ 10cm corresponds to a juvenile elephant

Bolus diameter > 10 cm corresponds to an adult and sub-adult elephant

[3] An elephant dung pile consists of 2 – 4 ***boli***, each of which is roughly cylindrical in shape with average diameters varying from 6 – 18 cm, depending on the age of the elephant.

Presence of coffee seeds: Number of coffee seeds (individual cotyledons) was estimated according to the following categories:

- 0 coffee seeds
- 1-50 coffee seeds
- > 50 coffee seeds

DATA ANALYSIS

Current status of conflict

Number of crop compensation and human death and injury cases was considered as an indicator of the intensity of crop raiding in the area (Nath & Sukumar 1998; Kulkarni et al 2007). FD crop compensation data were used to generate temporal and spatial trends for HEC in Virajpet Division over the last 10 years. Incidence of damage and human deaths for each year was plotted from 1997-2007 and incidence of damage for each crop was plotted from 2006-2007. Frequency of crop damage/compensation for each village from 1997-2007 was plotted using GIS software to generate a *conflict map*.

To estimate elephant visitation to coffee estates from FD data, we made the assumptions that (1) one application filed corresponds to one incidence or *case* of crop damage/raiding by elephant and (2) that the correlation between the number of cases and the number of visitations is linear.

1 application for crop compensation	→	1 case of crop damage/raiding	→	1 visitation to the coffee estate

Stakeholders' Perceptions

Interviews were analyzed to obtain quantitative data, in terms of number/proportion of respondents, on the three topics emerging from the discussions: causes of HEC, mitigation strategies and the role of FD.

Estate Characterisation

We used regression analysis to test if elephant visitation (dependent variable) to an estate was related to the habitat variables of the estates. Estates were categorized into two groups, more than four visits per month and less than four visits per month, based on the questionnaires. T-tests were performed to find significant differences in each of the independent variables across the study estates.

Patterns in seasonality were tested through non-parametric correlations by looking for significant relationships between seasonal visitation of elephants and the quantity of the seasonal resource available within the study estates. We calculated the non parametric correlation, Kendall's Tau-B in addition to Spearman's correlation since the former is preferable to the latter for small datasets with tied ranks (). The hypothesis being tested against was that elephant visitation was expected to increase with increase in the seasonal resource.

Study on Coffee Consumption:

Chi-square tests were conducted to look for a preference for coffee berries among the elephants visiting the study estates. An assumption of these was that each dung pile represents a *feeding instance* and not necessarily an individual elephant. Therefore the proportion of dung piles with coffee seeds present in them, as well as the quantity of coffee seeds per dung pile are expected to be positively related to the amount of time spent (by an unknown number of elephants) feeding on coffee.

1 dung pile $\longrightarrow$ 1 feeding instance,

Comparisons were carried out between juveniles, adults and the total sample set.

NOTE: For all statistical tests, we generally considered 0.05 as the significance level. However, we have also mentioned results that were significant at $p < 0.10$.

RESULTS

CURRENT STATUS OF HEC

A. Year[4] wise trend

Crop Raiding Cases: Figure 7 shows the variation across 10 years of crop raiding data (1997-2007) for Virajpet division.

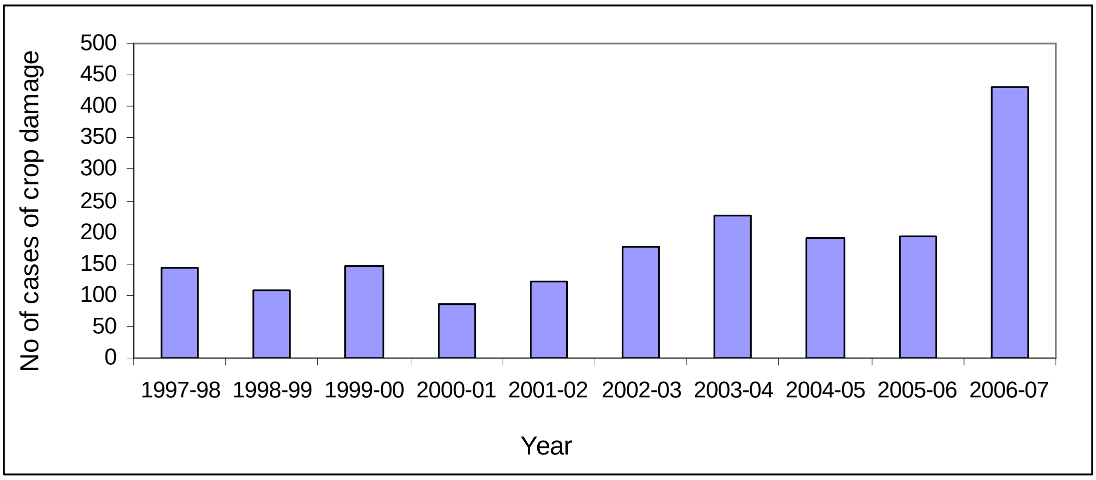

Figure 7: Year-wise trend in crop raiding for Virajpet division during 1997-2007

The above graph shows that crop damage in Virajpet fluctuates around an average of 155 cases per year from 1997-2006. Year 2006-07 shows exceptionally high conflict as compared to previous years.

Table I: Non parametric (Spearman's) correlation for annual number of crop raiding cases from 1997-2007.

YEAR	SPEARMAN'S CORRELATION COEFFIEICENT (r_S)	t-STATISTIC	SIGNIFICANCE (*p*)
1996-2006	0.80606	3.852242	0.002431
1996-2005	0.733333	2.85381	0.012277

Results (Table I) show a strong positive correlation between time and the number of crop damage cases indicating that damage is higher in later years, as is also seen from Figure 7 wherein cases for years before 2002 are below average.

[4] A year in the FD records starts from 1st April to 31st March of the following year.

Human Death and Injury Cases: Number of human mortality cases was highest in 2003-04 and cases of injury were highest in 2004-05. We do not see any trend in the data (Figure 8).

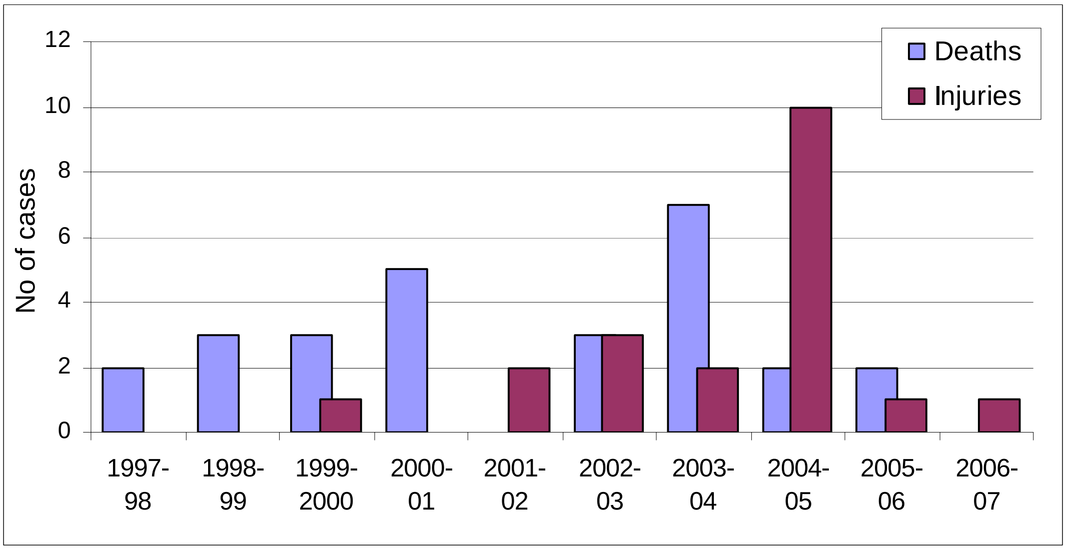

Figure 8: Number of human death and injury cases in Virajpet division

Therefore, on an average, the division experiences 155 cases of crop and property damage, three cases of human death and two injury cases every year. This requires an expenditure of over six lakhs per annum as *ex-gratia*[5] payments by the Virajpet FD.

B. Month wise trend

Figure 9 shows the monthly pattern of crops raiding incidents and the nature of the crops raided or damaged incidentally.

[5] Payments for crop damages, loss of human life, permanent disability, loss of life of domesticated animals due to wild animals attack and damages to the property due to attack by elephants and human injuries by the Forest Department (GO No. FEE 52 FWL 96 Bangalore dated: 12-2-2002)

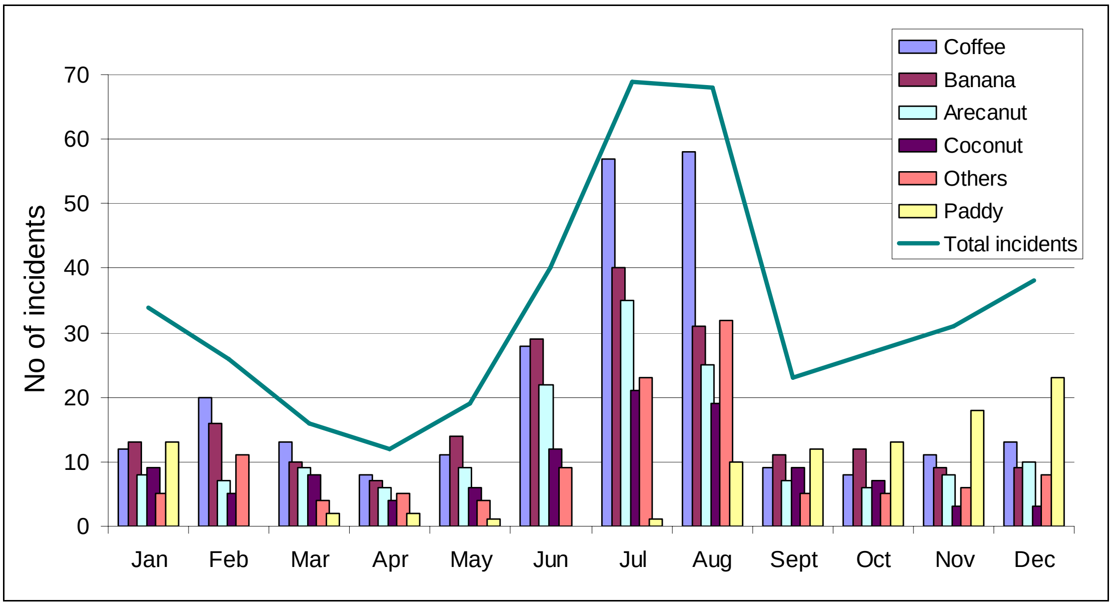

Figure 9: Incidence of damage for each crop in Virajpet Division during 2006-07 (Other crops include orange, cardamom, ginger and pepper)

There are two peaks in crop raiding as indicated by crop compensation applications (Figure 9):

1. June-August
2. November-January

Perennial crops like coconut, arecanut and banana exhibit similar patterns with two peaks in crop damage annually while seasonal crops like paddy exhibit a different behaviour altogether, starting to peak exclusively from October-January. Coffee, though seasonal, shows a pattern similar to the perennial crops except in February when it peaks in damage for a second time.

C. Spatial Trend

The ***conflict map*** developed from 10 years worth of FD data (1997-2007) for Virajpet division demarcates areas of higher conflict (Figure 10)[6]. Villages were colour coded according to the total number of compensation cases per village for all the years. Red areas are indicative of high conflict whereas white areas indicate no conflict.

[6] The results are in the process of being updated with the additional data being gathered from forest divisions outside the Virajpet Forest department.

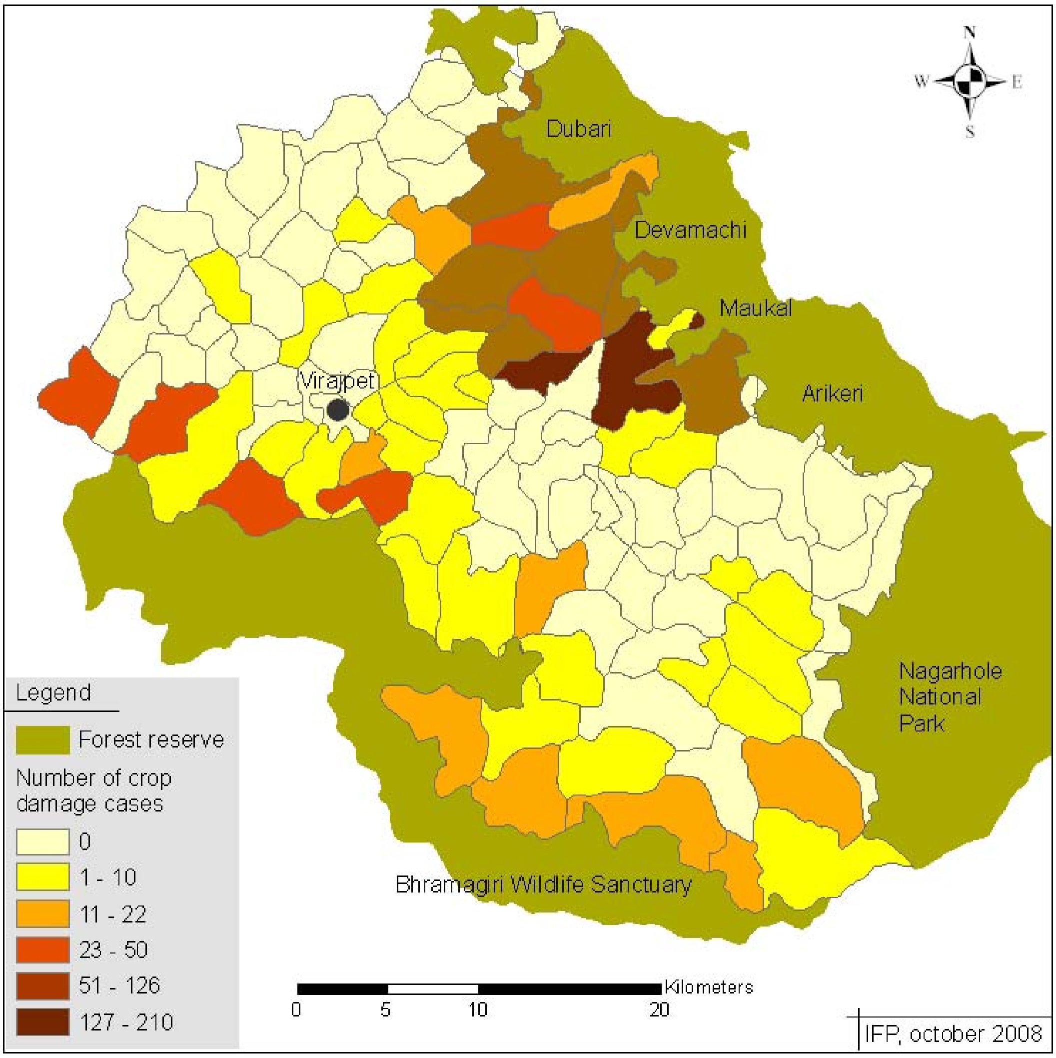

Figure 10: HEC map highlighting extent of human-elephant conflict for Virajpet division based on forest department records (1997-2007)

The region of highest conflict lies in the north-eastern part of the division. A band of high conflict area extends from the east to the west across the district. A number of villages seem to experience contrastingly low levels of conflict despite lying adjacent to high conflict areas or forest boundaries.

There were no registered cases from settlements (if any) within the surrounding RF because these were not entitled to legitimate land rights, prior to the enforcement of the Forest Rights Act 2006 (31st December 2007). Thus any conflict experienced by these settlements generally went unreported and uncompensated.

STAKEHOLDERS' PERCEPTIONS

The problem of HEC was reported to have started 10-20 years ago by seven of the interviewees (I.2[7], I.8, I.11, I.16, I.17, I.19) and nine of the estates (E.5, E.6, E.7, E.8, E.10, E.11, E.12, E.19, E.20). But oldest recollections went back to 30 years (I.12)[8] and there were also reports of the problem having always persisted (E.14, E.17). We assessed the stakeholders' perceptions on the causes of the HEC and the mitigation strategies developed by the KFD.

1. Causes of conflict

- **Lack of resources in the forest:** Seven respondents out of 16 believed that the elephants came into the estates because there was nothing in the forest for them to eat, "no green plants, no bamboo" (I.2). In comparison, "Estates are greener" (I.19) and provide better forage, particularly jackfruit trees, paddy, banana and even coffee (7 respondents). They also stated that the few water bodies in the forest did not retain water even after monsoon showers unlike coffee estates where water tanks have been established to irrigate the crop. Those water tanks provide a perennial water supply that elephants can tap easily.
- **Habitat preferences:** Seven interviewees out of 16 stated that the elephants had now marked preferences for the habitat inside coffee estates, where they would find resources, water and shade. "They don't like to stay in the forest. They want to come and live in the estates because they can get everything in the estates." (I.11); "They are accustomed to the plantation and now they don't want to go back to the forest" (I. 2); "Given the area, the water sources, jackfruits, greenery […] why would the elephant want to go back into the forest?" (I. 17).
- **Elephant population dynamics:** Seven of the respondents out of 16 believed that the elephant population in their area had increased. "The number of elephants has certainly increased. They are breeding here (in the estates)" (I.11). The increase in elephant population was causing an increased number of conflicts (I.17).
- **Teak (*Tectona grandis*) plantation within the Reserve forest:** Four out of 16 of the interviewees said that teak had taken the place of the original palatable plants in the forest, thereby causing an increase in HEC. "There is no food in the forest,

[7] "From nearly 8-10 years it has started coming, otherwise it was not there" (I.2)
[8] "Since 30 years I've been here and we have had this problem every year." (I.12)

only teak which forms 75% of the forest." (I.9). "Nothing grows under teak plantation." (I.13). One interviewee objected to this, indicating that the teak plantations are much older than the onset of the HEC (I.17).

- **New patterns of seasonality:** According to four and six interviewees out of 16, respectively, elephant visitation was more frequent during the jackfruit and paddy[9] seasons. However, eight interviewees out of 16 reported that the elephant behaviour had now changed. While there used to be seasonality in their visitations to the estates, this was no longer the case. "Elephants come into the estate throughout the year. There used to be seasonality 5-6 years back." (I.19); "Now there is no season for them because they don't like the forest anymore." (I.11); "It seems that the elephants are being seen even out of season." (I.17); "Damage is not as frequent even though the elephants are present *every day*." (I.16)
- **Increased aggressiveness of the elephants:** This was stated by 3 out of 16 of the interviewees. According to I.1, the elephants had become more aggressive, particularly in the north part of Kodagu where the conflict was intense owing to the constant disturbance and confrontation with humans. "They are not very aggressive animals by nature but they are made aggressive." (I.19).
- **Habitual elephant movement:** 2 out of 16 interviewees believed that the elephants were merely opportunistic feeders while en-route through the estates, on their habitual movement paths. "They are passing through my estate to go into the forest; it is an elephant route" (I.10). Additionally, dams were said to be restricting and channelling elephant movement (I.1).
- **Habitat fragmentation:** 2 out of 16 respondents suggested that the elephants didn't have enough space to live in since their habitat had decreased over the years.

2. Mitigation strategies and role of Forest Department:

- **Solar fences and elephant-proof trenches:** All the interviewees to whom the question was asked (12) considered solar fences and EPTs to be currently ineffective for want of maintenance. 8 of the 16 believed solar fences would be ineffective even if maintained properly. "It's a useless thing to do electric fencing. Personally, I feel it's a waste because the elephants are too smart." (I.2); Solar

[9] "Elephants come daily During paddy harvesting" (I.8)

fences were said to be made of poor quality materials, had insufficient voltage and occasional gaps owing to time lag between damage and repair in the fence. 10 out of 16 said that trenches could be a possible solution if maintained properly i.e. if they were deep, wide, and continuous, and were re-dug periodically after rains. "Trenches made of concrete could be effective against the elephant" (I.17).

Chilli smoke method (1 respondent) to drive away elephants; and translocation (2 respondents) and culling (2 respondents) as a means to reduce HEC were mentioned. Radio collaring elephants to safeguard estate workers from approaching elephants was suggested by a respondent who was of the opinion that solutions for HEC called for larger investments; "Prevention cannot work, unless it is on a mega-scale" (I.17).

- **Attitude towards the Forest Department:** There was general feeling of discontent among the local people towards the Forest Department because of the following stated reasons:
  - No follow up on the part of the FD on the maintenance of solar fences and EPT (3 respondents)
  - Delay in providing help and support to farmers suffering crop damage (12 respondents)
  - Repeated visits to the FD offices for the application procedure (4 respondents)
  - Lack of transparency and accountability. (6 respondents)
  - Lack of motivation from FD staff to assist the people affected by HEC (3 respondents)
  - Lack of infrastructure and staff to deal with HEC (3 respondents)
  - Ineffective use of allotted HEC funds (1 respondent).

Some attitudes were more constructive: "We cannot tell the FD that they are slacking in their work. We cannot because we don't know what their problems are. But if they can join hands with us and express their problems, then we can see where else we can find a solution. If not the FD, who else can we go to?" (1.19).

ESTATE CHARACTERISATION

The estates selected for the study were located in villages with medium to high conflict (Figure 11) wherein amount spent on compensation for crop damage was between Rs. 17,000 and Rs. 80,000 in 2006-2007 (Table II).

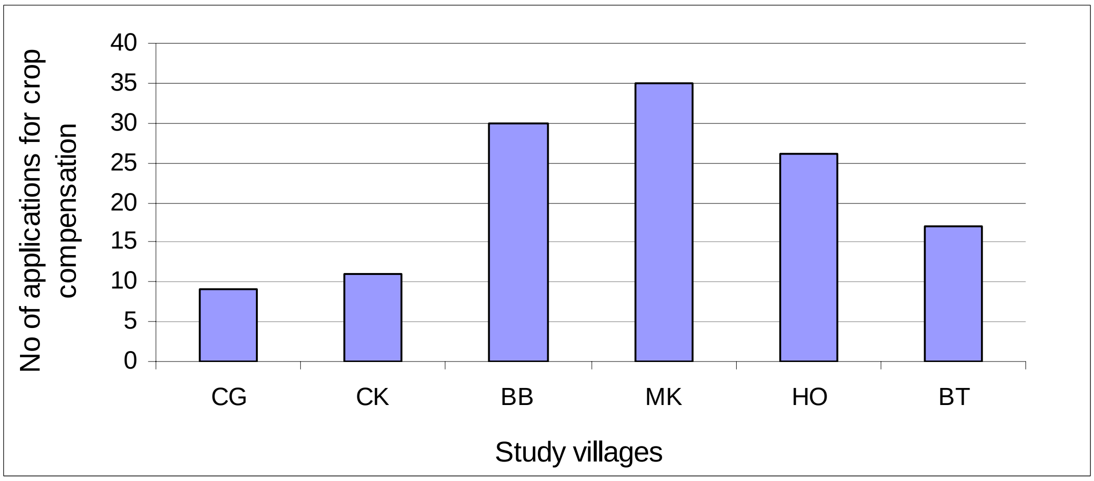

Figure 11: Conflict levels for study villages for 2006-2007 (CK: Chennayanakote, CG: Chennangi, MK: Mekur Hosakeri, BB: Badaga Banangala, HO: Hosur, BT: Bettageri); villages are arranged in increasing distance from the RF.

Table II: Amount (in rupees) spent on crop damage by the FD for 2006-07.

	No. of applications for crop compensation	**Total amount claimed (Rs)**	**Total amount received (Rs)**
Channayanakote	11	39,825	30,210
Chennangi	9	19,770	17,385
Mekur Hosakeri	35	1,32,090	71,145
Badaga Banangala	30	1,03,225	79,915
Hosur	26	49,520	45,345
Bettageri	17	31,119	29,339

All study estates experienced elephant visitations during at least one month in 2007 (see Appendix 2). We tested for significant linear regressions of elephant visitation on various habitat variables (Table III & Table IV). The frequency of elephant visitation to study estates was represented by the number of months in 2007 when the elephants were observed in the estates.

Table III: Details of habitat variables across the 20 study estates

S.No.	HABITAT VARIABLE	MIN VALUE	MAX VALUE	MEAN	SD
1	Estate area (ha)	1.74	446.96	75.01	140.91
2	Distance from RF (m)	40.00	6625.00	1858.48	1954.89
3	Tree density (per ha)	145.07	689.93	354.85	142.42
4	Percentage of canopy cover	38.46	83.26	61.06	15.06
5	Area of paddy cultivation (ha)	0.00	58.50	17.84	14.52
6	No. of water bodies	1.00	18.00	7.60	5.01
7	Percentage of fruit trees	0.00	57.00	14.65	13.84
8	Percentage of *preferred* trees	4.00	47.00	22.50	11.70
9	Percentage of Erythrina	0.00	38.00	15.20	11.64
10	Percentage of Jackfruit	0.00	7.00	2.50	2.50

Table IV: Linear regression results

S.No.	INDEPENDENT VARIABLE	SLOPE (B)	TEST STATISTIC (F)	SIGNIFICANCE (*p*)	STRENGTH (R2)
1	Estate area	4.986	13.977	**0.002**	0.437
2	Distance from RF	9.177E-02	4.280	0.053	0.192
3	Tree density	-1.71E-02	5.953	**0.025**	0.249
4	Percentage of canopy cover	1.781E-02	0.054	0.818	0.003
5	Area of paddy cultivation	6.733E-02	0.750	0.398	0.040
6	No. of water bodies	0.613	11.742	**0.003**	0.395
7	Percentage of fruit trees	-0.545	0.744	0.400	0.040
8	Percentage of *preferred* trees	-0.170	3.550	0.076	0.165
9	Percentage of Erythrina	-0.130	1.902	0.185	0.096

Estate area, tree density and number of water bodies were significantly related to elephant visitation (p = 0.002, 0.025, 0.003 respectively) whereas distance from RF and percentage of *preferred* trees (p = 0.053, 0.076 respectively) showed a relationship significant at $p < 0.10$. Tree density (B = -1.71E-02) and percentage of *preferred* trees (B = -0.170) showed negative relationships with elephant visitation.

Based on the results of regression, we used parametric and non-parametric (1-tailed) tests to look for significant differences in the habitat variables across study estates (Table V). The estates were categorized according to dichotomous data on elephant visitation (< 4 and > 4 visits per month). There were 10 estates in each category.

Table V: Results of T-tests

S.No.	VARIABLE	t	1-TAILED SIGNIFICANCE (*p*)
1	Estate area	-1.781	**0.047**
2	Distance from RF	-1.856	**0.040**
3	Tree density	1.397	**0.090**
4	Percentage of canopy cover	-1.222	0.119
5	Area of paddy cultivation	0.346	0.367
6	No. of water bodies	-2.266	**0.021**
7	Percentage of fruit trees	1.080	0.148
8	Percentage of *preferred* trees	1.456	**0.081**
9	Percentage of Erythrina trees	0.959	0.175

Estate area ($p = 0.047$), distance from RF ($p = 0.040$) and number of water bodies ($p = 0.021$) were significantly different in the two categories of study estates but differences in tree density ($p = 0.090$) and percentage of *preferred* fruit trees ($p = 0.081$) were significant only at $p < 0.10$.

According to the results on seasonality from FD data, jackfruit, preferred trees and paddy were tested for their influence on elephant visitation. Non-parametric correlation was used to find a relation between seasonal elephant visitation and the corresponding seasonal resource (Table VI).

Table VI: Results for non-parametric correlations to test for seasonality in visitation

S.NO	SEASONAL RESOURCE: HABITAT VARIABLE	SEASONAL VISITATION: NUMBER OF MONTHS THE ESTATE WAS VISITED	SPEARMAN'S CORRELATION COEFFICIENT	SIGNIFICANCE (*P*-1 TAILED)	KENDALL'S TAU-B CORRELATION COEFFICIENT	SIGNIFICANCE (*P*-1 TAILED)
1	Percentage of jackfruit trees	Visitation in Jackfruit season	0.098	0.341	0.079	0.337
2	Percentage of *preferred* trees	Visitation in Jackfruit season	-0.305	0.096	-0.268	0.066
3	Area of paddy cultivation	Visitation in Paddy season	0.387	**0.046**	0.307	**0.042**

Results show that the number of jackfruit trees does not influence elephant visitation during jackfruit season. However, the relationship between *preferred* trees, which is inclusive of jackfruit, and elephant visitation in the jackfruit season is significant (p = 0.096 / 0.066, 1-tailed) at $p < 0.10$. Area under paddy cultivation shows a significant relationship with elephant visitation during the paddy harvest season (p = 0.046 / 0.042, 1-tailed).

STUDIES ON COFFEE CONSUMPTION

The figures below represent proportional presence of different quantities of coffee seeds[10] in dung piles from the total sample (Figure 12a) and in the two age categories of elephants (Figure 12 b and c).

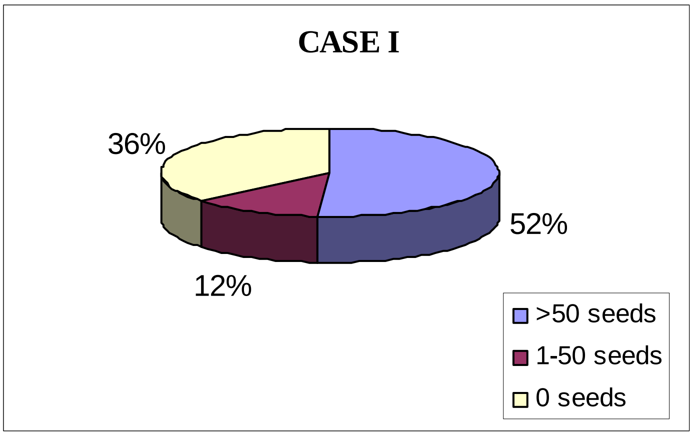

Figure 12a: Proportions of dung piles with different amounts of coffee seeds (>50, 1-50, 0) from **total sample,** N = 209

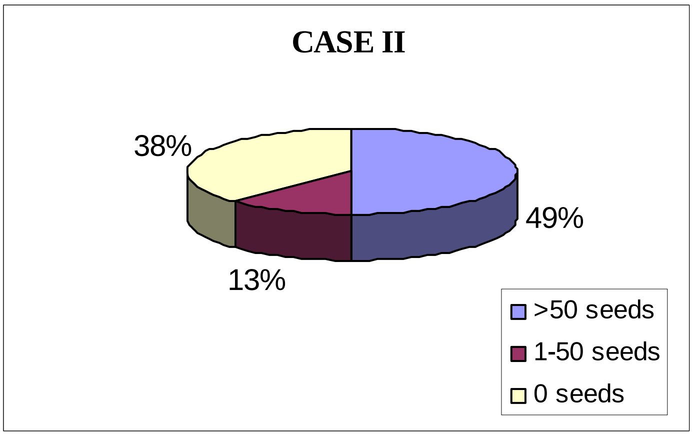

Figure 12b: Proportions of dung piles with different amounts of coffee seeds (>50, 1-50, 0) from **sample of juvenile elephants** (bolus diameter $\leq$ 10cm), N = 24.

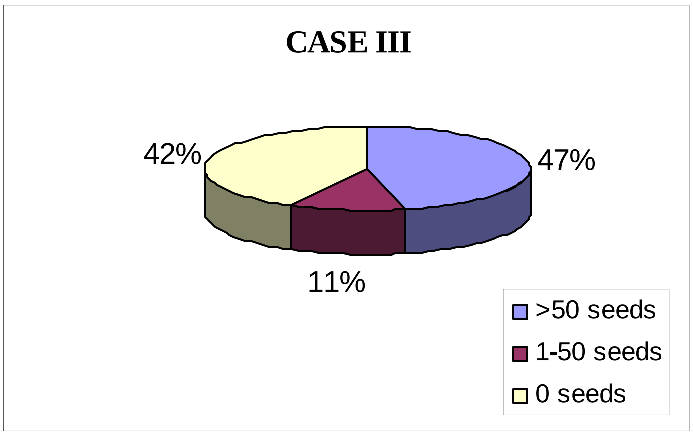

Figure 12c: Proportions of dung piles with different amounts of coffee seeds (>50, 1-50, 0) from **sample of adult elephants** (bolus diameter > 10cm), N = 123.

[10] 'Seed' represents one of the two cotyledons of the coffee fruit.

 

15 (a) 15 (b)

Figure 13 (a): Elephant dung containing > 50 coffee seeds; (b) Elephant dung with < 50 coffee seeds; cylindrical *boli* can be observed in the pictures.

Pie-charts show that in all three cases, close to 50% of dung piles contained more than 50 coffee seeds in them. Chi square tests (Table VII) were used to compare the presence of coffee seeds in the three categories to determine if:

a) Seeds were eaten by ***chance*** (test to see if 5% of the dung piles have more than one coffee seed) or
b) Seeds were present in the dung because the elephants were showing a ***strong preference*** for inclusion of coffee in their diet (test to see if 50% of the dung piles have more than one coffee seed).

Table VII: Chi-Square Conformity Test for preference for coffee; observed and expected values are for the number of dung piles with coffee seeds (62 dung piles out of the total sample of 209 could not me measured for bolus diameter and are therefore excluded from the sample considered for age categorization).

SAMPLE	N	OBSERVED NO. OF DUNG PILES WITH COFFEE SEEDS	OBSERVED %	EXPECTED %	χ^2	SIGNIFICANCE (*p*)
Case I: Total	209	133	63.64	5	1512.81	<< 0.001
				50	15.54	< 0.001
Case II: Juveniles	24	15	62.50	5	167.05	<< 0.001
				50	1.50	0.221
Case III: Adults	123	71	57.72	5	719.81	<< 0.001
				50	2.93	0.087

The test for 5% is strongly significant in all three cases. The test for 50% is significant only for the total sample set while for adults it can be considered significant at 0.10 and for juveniles it is not significant.

However the proportion of dung piles with at least one coffee seed is seen to be the same in juveniles and adults ($\chi^2 = 0.1887$, N = 147, df = 1, $p = 0.6639$) (Figure 14, Table VIII) and thus we may conclude that adults and juveniles spend similar amounts of time eating coffee berries.

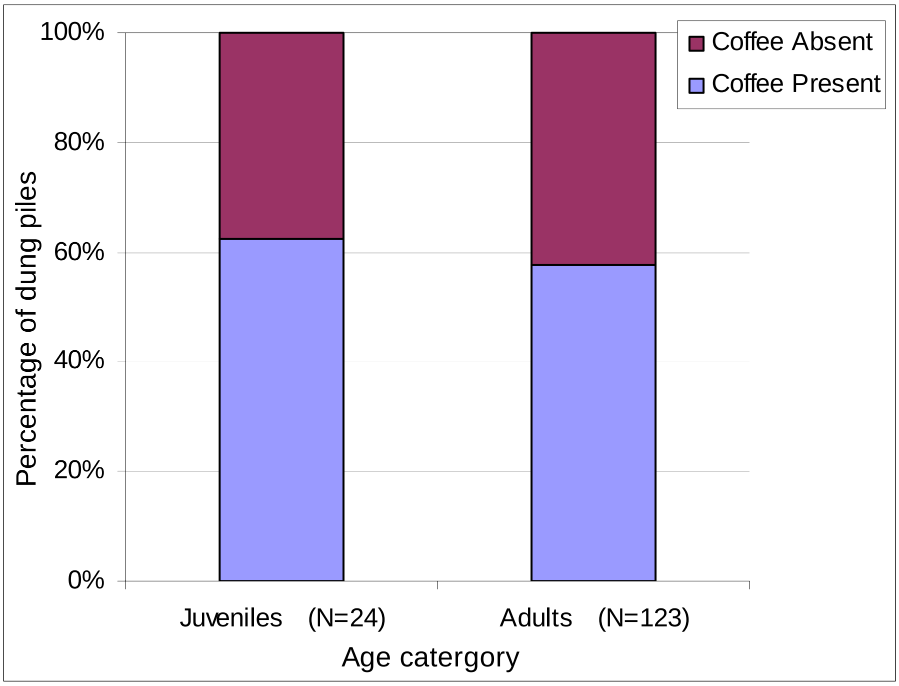

Figure 14: Comparison of time spent on feeding on coffee by juvenile and adult elephants.

Table VIII: Chi-Square Homogeneity Test results of time spent on feeding on coffee by juvenile and adult elephants.

		Age Category		
		Juveniles	**Adults**	**Total**
Presence/Absence of coffee seeds	Coffee present	15	71	86
	Coffee absent	9	52	61
Total		24	123	147
χ^2		0.1887		
Degrees of freedom		1		
***p*-value**		0.6639		

DISCUSSION

CURRENT STATUS OF HEC IN VIRAJPET

HEC level in Virajpet division has increased over the past ten years. This increase is not linear and there is high inter-annual variability maybe correlated to the local rainfall patterns but this has yet to be explored. Our study shows a significant increase in crop damage as time goes by (r_s = 0.80606, t = 3.8522, *p* = 0.0024). This result sheds new light on previous studies (Kulkarni *et al.* 2007) that found no significant increase in the number of cases in the period 1992-2004 and has considerable implications in terms of management strategies. Additional data following 2006 would show whether or not this trend is established. Monitoring must therefore continue.

Records for the last year of data collection (2006-07) highlight **seasonality** in elephant visitation to the estates. As also reported by earlier studies in Kodagu (Nath & Sukumar 1998, Kulkarni et al 2007), there are two peaks or ‘seasons’ of high elephant visitation to coffee estates in the first (June-August) and second monsoon (November-January). It appears that the peaks correspond to two distinct seasonal resources *fruit tree* and p*addy* (Table IX).

Table IX: Seasonality of some of the crop plants found in coffee estates, arranged in decreasing order of damage cases per year.

Name of crop	**Fruiting/Yielding season**
Coffee (berry)	Dec-Feb
Paddy	Nov-Jan
Banana	year round
Arecanut	year round
Coconut	year round
Orange	Dec-Jan & July-Sept
Jackfruit*	May-Sept
Mango	May-Aug

The **first peak** shows damage primarily to arecanut, banana, and coconut. However, these are permanent crops, fruiting throughout the year and hence lead us to believe that jackfruit (and possibly mango) might be the important seasonal attractant, although damage to jackfruit trees is generally not reported. Interviews during the initial phase also reported elephant visitation to be more frequent in the jackfruit season (I.8, I.11, I.12 and I.19). Other crops such as orange, cardamom, ginger and pepper could be showing a similar pattern owing to incidental damage during these months. The observed increase in coffee damage during this season may be also incidental due to the higher elephant intrusion into estates, as coffee does not ripen during this time and thus is unlikely to be the primary attractant. Alternatively, increased damage to coffee could also be due to elephants feeding on coffee leaves; however, this has not been reported or observed till date.

Figure 15 (below) shows that the total number of crop raiding cases from February to mid-September is primarily due to applications for damage in coffee estates while from mid-September to January this is due to paddy damage. The **second peak** therefore, distinctly corresponds to the paddy ripening and harvest season. There is less corresponding damage to coffee during this time due to the spatial segregation of coffee estates and paddy fields.

There is an exclusive peak particularly showing coffee damage in February which coincides with the coffee ripening season. This indicates that coffee (*Coffea robusta*) itself could also be a seasonal attractant[11]. The analysis of presence of coffee seeds in the dung (see Figure 13) shows that the elephants in this region are feeding on the berries. This is a new finding in this region, as previous studies on HEC did not report elephants feeding on coffee (Nath & Sukumar 1998, Kulkarni *et al.* 2007). The fact that coffee may not have been a part of their usual diet may explain partially the recent increase in HEC. (Elephants' feeding on to coffee is discussed later).

[11] "We can see a lot of elephants during coffee picking season." (I.19)

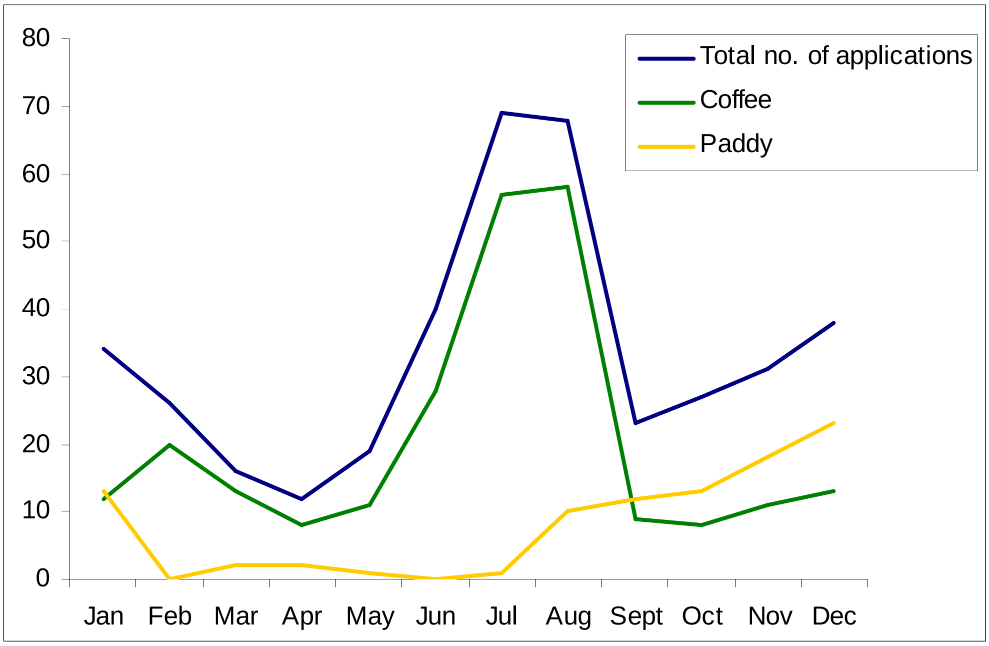

Figure 15: Comparison between total number of applications (in blue) vs. number of applications for coffee damage (in green) for 2006-07.

Our ability to verify the observed temporal pattern of visitation to estates and the possible seasonal resources causing this pattern on the basis of FD data is limited. This is because of the following reasons:

1. Five out of 16 interviewees said that they had discontinued the process of filing for compensation after an initial incidence of damage because they felt that there was a lack or delay in follow up action in spite of repeated visits to the FD (I.2, I.8, I.11, I.12, I.13). This point of view is possibly shared by other estate owners in Virajpet division such that all crop damage cases are not represented by FD applications. As a result, we derive an underestimate of crop damage (and consequently visitation) in the study area from the FD data.
2. Additionally, elephant visits to coffee estates without damage (field notes and observations) are unrecorded in the FD data. Therefore, all visitations are not represented by crop damage data, adding an additional bias (underestimation) to elephant visitation to coffee estates.
3. Coffee is the single most important cash crop in the district. As such, damage to coffee bushes will be recorded in the FD data much more accurately than damage to other crops. This creates a source of bias wherein the extent of damage to non-commercial crops may be underestimated.

4. Certain preferred fruit trees such as jackfruit and mango, which may be important seasonal attractants, are not included in FD data.
5. Coffee bushes and other plants may simply be damaged because they are in their movement path, not because they are targeted by the elephants. Incidental damages, make it difficult to clearly establish preferences for the different seasonal attractants.

CONFLICT MAP

Extent of HEC in Virajpet division has been illustrated in the **conflict map** through a mosaic of high and low conflict areas. Preliminary results show an absence of crop damage during the last 10 years for areas in the northern, central and southeastern parts of the division. Villages on the eastern side, lying close to the Devamachi RF, experience high conflict levels. We suggest that the bordering deciduous forest (as opposed to the evergreen forest on the western side) and larger corporate estates on the eastern side contribute to higher conflict in this area. The band of higher occurrence of crop raiding cases, if corroborated following the addition of the missing data, suggests a corridor of elephant movement between the eastern dry deciduous and western wet evergreen belts of the district and is congruent with previous studies (Nath and Sukumar 1998).

STAKEHOLDERS' PERCEPTIONS

Our interviews suggest that while visitations have been occurring for a long period of time, they became problematic 10 years ago. *Intensification* of HEC could mean an increase in elephant visitation in some estates or new visitations to previously unvisited estates, since some estates report the problem to be one or two years old only for them (E.15, E.18). We list the stakeholders' perceptions on the causes of this intensification based on our study and on what is described by Nath & Sukumar (1998), Kulkarni et al (2007) and Laval (2008),

Causes of HEC

Habitat Degradation: Large scale deforestation of prime elephant habitat and conversion of forest land for economic purposes has been proposed as a major cause of crop raiding leading to man-animal conflict in the world (Blair et al 1979).

Landscape changes in Kodagu can be attributed to human population growth (Figure 16).

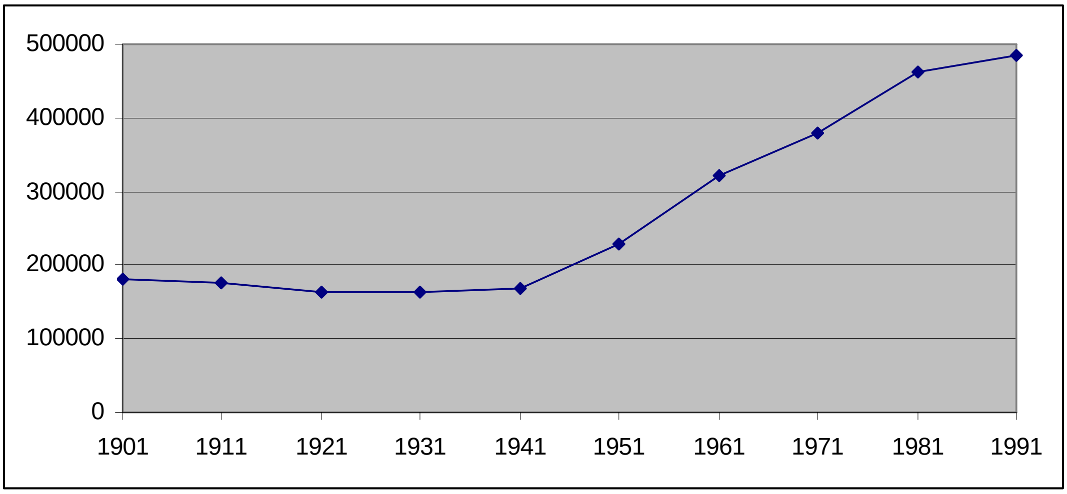

Figure 16: Population increase in Kodagu district 1901-1991 (Source: Guilmoto 2000)

Guilmoto (2000) suggests that the resulting resource depletion (which could lead to an increase in HEC) is not solely caused by a burgeoning human population but by changes in agricultural practices. Laval (2008) reported that according to the people of the area conversion of private forest ecosystems into coffee estates, felling of selected tree species, uncontrolled cattle grazing and certain agricultural practices has added to the degradation of elephant habitat, leading to scarcities in food and water.

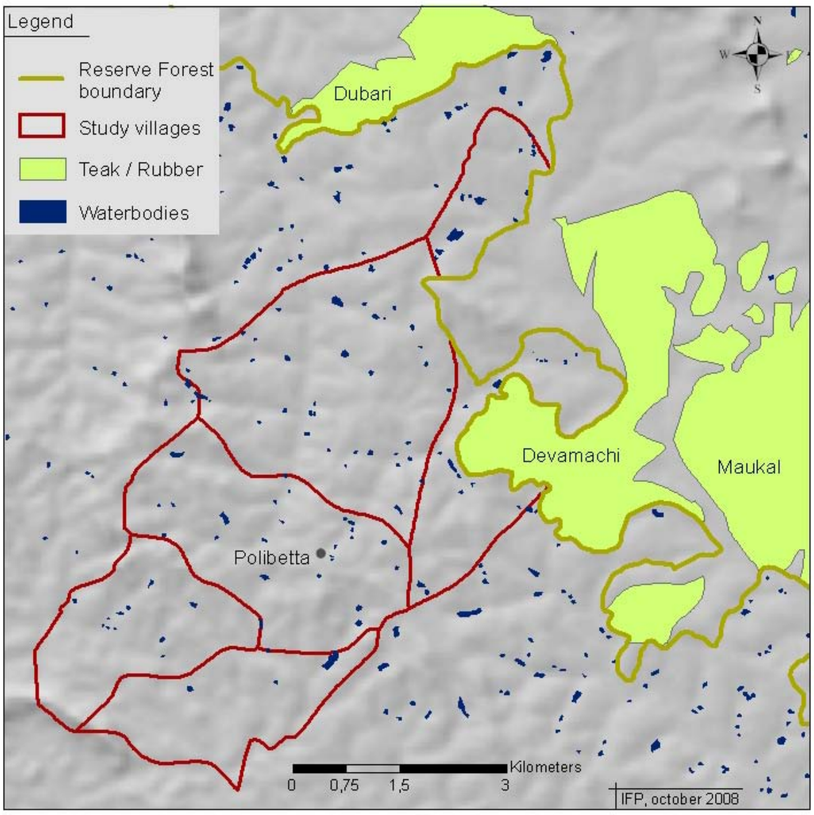

Figure 17: Location of teak plantations and water bodies in the study villages

In addition, some stakeholders expressed the view that large scale **teak** plantations in the RF of Virajpet division 100 years ago (Misra 2003) could have contributed to the current state of habitat degradation. According to them, this has driven the elephants into coffee estates in search of food. Misra (2003) shows that out of the total area of 11575.40 ha comprising the three RFs (Dubare, Devamachi and Mavkal RF) neighbouring the study area, 36.17% is under teak plantations (Figure 17). On the other hand, an NGO (*Ane Mane* Foundation) working on elephants in the area claims that based on their observations, teak plantations do not hinder elephant foraging behaviour (Gauthier, P. pers. comm.).

Even though teak could have been a cause of habitat degradation up to 1997, there has only been a 1% increase in teak plantations in the last 30 years (P.S. Ramakrishnan 2000, FIP Survey). Therefore, it seems questionable to label it as the cause for the conflict that has revealed itself primarily over the last decade.

Habitat fragmentation and a loss in tree cover over the past 30 years can primarily be attributed to expansion of coffee within the district (Elouard, 2000, Moppert, 2000) (Figure 18) which has been more significant along the western side of the district (Ramakrishnan 2000, Garcia et al. 2007) as compared to the eastern side.

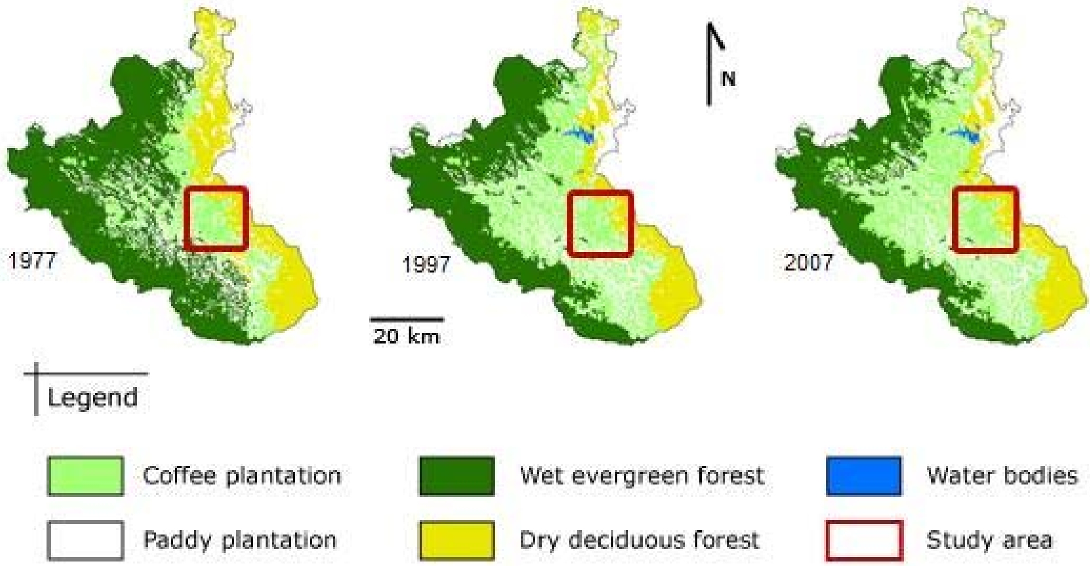

Figure 18: Landscape dynamics in the past 30 years (Source: French Institute of Pondicherry)

The eastern side of the district had already been converted into coffee and teak plantations prior to 1977. Thus, there has been no major change in land use during the last 30 years on the eastern and south eastern side of the district, which includes our intensive study area.

Fragmentation and loss of habitat could also be due to **construction of large dams** such as Harangi and Chiklihole (Boominathan et al, 2008). FIP surveys show an increase in area of large water bodies from 1977 to 1997 from 1km^2 to 19km^2 (Elouard 2000). The dams have created backwaters causing relocation of villages to corridor areas (Boominathan, pers. com. 2007). As a result, elephant encounters and damage inside estates may a result of migratory movements through estates as opposed to purposeful entry for foraging. High incidences of crop raiding by elephants in Kodagu have been recorded along the likely migration routes between eastern deciduous and western evergreen forests (Nath and Sukumar 1998: 14) and in the northern part of Kodagu i.e Kushalnagar area (Boominathan, pers. com. 2007) which now largely consist of agricultural lands with small pockets of forest.

The problem of crop-raiding may be a result of degradation and fragmentation of elephant habitat over the years, stemming from broader processes of landscape change (Mahanty 2003). As a result, the phenomenon of fragmentation may not appear to be prominent at the local scale; also probably why it was considered by only 2 of the interviewees as a cause for HEC. However it seems significant on larger temporal and spatial scales wherein expansion of agriculture over the past 100 years has compressed elephant populations into smaller forest pockets (Ratnam 1984) and interrupted established elephant movement patterns (Sukumar 1989, Nath and Sukumar 1998).

Elephant population: According to Kulkarni et al (2007), elephant population in Kodagu has significantly increased during 2002-2005 probably due to the strict protection offered to the species. An increase in elephant population in a local area could also be due to migrations from the neighbouring protected areas (Tchamba 1995).

On the other hand, it is also possible that the reduction of available habitat might have brought the population closer to the carrying capacity of the ecosystem, forcing the existing herds to enter estates in search of additional resources. Therefore, the increase in population may be a perceived rather than the actual cause of increased intrusion of elephant into estates over the last 10 years.

Elephant behaviour: Frequency and duration of elephant visitations to coffee estates as well as aggressive behaviour of elephants, all seem to have increased according to the people. Reports of increased aggressive behaviour have also been made in the Mudumalai Sanctuary, Tamil Nadu, “Local adivasis have noted that animal behaviour patterns have changed. The elephants are more angry and aggressive than ever before. Where adivasis walked confidently through the herds, now they must be careful.” (Thekaekara, The Hindu, 28July 2008). In addition, interviewees believed that the elephants had acquired a preference for coffee estates due to the following reasons:

- ***Estates are greener*:** The coffee plantations on the eastern side (the original "coffee belt" of the district), where the intensive study area was located, are derived from originally moist deciduous vegetation (P.S. Ramakrishnan 2000). It is expected, therefore that the plantations still retain some trees from the original vegetation. A study by Bhagwat et al (2005) in the south-western part of the district showed tree species compositions of coffee plantations and the nearby forest reserve to be 52% similar, while coffee plantations and nearby sacred groves were 69% similar. Moreover, coffee plantations may also contain some useful species from the evergreen forest belt such as *Artocarpus hirsutus and A. heterophyllus,* which are planted by farmers. In addition, the use of sprinklers and fertilizers inside coffee plantations may produce better grass growth during the dry season. By comparison, the RF in the eastern side of the district, though originally a mixture of moist and dry deciduous forests, is now primarily dry deciduous since most of the moist deciduous vegetation was converted to teak and coffee plantations prior to 1977 (Elouard 2000).
- ***Estates provide better forage*:** Sukumar (1990) proposed higher palatability and nutritive value of crops to have caused an increase in HEC in BR Hills, Southern India. The estates in Kodagu are also abundant in fruit trees (jackfruit, wild mangoes, banana, coconut, papaya, etc) and other seasonal and non-seasonal resources such as paddy, arecanut, etc. The fact that coffee estates offer a bundle of highly palatable, densely packed and easily accessible food resources makes them more attractive, in accordance with the optimal foraging strategy theory (Sukumar 1990). As a result, elephants are known to visit estates throughout the year. However, we need additional data from the study area for comparative studies looking at available resources in the estates and the forests to substantiate the claims made by the interviewees.
- ***Estates have perennial water supply*:** Satellite imagery (Figure 17) shows that the RF has very few water bodies compared to nearby plantations, where the water tanks often retain water throughout the year (field notes & interviews).

Some of these claims have been further investigated in the estate characterisation study.

Elephant visitation was said to have new seasonality patterns by the interviewees. This could probably due to the cumulative effect of habitat degradation, population increase and elephant behaviour, although visitation was still more frequent in the paddy and jackfruit seasons. Other innate reasons for elephant intrusion into the estates have also been proposed by previous studies such as a ‘high risk-high gain’ strategy for promoting reproductive success in males (Sukumar & Gadgil 1988). On the other hand, local people believed that crop raids in Kodagu were mainly because of family groups (Kulkarni *et al.* 2007).

Mitigation Strategies

Out of the known elephant deterrent methods (translocation, culling, chilli smoke, electric fences, EPTs, lights, loud sounds, etc) only fences and trenches were given more weight by the interviewees. But these were considered ineffective in preventing elephant intrusion into coffee estates. However, there are some fences which have been maintained well and have reduced the instances of elephant intrusion (Laval 2008, Garcia pers. com.). The cooperative fence of the Tibetan settlement in Gurupura is an example of an actively maintained, effective fence (Nath & Sukumar 1998).

Studies in Africa consider electrified fences around community enclosures to be the most effective solution(Hoare 1995), if maintained properly, in comparison to trenches, moats, stone walls, buffer crops, etc. (Nelson et al 2003). Other studies recorded a 65% decrease in crop raiding incidents in Nyaminyami district, Zimbabwe following the installation of solar fences (Taylor 1993). On the other hand no fence or barrier was found to be completely elephant proof from studies in Kenya (Thouless & Sakwa 1995, Smith & Kasiki 1999).

The performance of solar fences and EPTs therefore seems *relative* to the site, the degree of maintenance and the nature of the man-animal conflict of the area.

Role of the Forest Department

The management of HEC in Kodagu, though primarily undertaken by the FD, is also influenced by the presence of local Non-Governmental Organisations (NGO) like the Coorg Wildlife Society (CWS), various research projects, different land management regimes, presence of a large tribal population and the awareness of the local people regarding ongoing research. The FD in turn has therefore delegated some of its responsibilities of prevention of HEC by forming the Eco-Development Committees (EDC) and Village Forest Committees (VFC) as a part of the Joint Forest Management scheme (Laval 2008). For example, one of the objectives of the EDC is to manage HEC by closing the access between RFs and human habitations with solar fencing set up by the FD (Laval, *ibid*).

But the discontent among the local people with current elephant deterrent methods and compensation schemes offered by the FD has translated into a discontent with the department. Due to the reasons stated for the same, some of the interviewees (I.2, I.11, I.12, I.13) said that they had stopped approaching the FD to file claims for compensation. In addition the interviews highlight a lack of communication between the FD and the farmers. This directly translated into a lack of trust among the stakeholders which is liable to hinder any strategy that is proposed to resolve the elephant menace problem.

The local stakeholders do not seem to have yet realised the *wicked nature* (Conklin 2006) of the problem, thereby putting the blame solely on FD for any setbacks to mitigation and management of HEC. FD in turn is said to be facing financial and bureaucratic constraints at various levels of the hierarchal system due to which it is occasionally criticized (interviews, field notes and observations). It must be noted that the view point of the FD is missing from this study and thus our representation of the social aspect of the problem is currently one-sided.

"WHY ARE THE ELEPHANTS COMING INTO COFFEE ESTATES?" (ESTATE CHARACTERISATION STUDY)

Area of the coffee estate, availability of **water** and **tree density** within the estate emerge as the *proximate causes* for elephant visitation, from the results of regression analysis and t-tests. It is unexpected that our data did not show any significant relationship between frequency of visitation and percentage of canopy cover, unlike previous studies (Short 1981, Barnes *et al.* 1991, Vanleeuwe & Gautier Hion 1998, Theuerkauf et al 2000, 2001).

However, higher elephant intrusion into large coffee estates could merely be a result of greater resource capacity of these estates and we need further statistical analysis to confirm this relationship. The inversely proportional relation between tree density and elephant visitation is contrary to our expectation and the current study does not offer any explanation for this behaviour. Out of the three factors, water appears to be one of the reasons for elephant visitation into the estates. We can account for this through the statistical comparison of number of water bodies among estates and spatial comparison between plantations and the RF show that elephant visitation was most frequent in places with greater water availability.

It was also seen that elephant visitation was less in estates with higher **percentage of *preferred* trees,** (relationship was considered significant at $p < 0.10$). However, this could be a direct consequence of the stronger relationship between tree density and visitation since percentage of *preferred* trees is derived from tree density data.

It is expected that frequency of elephant visitation will decrease with increase in **distance from the RF**. However, this will not hold true in case of *corridors*, wherein the frequency of visitation within a movement corridor will be independent of the distance from the RF (Deviprasad, K.V., pers. com.). Test results do not show a strong relationship (B = 9.177E-02) with visitation. In addition, the conflict map and previous studies (Nath & Sukumar 1998) indicate the possibility of an east-west elephant movement corridor across the district, the intensive study area appears to fall within this proposed migratory route.
At the same time, if the relation is considered to be significant at 0.10 (p= 0.053), the positive slope indicates a contradictory trend such that elephant visitation increases with increase in distance from the RF (results confirmed with T-tests). This suggests that the elephants visiting the coffee estates generally do not come from the RF at all but from forest patches and other neighbouring estates. We need more data to confirm this result.

By means of the estate characterisation study we could also identify the seasonal resources responsible for the two seasonal peaks in visitation as indicated by the FD data. Arecanut, banana, coconut, erythrina along with jackfruit (and not jackfruit alone) seem to act as seasonal attractants during May-Sept, which is inclusive of the first raiding peak (June-August). Other fruit trees such as orange and mango were not considered since damage to these is relatively less compared to other fruit crops. Paddy was found to be the seasonal attractant for the second peak (Nov-Jan). Therefore, the interview and estate characterisation data help in validating FD results at a smaller scale.

The following considerations can be made to further improve the estate characterisation study:

1. The data has a lot of variability. Some factors can be considered individually in isolation of other factors such as estate size as it is possible that the other variables are a function of the estate area. A residual analysis to remove area effect could be done to improve our understanding of the estate characteristics that attract elephants into CAFs.
2. It is also possible that none of these variables work in isolation. Instead, there may be multiple factors that influence elephant visitation at any given time of the year. We therefore need to look at multi-factor analysis for the data.
3. An important factor not considered in the current analysis is that all study estates were located in high conflict region of the division. We need to expand our study through comparative sampling in low or no conflict areas.
4. The sample size is low. Expanding the data could give more confidence to the analysis.

“ARE THE ELEPHANTS EATING COFFEE?” (STUDIES ON COFFEE CONSUMPTION)

The results showed that coffee is present in considerable amounts (> 50 seeds) in approximately 50% of the samples. This suggests that elephants are choosing to eat coffee in the study area. Moreover, juvenile and adult elephants appear to feed on coffee during at least half of their total feeding time within the estates.

If the coffee found in dung piles is considered to be a ***chance*** occurrence wherein coffee was ingested while the elephants were feeding on other vegetation such as leaves, bark, grass, etc., we would expect that less than 5% of the dung piles would have one or more coffee seeds. This scenario of chance is ruled out in all three test cases (total sample set, juveniles and adults). The elephants appear to be actively ***choosing*** to include coffee berries in their diet.

The test for 50% presence of coffee further establishes a ***strong preference*** to coffee for the total sample set, such that elephants are seen to eat coffee berries during more than half of the total feeding time within the estates. This preference is less or not significant within individual demographic categories (adults and juveniles, respectively) primarily because of the smaller sample sizes. This is evident from the fact that even though the observed percentage of dung piles with coffee seeds was seen to be lower in adults as compared to juveniles, the test was significant (at 0.10) for adults and not significant (p = 0.221) for juveniles. It is expected that the test results would prove significant for both the age classes if the sample sizes are increased. Additionally, it was seen that elephant behaviour in both the age classes was similar in terms preference for coffee.

The results obtained could represent deviant behaviour of some individual elephants, a segment of the population or the entire local population of the study area and it is unclear as to which level of organization this behaviour can be attributed to.

Given the high defecation rate in elephants, of the order of 17 droppings per elephant per day (Jachmann & Bell 1984, Merz 1986, Watve 1992, Tchamba 1992, Ekobo 1995, Thererkauf & Ellenberg 2000), it could be argued that the sample of dung piles represents only a few individuals. However, this seems unlikely since the sample of 209 dung piles were observed over a three month interval and spanned an area of 5600ha. Moreover, the sample represents different age classes.

By looking at the spatial spread of dung piles (Figure 19), we see that dung piles with coffee seeds occurred at more than half of the estates sampled and do not show any spatial localization. This further strengthens our assumption that several different individuals were represented in the sample. Therefore, it is reasonable to believe that coffee feeding behaviour may be a trend in the local elephant population.

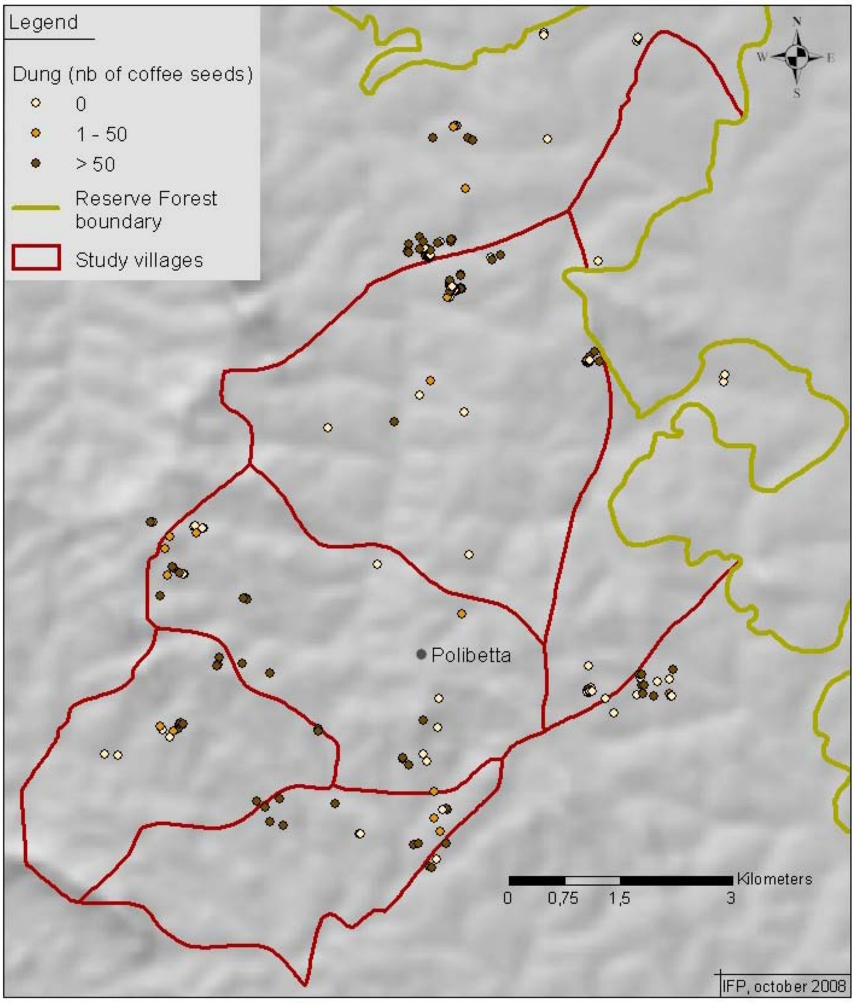

Figure 19: Location of dung piles with varying amounts of coffee seeds across the study area

It is equally likely that this behaviour can be attributed to a segment of rather than the entire population since it has been proposed that problem elephant activity may be caused by a proportion of individuals within the population (Hoare, 1999c; Hoare, 2000, Nelson et al 2003). We propose DNA analysis to further this study by finding out if dung piles with coffee seeds within the study area belong to a specific set of elephants. Hence, we will be able to establish whether only some elephants develop a ***preference*** to coffee or it is widespread trait among the local elephant population of the area. Even if currently confined to a few individuals, this novel behaviour could rapidly spread through the local population via cultural transmission and learning, which have been documented foe other behaviours by elephants (Thouless & Sakwa 1995).

CONCLUSION

HEC in Kodagu may be a result of localized spatial and temporal changes over the years that have now started to become evident at the landscape level. However besides landscape dynamics, the conflict in the district is also influenced by environmental factors, social factors and species ecology.

The development of cultivation area over the past 40 years in the district and the movement of elephants along migratory corridors or between forest patches and cultivated areas have led to the present day conflict situation in the study area. In addition established dietary preference for resources available inside coffee estates, including ripe coffee berries, is resulting in new patterns of seasonality in crop raiding. Limits of the existing mitigation strategies and the lack of coordinated action between local stakeholders also seem to have led to less than optimal management of the problem.

The multi-dimensional nature of the problem at hand makes it clear that there is no single 'end-all' solution; thereby making HEC, as is termed in management sciences, a *wicked problem*. Such a nature can primarily be attributed to the involvement of multiple stakeholders, each with a different view of the problem and its possible solution.

Thus, conflict resolution in Kodagu requires a combination of deterrent, compensating and tolerance raising strategies and the acknowledgement by stakeholders of the true nature of the problem at hand. We must first accept the fact that HEC is *likely* to be an eternal problem, as a never-ending *arms race* develops between combinations of methods and elephants' abilities to learn and habituate (Nelson *et al.* 2003).

Applying this concept could further help local stakeholders to devise alternative management strategies besides better maintenance of solar fences and trenches around large estates or community enclosures. This study, therefore, puts forth some suggestions in addition to those proposed by previous studies on HEC in Kodagu (Nath & Sukumar 1998, Kulkarni *et al.* 2007, Bhoominathan *et al.* 2008);

- **Additional research:** Though the distribution and frequency of problem elephant activity can be easily recorded, we need more precise quantitative assessment of intensity of elephant damage (Msiska & Deodatus 1991; Lahm 1996; Wunder 1997). Therefore, we suggest the use of radio collaring of elephants to track their movement and accurately record location and time of damage instances. We would also like to continue the study on elephant dung with DNA analysis studies to understand the new behavioural pattern of elephants' preference to coffee. In addition, to understand spatial and temporal trends in HEC we plan to continue to update our database for the entire district.
- **Communication:** Any activity that would focus on improving the communication between the civil society and the policy makers and enforcers is likely to help in resolving the issue since it is clear that there are problems on either side that need to be addressed jointly. We understand that it is not a lack in action that has led to the current status of man-animal conflict in Kodagu but rather the *wickedness* (Conklin 2006) of the problem that has made it impossible for the FD to achieve all the objectives set by them in the past.
- **Coffee label:** Applying the concept of *wicked problems* (Conklin 2006), this study looks at devising alternative strategies to cope with the HEC in Kodagu. One such strategy is the development of insurance schemes or an *elephant friendly coffee* label that could raise public tolerance towards elephants. We have proposed such a label, *Ane Kaapi*, to the local stakeholders keeping in mind the conservation importance and the charismatic nature of the elephant and hence it's marketing potential. If supported by the consumer, the label could help compensate the planter who suffers a higher cost of production due to damage by elephants. This can especially go a long way in helping farmers who cannot otherwise afford to implement expensive mitigation solutions. The label could also contribute towards organising stakeholders to look at the management possibilities for the region such as buying land to establish new corridors in targeted, specific areas or to jointly maintain solar fences and EPTs, among other solutions.

- **Alternative strategies:** Due to the presence of a possible corridor of elephant movement and also possible emergence of new behavioural patterns, we realise that the existing elephant deterrent methods alone will not prove to be effective in the concerned areas. We therefore need to look at a combination of adaptive strategies including deterrent, compensating and tolerance raising strategies. However, most importantly the stakeholders need to acknowledge the true nature of the problem at hand and realise that there will not be a permanent technical solution to the HEC in Kodagu.

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APPENDICES

APPENDIX 1: DETAILS OF INTERVIEWEES

CODE	INTERVIEWEE	VILLAGE	AREA OF LAND HOLDING (approx.)	SEVERITY OF CONFLICT[12]
I.1	Wildlife Researcher	_	_	_
I.2	Planter	Badaga Banangala	18.72+	very severe
I.3*	Planter	Badaga Banangala & Mekur Hosakeri	18+	very severe
I.4*	Estate worker	Basavanahalli, Chennayanakote	_	very severe
I.5*	Planter	Basavanahalli, Chennayanakote	3approx.	very severe
I.6*	Planter	Basavanahalli, Chennayanakote	8	very severe
I.7	Planter	Basavanahalli, Chennayanakote	11	very severe
I.8	Planter	Basavanahalli, Chennayanakote	5+	very severe
I.9	Planter	Chennangi	12	severe
I.10	Planter	Chennangi & Basavanahalli, Chennayanakote	14	very severe
I.11	Planter	Chennangi	22	not severe
I.12	Planter	Chennangi	25	severe
I.13	Planter	Chennangi	27	severe
I.14	Planter	Chennangi	130	very severe
I.15	Planter	Chennayanakote & Abur	6	very severe
I.16	Estate manager	Corporate Estate	860	not severe
I.17	Estate manager	Corporate Estate	950	very severe
I.18	Estate Workers	Corporate Estate	_	_
I.19	Estate manager	Corporate Estate	648	_
I.20	Estate Workers	Corporate Estate	_	_

*Interviews not considered for analysis due to lack of proper documentation

[12] Evaluation of severity was based on data obtained from the interviews and field notes of elephant damage within the estate. It is subjective estimation and is not based on cut-offs or standards.

APPENDIX 2: DETAILS OF STUDY ESTATES

ESTATE CODE	VILLAGE	ESTATE AREA (ha)	ELEPHANT VISITATION (no. of months/year)
E.1	Badaga Banangala	20.53	12
E.2	Chennangi	8.27	1
E.3	Chennangi	25.10	2
E.4	Mekur Hosakeri	38.49	8
E.5	Badaga Banangala, Mekur Hosakeri, Chennayanakote	37.56	6
E.6	Mekur Hosakeri, Chennayanakote, Chennangi	44.03	12
E.7	Mekur Hosakeri	4.72	2
E.8	Mekur Hosakeri	446.96	12
E.9	Badaga Banangala	367.92	12
E.10	Hosur	382.99	12
E.11	Mekur Hosakeri, Chennayanakote	20.15	2
E.12	Chennangi	7.57	2
E.13	Chennangi	15.32	2
E.14	Chennayanakote	9.71	4
E.15	Chennayanakote	17.44	1
E.16	Chennangi	3.36	1
E.17	Badaga Banangala	10.06	12
E.18	Badaga Banangala	1.74	1
E.19	Hosur	23.43	10
E.20	Bettageri	14.87	12

APPENDIX 3: CHI-SQUARE TEST FOR COMPARING STUDY SAMPLE TO ELEPHANT CENSUS ESTIMATES.

Comparison of ratio of juvenile to adult elephants in the sample to the estimated ratio (according to the 2005 KFD elephant census) for the population:

		Age Category		**Total**
		Juveniles	**Adults**	
Number of dung piles	Observed frequency	24	123	147
	Expected frequency (acc. To KFD census, 2005)	28.44	118.54	146.98
χ^2	0.8622			
Degrees of freedom	1			
***p*-value**	0.3531			

The proportion of juvenile to adults in the population corresponds to that considered in the sample.

APPENDIX 4: QUESTIONNAIRE

Date:

QUESTIONNAIRE FOR STUDY ON *ELEPHANT VISITATION TO COFFEE ESTATES***							
***For this particular study, visitation implies elephant entry into the estates with or without damage being caused**							
Name: Village:							
I. Details of elephant visits:							
1	Are the elephants visiting your estate?	Yes	No				
2	When was the **last** (most recent) visit?	This week	Past week	Last month (Jan 2008)		Last year (Jan2007-Dec2007)	
3	Details about the last visit:						
a	Was it a direct sighting or a report?	Direct sighting		Reported			
b	How many elephants were there?	Single	Less than 3	More than 3	With calves	Tusker	Other
c	What time of the day did they visit your estate?	Morning	Afternoon	Evening	Night		
d	How long did they stay inside your estate?	Less than 2 hrs	More than 2 hrs	Overnigh t	Don't know		
e	Was this last visit different from what you've previously experienced in any way?						
f	Was there any damage caused?	Yes	No				
g	If yes, what kind of damage was caused?	Coffee	Equipment	Food plants of the elephant		Non-food plants of the elephant	
4	Apart from the above, any visits over the last month?	Yes	No				

5	Any visits over the last year (i.e. from January 2007-December 2007)?	Yes	No				
6	Please tick the months in which elephants have visited your estate?	Jan	Feb	Mar	Apr	May	June
		July	Aug	Sept	Oct	Nov	Dec
7	How frequent were the visits last year?	More than 4/month		Less than 4/month			
8	Since when did the elephants start coming into your estate more frequently?	Past 1 year	Past 5 years	Past 10 years	Past 20 years	They were always coming	
9	Did the elephants eat any part of the coffee plant in your estate?	Yes	No	Don't know			
10	Have you seen calves inside your estate?	Yes	No				
11	Were there any calves born in your estate last year?	Yes	No				
II. Details of the estate:							
1	Survey number/numbers included in the estate area						
2	Size of the estate	Less than 4 hectares (or 10 acres)		4-10 hectares (or 10-25 acres)		More than 10 hectares (or 25 acres)	
3	Number of people working in the estate during each quarter last year	Jan-March	Apr-June	July-Sept	Oct-Dec		
4	How many acres of each do you grow?	*Robusta* Coffee					
		Arabica Coffee					
		Paddy					
		Cardamom					
5	How many trees do you have of the following (tick the appropriate coloumn):	None	Less than 5	5 to 10	more than 10		
a	Jackfruit						
b	Coconut						
c	Banana						

d	Papaya						
e	Arecanut						
f	Orange						
g	Guavas						
h	Dadup (*Murukke*)						
i	Teak						
j	*Balanji*						
k	*Tadchil*						
l	*Atti*						
m	Pine (*Patt*è)						
6	Do any of your immediate neighbours have paddy fields adjoining your estate?	Yes	No				
	If yes, how many acres of adjoining paddy field?						
7	How many water tanks do you have inside your estate?						
	Please specify approximate size (area) and how old these water tanks are:		Size of water tank		Age of water tank (years)		
		1)					
		2)					
		3)					
		4)					
		5)					
8	Do any of these tanks have water during the dry season?	Yes	No				
9	Do you irrigate your plantation?	Yes	No				
10	How many times was weeding done last year in your estate?						
11	What month was the last weeding done?						
1	Have you used chemical weedicides? (specify month/months)	This year		Last year		Not used	

2							
13	How many times was fertilizer application done last year?						
14	What kind of fence do you have around your estate?	Live plants	Wire	Electric/Solar		I don't have any fence	
15	Does the fence help reduce elephant visits?	Yes	No				
16	Are there electric fences maintained by your immediate neighbour?	Yes	No				
17	Is there a *kaadu* next your estate?	Yes	No				
	What type of *kaadu* is it?	*Devara-kadu*	*Baane*	*Urudve*	Reserve Forest	Wildlife Sanctuary	National Park
	How far is the *kaadu* from your estate?						
18	Was there a forest fire in the nearby *kadu* last year?	Yes	No				
19	Is there a *kaadu* within your estate?	Yes	No				
	What type of *kaadu* is it?	*Devara-kadu*	*Baane*	*Urudve*	Reserve Forest	Wildlife Sanctuary	National Park
	How big is this *kadu*?						
20	Is there a fence along the edge of the nearest *kadu*?	Yes	No				
	If yes, what kind of fence is it?	Live plants		Wire		Electric/Solar	
	Is it in working condition?	Yes	No				
21	Is there an EPT along the boundary of the *kadu*?	Yes	No				
22	What measures do you adopt/ have you adopted in the past to prevent elephant damage?						
23	What measures would you like to try (if any) to prevent elephant damage?						
24	Any additional details you would like to give regarding the topic						

LIST OF FIGURES

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LIST OF ABBREVIATIONS

BWS	:	Bhramagiri Wildlife Sanctuary
c.	:	approximate
CAFs	:	Coffee Agro-forestry Systems
CITES	:	Convention on International Trade in Endangered Species of Wild Fauna and Flora
DCF	:	Deputy Conservator of Forest
EDC	:	Eco-Development Committee
EPT	:	Elephant-proof Trench
FAO	:	Food and Agriculture Organisation
FD	:	Forest Department
FIP	:	French Institute of Pondicherry

gbh	:	girth at breast height
GIS	:	Global Information System
GPS	:	Global Positioning System
HEC	:	Human-elephant conflict
IUCN	:	International Union for Conservation of Nature
KFD	:	Karnataka Forest Department
NNP	:	Nagarhole National Park
PQC	:	Point Quadrat Centre (data collection point)
RS	:	Remote Sensing
Sp.	:	species
VFC	:	Village Forest Committee