Final report

Effect of habitat fragmentation on Asian elephant (*Elephas maximus*) ecology and behaviour patterns in a conflict-prone plantation landscape of the Anamalai hills, Western Ghats, India

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Executive summary

In human altered elephant habitats, understanding ecological and behavioural adaptation of elephants is essential to mitigate human-elephant conflict and conservation of elephants. This study on Asian elephants (*Elephas maximus*) was conducted between April 2004 and May 2005 in the plantation landscape of the Valparai plateau within the Anamalai_Parambikulam Elephant Reserve. This elephant reserve is a home for second largest elephant population in India and contains 6% of total elephant population in India. The Valparai plateau is an enclave of plantations embedded in the protected areas of the Anamalai hills. In this study, two individually identified elephant herds called the Monica and the Step-ear herds were followed over a period of one year to study elephant use of fragmented habitats, distributional range, their behavioural responses of to human activities, and human-elephant conflict on the Valparai plateau.

The study revealed that there is a significant difference in use of habitats by the Monica and Step-ear herds. In the dry (December – May) and wet seasons (June – November) both herds seem to prefer natural vegetation in rainforest fragments and riparian habitats with high percentage than *Eucalyptus*, coffee, and tea habitats which are the dominant habitats on the Valparai plateau. In the absence of rainforest fragments or fewer rainforest fragments in the distributional range of elephants, *Eucalyptus* habitat seem to be the most preferred refuges for elephants on the plantation mosaic of the plateau. There was high concentration of elephant sightings along Nadu ar and Sholayar Rivers which run through the middle of the plateau. This is an important corridor for elephants on the plateau. The Monica and Step-ear herds did not seem to differ much in terms of their distribution, covering areas of around 11,000 and 10,700 hectares of the plateau respectively. The overlap range between these two herds seems to be around 8,700 hectares. In a gird based analysis on distribution conflict incidents in relation to forest cover showed that human-elephant conflict incidents are less in areas where percentage of forest is high. The Monica herd did not show any regular pattern of movement in dry and wet seasons where as the Step ear herd moved mostly in north and north eastern parts during the wet season, and in south and centre of the plateau, the herd showed regular movement during the dry season to move between rainforest fragments.

In human dominated elephant landscapes behavioural understanding elephants are essential for the management of human-elephant conflict and to promote coexistence between people and elephants. I studied behaviour of elephants in different habitats and human impact on the behaviour of elephants in the Valparai region. The results revealed that both herds exhibited high percent of feeding in riverine habitat but movement was more in *eucalyptus* habitat for the Monica herd and the Step-ear herd showed high percent of movement behaviour in tea habitat. However, alert behaviours such as stretching ears, threat signals, freeze etc., were noticed more in tea and swamp habitats which are largely surrounded by tea habitat and human activity in such habitats are also high. Results on impact of human pressure on threshold levels of elephant's tolerance to human presence indicated that more than 10 people in close vicinity of elephants increased alert, assurance and avoidance behaviours in both herds. The study also suggests that at least a minimum of 30 meters or above distance should be maintained between people to reduce alert and avoidance behaviours in elephants. There is a gradual increase in feeding, resting behaviours as number of people are less than 10 and the distance was beyond 50 meters between people and elephants.

Human-elephant conflict incidents spatially distributed across plantations, but are high in the middle of the plateau. Human-elephant conflict is mainly due to damage to ration shops and noon meal centres in schools which are run by state Government to provide food for school children. More number of conflict incidents was noticed inside tea habitat than in coffee habitat on the Valparai plateau. Monica herd caused more damage to property than Step-ear herd. Temporally, two peaks were observed in the pattern of conflicts and resultant monetary cost of damages. The first peak was around June and September and second peak was noticed between November and March. High number of conflict incidents

was noticed to residential places which are close to ration shops and noon meal centres. Negligible amount of damage was noticed to crops. Areas close to sanctuary boundary have less number of conflict incidents than areas which are away from the protected area. The study suggested immediate shifting of ration shops to isolated places as far as minimum 300 meters away from human colonies. This may help reduce direct counters with elephants and damage to houses on the Valparai plateau. Conflicts were distributed temporally across months. There are two conflict peaks noticed due to Monica and Step-ear herds during the study period. More number of conflict incidents and costs were noticed from June to September and November to March.

Mitigating human-elephant conflict on the Valparai plateau requires multidimensional approach. Management of conflicts should consider log term conservation strategies such as protection and improvement of natural vegetation in rainforest fragments and riverine habitats, avoid harassment of elephants, better communicating system about elephant presence in estates, and educating the public and awareness programmes with regard to elephant behaviour and undesirable consequences of harassment. Short term conservation strategies include shifting of ration shops away from human colonies, better storage facilities of ration, experimental study on elephant responses to conflict mitigating methods such as trip wire alarm system and installation elephant warning system, etc. Results of this study are useful in identifying sensitive areas of conflict and to develop suitable conflict mitigating measures for conservation of Asian elephants on the Valparai plateau.

Chapter 1. Project background

The Asian elephant (*Elephas maximus*) is a globally endangered species, listed within India in Schedule 1 of Wildlife (Protection) Act of 1972 (Anonymous 1994). The Anamalai hills (in local language, Tamil: elephant hills) in the Anamalai-Parambikulam elephant reserve in the Western Ghats is an important elephant conservation area believed to hold the second largest elephant population in India with around 1,500 elephants in an area about 5,700 km² (Sukumar 1989, Desai 2000). Within this region, human-elephant conflict is a conservation concern in a 220 km² enclave of private tea and coffee plantations amidst mid-elevation rainforests on the Valparai plateau. The present study builds on prior ground work (Kumar *et al.* 2004) to comprehensively address causes of human-elephant conflict in relation to elephant ecology and behaviour, in order to devise appropriate conservation management measures. Few studies on Asian elephants have integrated ecological and behavioural aspects within a landscape perspective and the present study aims to add to the growing efforts in this arena.

Conservation issue

The Valparai plateau is an island of plantations embedded in the middle of protected areas within the Anamalai-Parambikulam elephant reserve, adjoining the Indira Gandhi Wildlife Sanctuary (Figure 1.1). The Valparai plateau has been historically used by elephants (Congreve 1942) and continues to be used by elephants to move between surrounding

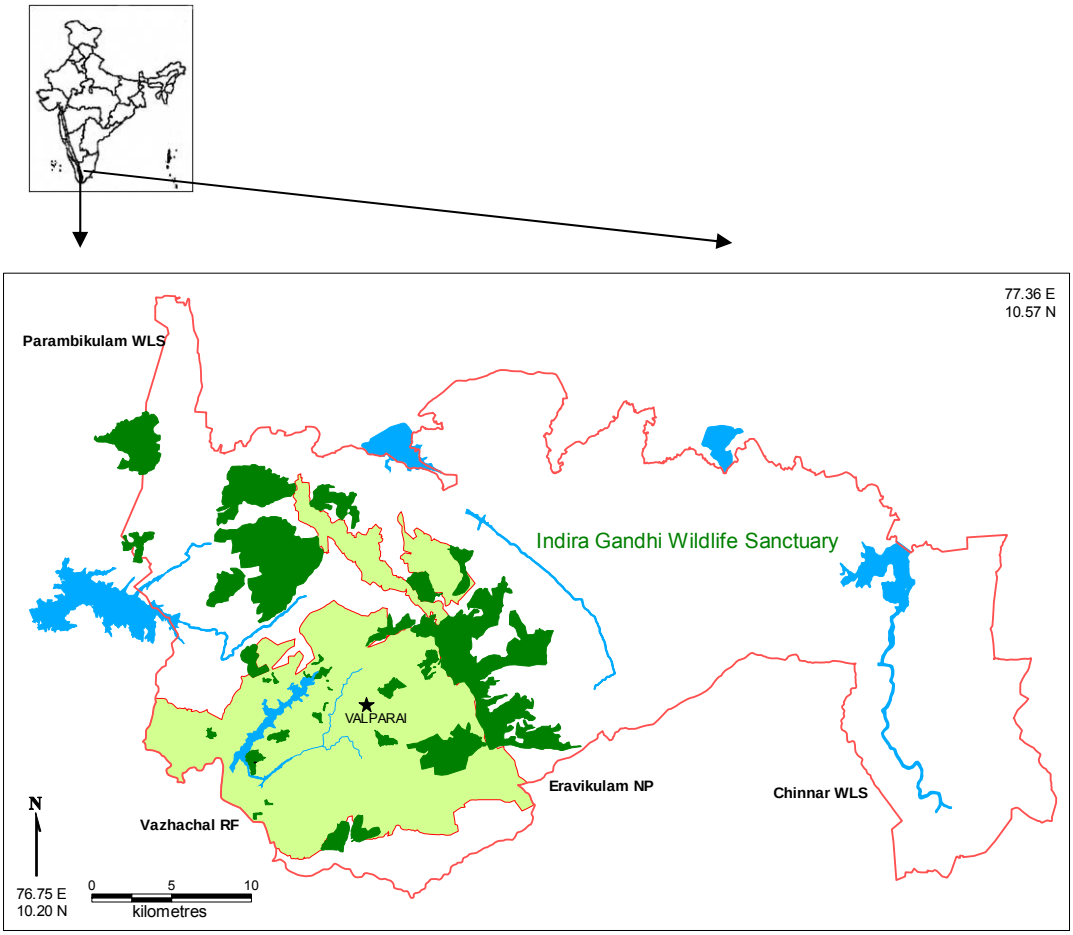

Figure 1.1. Map of the Valparai plateau with plantations (light green), rainforest fragments (dark green), and surrounding protected areas.

protected forests. Our previous study (Kumar *et al.* 2004) revealed that elephant herds move across the Valparai plateau using tea and *Eucalyptus* plantations, rainforest fragments, and riverine forests. In the Valparai plateau, human-elephant conflict is mainly in the form of damage to properties (rooms, stores) where food grains such as rice, lentils, and sugar are stored. Damage to crops is negligible as elephants as do not feed on tea which is the most dominant crop on the plateau. Most of the conflict incidents are caused by family herds in contrast to other places where higher proportion of conflicts are due to adult bull elephants (Sukumar 1990, Nath and Sukumar 1998). Several hundred scattered human settlements on the plateau occur along elephant movement routes, especially close to water sources. This results in frequent encounters of elephants with humans, leading to trauma and loss of human lives (on average 2-3 people per year) and the harassment and death of elephants.

Addressing this issue requires (a) knowledge of ecological and behavioural factors influencing conflict, (b) understanding landscape-level correlates of elephant ecology, behaviour, and conflict incidents, and (c) influencing people's awareness and attitudes to elephants utilizing the landscape. This requires information on elephant use of habitats especially in relation to forage availability and ranging, on elephant behaviour in the vicinity of people and settlements, and on the responses of people to elephants. Possible learning of raiding behaviour by young animals also needs to be investigated as it has long-term consequences. This project aimed to gather such pertinent information relevant for elephant conservation and management on the Valparai plateau. Specifically, within this fragmented plantation landscape, it aimed to:

1. Assess the seasonal use of rainforest fragments and other landscape elements by two identified Asian elephant herds,
2. Study the movement patterns of the two elephant herds,
3. Investigate the impact of human disturbance on behavioural patterns of elephants, and
4. Study the spatial and temporal distribution of human-elephant conflict incidents.

Study area and focal herds

The Anamalai-Parambikulam elephant reserve in the Anamalai hills in an important conservation area for Asian elephants. From the 1890s onwards, nearly 220 km² of mid-elevation rainforests in the gentle undulating plateau region in the Anamalai hills, around the present town of Valparai, were clear-felled for establishing plantation crops like tea, coffee, and cardamom (Congreve 1942). This resulted in the creation of around 40 rainforest fragments (Umapathy and Kumar 2000, Mudappa and Raman *in press*) varying in size from 0.3 ha to 2600 ha among the tea, coffee, and cardamom estates in the Valparai plateau. Today, human habitations are spread all over the plateau and the human population density is about 500/km² in the 220 km² Valparai plateau area. The commercial plantations on the plateau are mostly owned by six major companies and a host of smaller estates. The plateau is surrounded by several wildlife sanctuaries, national parks, and reserved forests. The natural vegetation in this region, receiving around 3,500 mm of rainfall annually from both southwest and northeast monsoon, is classified as mid-elevation tropical wet evergreen forest of the *Cullenia-Mesua-Palaquium* type (Pascal 1988). The altitude in the Valparai plateau ranges between 1,000 to 1,450 m above sea level. Most of the Valparai plateau is enclosed by Indira Gandhi Wildlife Sanctuary (987 km², 10° 12' N to 10° 35'N, and 76° 49' E to 77° 24'E (Figure 1.1). For the purposes of this study, the six month period from June to November is considered as wet season whereas the period from December to May is considered as the dry season.

This study focussed on two elephant herds called Monica and Step-ear herds (Table 1.1), whose home range includes the plantation area of the Valparai plateau. I investigated seasonal variation in distribution and habitat use, and differences in behaviour between the Monica and Step-ear herds.

Table 1.1. Age-sex distribution and herd size of Monica and Step-ear herds

Age-sex class	Monica herd	Step-ear herd
Adult female	3	10
Adult male	1	0
Sub adult female	0	1
Juvenile female	1	2
Juvenile male	1	1
Calves	2	4
Total	8	18

Chapter 2. Spatial patterns of elephant distribution and habitat use

Introduction

One of the main factors that govern the distribution of wild species is the richness and distribution of resources in natural habitats. Habitat loss, degradation, fragmentation, conversion, and natural resource exploitation due to human activities result in the reduction of available habitat. Fragmentation, in particular, often restricts wild fauna to islands of forest fragments (Laurance and Bierregaard 1997). Wide-ranging animals such as Asian elephants (*Elephas maximus*) are threatened by many such human activities. The juxtaposition of plantations and forest patches in and around the Valparai plateau influences elephant use of fragmented habitats, their movement, and conflict with people living in the landscape. Besides the density and movement patterns of elephants themselves, landscape variables such as spatial heterogeneity of vegetation cover (Murwira and Skidmore 2005), seasonal change in resource availability (Santiapillai *et al.* 1984), human density (Caro 1999, Hoare and Du Toit 1999), may also influence patterns of conflict. In the context of the Valparai plateau, it is essential to examine the use of various habitats such as tea, coffee, *Eucalyptus,* riverine forest, and rainforest fragments by elephant herds. In this project, I studied two herds of Asian elephants that regularly use much of the Valparai plateau. Based on the results obtained, I discuss implications for the management and conservation of Asian elephants in this region.

Objectives

The main objectives of this part of study on the Valparai plateau were to:

1. Assess the elephant use of rainforest fragments and other landscape elements,
2. Determine seasonal use of landscape matrix by identified elephant herds, and
3. Estimate the distribution of elephants and conflict incidents in relation to spatial pattern of forest cover.

Methods

Tracking of elephants

Direct surveys and information from local informants were used to detect elephants within the plantation landscape of the Valparai plateau. Once an elephant herd was found, the same herd was followed on subsequent days until the herd moved out of the private plantations into the surrounding sanctuary. Tracking of elephants was done using GPS (Geographical Positioning System, Garmin 12 XL) readings for every 500 m or less along the path/movement route used by the herd through the estates (Kumar *et al.* 2004). For every GPS location, I recorded date, season, time of the day, estate name, habitat, surrounding habitat within 500 metres, and the approximate distances to nearest human colony, forest fragment and *Eucalyptus* patch within a radius of 1 km.

Spatial pattern in forest cover and elephant distribution

Grids of 2 x 2 km were marked over the study area using Survey of India 1: 50,000 topographic sheets, digital maps, and MAPINFO Professional 7.0 computer software. All fragments which were mapped in our earlier work were overlaid on the grids. In each grid cell, the percent of forest and non-forest area was calculated by clipping forest and non-forest areas that falls within each grid, using Arc View GIS 3.2 software. In order to minimise biases due to spatial autocorrelation where multiple GPS locations were obtained on the movement route of a herd on the same day, I selected at random one daytime and one night-time location for days when multiple locations were available. These were overlaid on the grid map to obtain the frequency of elephant herd locations in each grid. For the purpose of

analysis, the percentage of forest cover in each grid used by the Monica and Step-ear herds was related to the frequencies of use in the respective grids. This preliminary grid-based analysis requires to be complemented by rigorous spatial regression analysis to estimate the role of non-forest and forest cover on elephant use and conflicts.

Results

Use of fragmented habitats

The fragmented mosaic of the Valparai plateau is dominated by monoculture plantation of tea, coffee, and *Eucalyptus*. However the landscape includes a lattice of habitats such as rainforest fragments, riverine vegetation, and grassy patches, which are important habitats for elephants on their movement through the plateau. Of the total of 184 and 137 locations (Figure 2.1) for Monica and Step-ear herds, respectively, both herds used rainforest fragments relatively frequently (35.9% and 26.3%, respectively) than plantations of coffee, tea, and *Eucalyptus*. Tea, the dominant crop on the Valparai plateau, is used 15.2% and 21.9% by Monica and Step-ear herds, respectively. However, usage of natural vegetation in fragments and along streams together contributed 54.9% for the Monica herd as compared to plantations (36.5%) whereas the Step-ear herd used plantation habitat more frequently (61.3%) than natural vegetation (36.5%). There is a statistically significant difference (χ^2 = 24.23, df = 7, P < 0.05) in the use of habitats between Monica and Step-ear herds, which is contributed by a higher percentage use of *Eucalyptus* (24.8%) by the Step-ear herd than the Monica herd (9.8%).

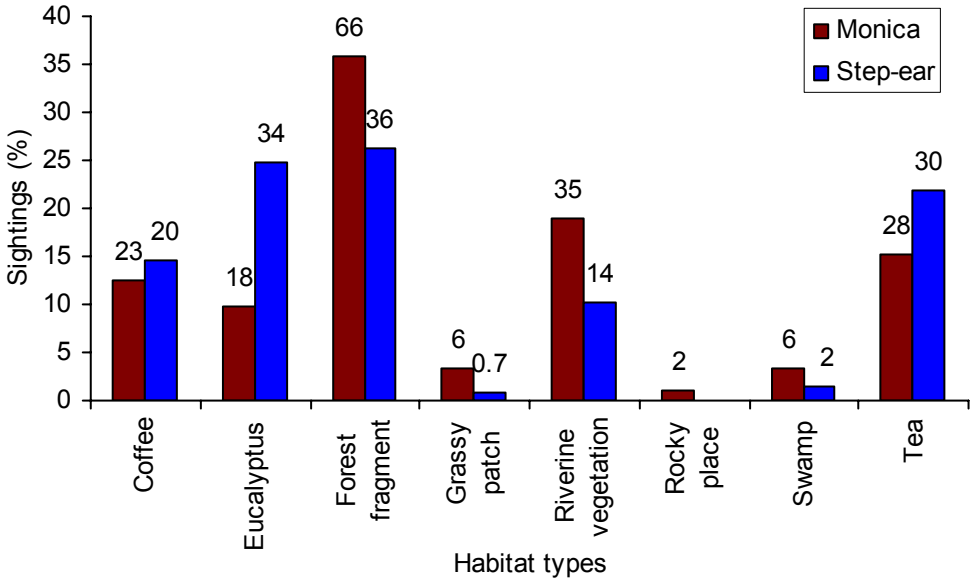

Figure 2.1. Use of different habitats by Monica and Step-ear herd on the Valparai plateau

Seasonal use

Differences between the two focal herds in habitat use emerged when data were analysed by season (Table 2.1). During the dry season, the Monica herd used natural vegetation relatively more often (58.9%) than the Step-ear herd (37.9%). In contrast, the Step-ear herd used plantation habitats such as coffee, *Eucalyptus*, and tea more frequently (60%) as compared to the Monica herd (35.6%). However, there was no statistically significant difference found between Monica and Step-ear herds in use of habitats during the dry season. During the wet season also there was higher usage of natural vegetation (50%) by the Monica herd than the

Step-ear herd (35.4%), with the latter showing higher use of plantation habitats (60%) than the Monica herd (39.4%). The usage of habitats differed significantly between the two herds during the wet season (Table 2.1).

Table 2.1. Comparative use of habitats by focal herds during the dry and wet seasons

Dry season (%)			**Wet season (%)**		
Habitat	**Monica**	**Step-ear**	**Habitat**	**Monica**	**Step-ear**
Coffee	15.6	22.4	Coffee	9.6	8.9
Eucalyptus	7.8	13.8	*Eucalyptus*	11.7	32.9
Forest fragment	35.6	24.1	Forest fragment	36.2	27.8
Riverine vegetation	23.3	13.8	Riverine vegetation	14.9	7.6
Rocky place	2.2	0.0	Grassy patch	6.4	1.3
Swamp	3.3	1.7	Swamp	3.2	1.3
Tea	12.2	24.1	Tea	18.1	20.3
Number of locations	90	58	Number of locations	94	79
χ^2 (*df, P*)	9.88 (6, <0.25)		χ^2 (*df, P*)	15.52 (6, <0.05)	

Spatial pattern of elephant distribution

A total of 79 grid cells of 2 x 2 km overlapped with the 220 km² of plantations on the Valparai plateau (including adjoining protected forests for peripheral grids). Movement of the Monica herd and Step-ear herd locations were plotted on the grid map of the Valparai plateau to calculate the home range area within the Valparai plateau using a 100% minimum convex polygon. The home range of both elephant herds within the plateau spanned a major part of the plateau (Figure 2.2) but most sightings of elephants were towards the centre of the plateau. However there are some areas bearing the grid numbers 56, 57, 65, 66, and 74 which have mostly coffee and *Eucalyptus*, were exclusively used by the Monica herd. Whereas areas bearing the grid numbers 94 and 95, which are dominated by *Eucalyptus* plantations towards the north east part of the Valparai plateau, were used by the Step-ear herd. According to the minimum convex polygon method the total home range of the Monica herd within the Valparai plateau is 11,254 hectares, spanning 40 grids on the map. The Step-ear herd has a home range of about 10,700 hectares within the plateau, covering 36 grids. The range overlap between the two herds is estimated to be 8,785 hectares within the plateau, covering 31 grids.

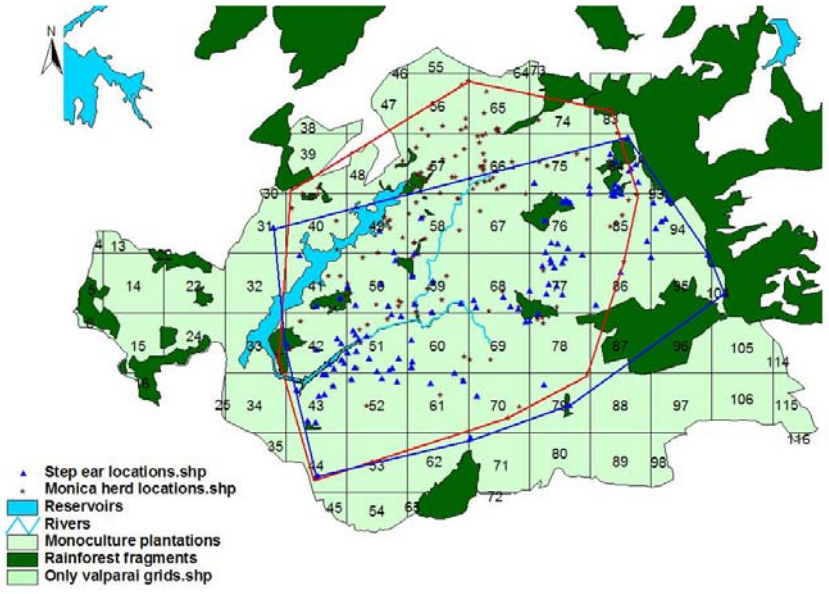

Figure 2.3. Distribution of locations of the Monica herd (in red) and Step-ear herd (in blue) and their home range (100% minimum convex polygon) on the Valparai plateau.

Spatial pattern of conflicts

The grid cells used by the Monica herd (40) and those used by the Step-ear herd (36) were considered for separate analyses of herd distribution in relation to forest cover within those grid cells. The number of conflict incidents decreases in relation to increase in forest cover (Figure 2.2). For both herds, most grid cells with two or more incidents of conflict contained less than 10% forest cover.

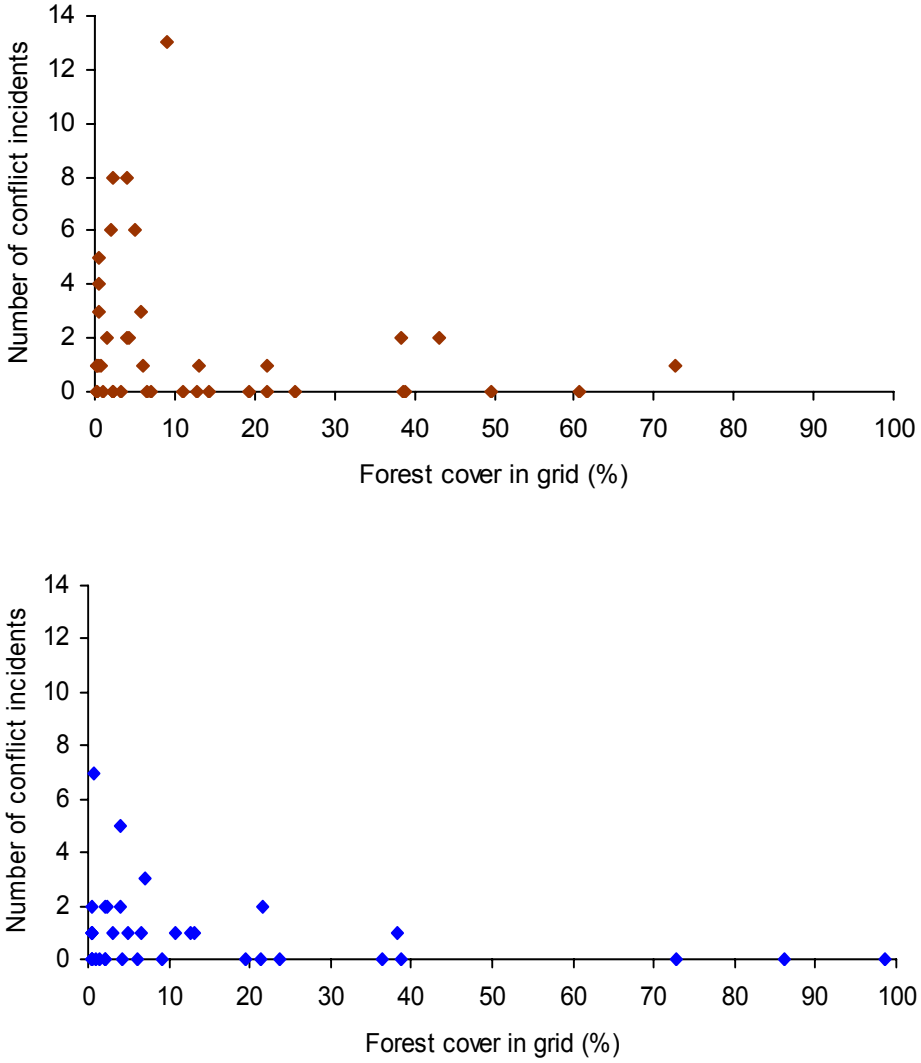

Figure 2.2. Incidence of human-elephant conflicts in relation to forest cover in the Monica herd (upper panel) and Step-ear herd (lower panel).

Seasonal ranging pattern

For the Monica herd, of the total 184 locations during the one-year period, 90 and 94 locations of elephant sightings were recorded during the dry (December – May) and wet (June – November) seasons, respectively. Monica herd moved in areas largely dominated by coffee towards northern part of the plateau during the dry season, whereas during the wet season, movement appears to be higher in the north and middle of the plateau along the Nadu ar and Sholayar rivers.

For the Step-ear herd, of the total 137 locations (Figure 3), 58 and 79 locations were during the dry and wet seasons, respectively (Figure 2.3). There seems to be a clear pattern in the herd movement between the dry and wet seasons. During the dry season, the herd frequents the centre of the plateau along the Nadu ar and Sholayar rivers, covering grid

numbers 42, 43, 50, 51, 52, 59, 60, and 69 and about 32 km² area. During the wet season, the herd moved in the northeast part of the plateau, covering grid numbers 58, 75, 76, 77, 84, 85,86, and 94, in an area of about 32 km².

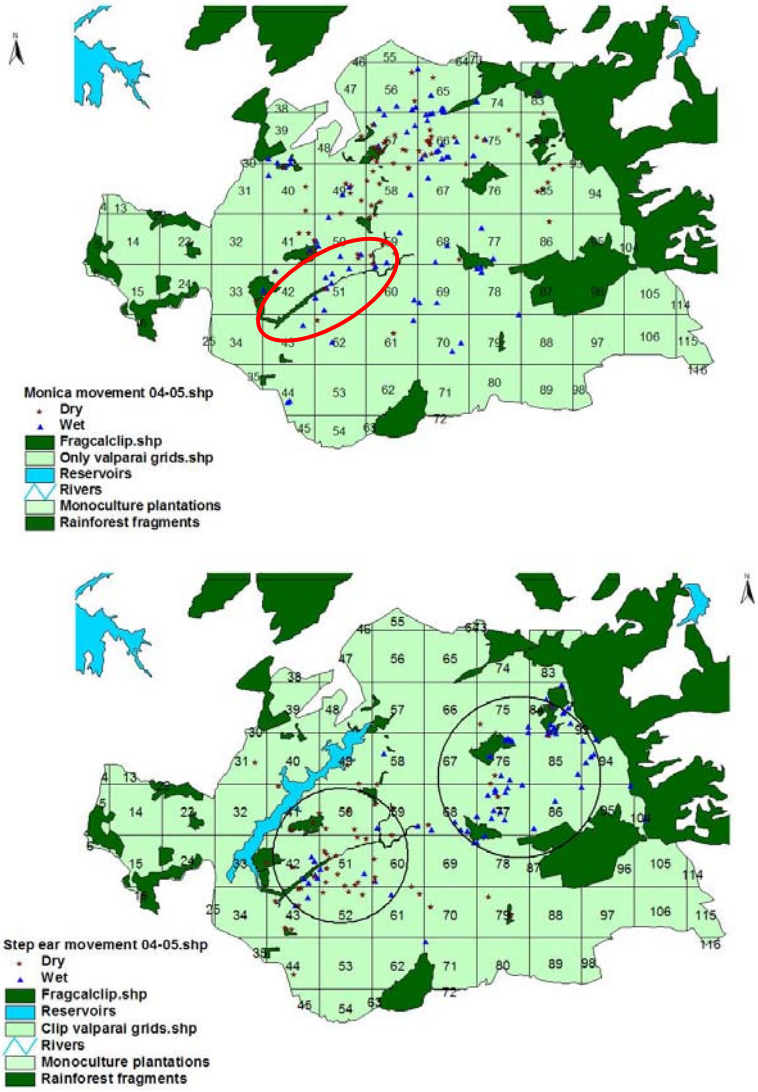

Figure 2.3: Seasonal movement and distribution of focal elephant herds on the Valparai plateau: Monica herd (upper panel), and Step-ear herd (lower panel). The red circle indicates the Sholayar river.

Distribution of elephants in relation to distance from rainforest fragments

Distance of nearest rainforest fragment for the GPS locations of each elephant herd was calculated for various distance categories (Table 2.2). Of the total 112 and 138 locations for Monica and Step-ear herds, respectively, the former tended to be found closer (1-100 m) to forest fragments more than twice as often as the latter did. Statistically there was a significant difference ($\chi^2 = 11.28$, $df = 2$, $P < 0.005$) between the herds in their distribution in relation to distance from rainforest fragments.

Table 2.2. Percentage of elephant herd locations in relation to distance from rainforest fragments.

Distance from fragment (in metres)	Monica	Step-ear
1-100	24.6	10.7
101-500	44.9	42.0
>500	30.4	47.3

Discussion

The Valparai plateau occupies a unique geographical position in the Anamalai hills. Because of gentle undulating terrain surrounded by protected areas, the plateau has been historically used (Congreve, 1942) and will continue to be used by elephants to move between forests of surrounding protected areas. In the landscape mosaic of monoculture plantations and natural vegetation on the Valparai plateau, an important role is played by the rainforest fragments and riverine vegetation for both the Monica and Step-ear herds. *Eucalyptus* plantations are raised as fuel wood clearings to meet the energy requirements of tea factories in the Valparai region. Despite the wide distribution of *Eucalyptus* patches across plantations, the Monica herd seems to prefer natural vegetation (rainforest fragments and riverine vegetation) more frequently (50%) than monoculture habitats (35.6%). In contrast, the Step-ear herd used monoculture plantations more often (60%) than natural vegetation (39.4%). This is probably because of fewer rainforest fragments and spatially isolated forest fragments within the movement range of the Step-ear herd as compared to that of the Monica herd within the Valparai Plateau. This may also explain why the Monica herd is more frequently recorded closer to forest fragments than the Step-ear herd. In the absence of natural vegetation within the movement range of the Step-ear herd, it seems to prefer *Eucalyptus* patches that provide cover, fodder, and water compared to the more open areas under tea cultivation.

An earlier study indicated the movement of elephants during their local migrations between west and east regions during wet (June – November) and dry (December – May) seasons in the Anamalai hills (Kumar *et al.* 2002). The data shows that Monica and Step-ear herd used different habitats, covering a large portion of the Valparai plateau. There is a high concentration of elephant movement and distribution in the centre of the plateau, with some areas used exclusively by either the Monica or Step-ear herd (Figure 2.3). The northernmost part of the plateau is used by Monica alone whereas some parts in northeast of the plateau are exclusively used by Step-ear herd. The home range area for both herds is similar within the Valparai plateau and overlap between the herds is around 8,500 hectares. The Valparai plateau is traversed by many streams and rivers of which Nadu ar and Sholayar river systems across the plateau contains key riverine habitat for both herds. It is in this region that there is a high concentration of elephants and overlap between herds (Figure 2.3). This part of the Valparai plateau is a major corridor for elephants to move across the plateau (Kumar *et al.* 2004).

There was a marked seasonal difference in the ranging pattern of the Monica herd on the Valparai plateau. This herd seemed to prefer and use natural vegetation and coffee which provide tree cover and food than other habitats during the dry season. On the other hand, coffee, *Eucalyptus*, and rainforest fragments are used more often by the Step-ear herd during the dry season. However, there is no significant difference found in use of habitats during dry season between Monica and Step-ear herds. During the wet season, *Eucalyptus* and coffee habitats were important alternate habitats apart from forest fragments and riverine habitats for both Monica and Step-ear herds. However, there is significant difference in use of habitats by both herds in wet season. This highlights the importance of *Eucalyptus* for elephants in both seasons. Retention of *Eucalyptus* patches and halting conversion of coffee plantations to tea plantations is likely to facilitate easy movement and foraging of elephants on the plateau. Tea is primarily used for movement between rainforest fragments since elephants do not feed on the tea crop and it does not provide shelter for elephants.

Preliminary analysis on influence of forest cover on incidence of human-elephant conflict shows that conflict incidence are less likely to occur in areas which have higher forest cover. This analysis needs to be refined through consideration of other possibly influential variables such as area under other habitats (coffee, *Eucalyptus*, and riverine vegetation), density of human settlements, and distance from the sanctuary boundary, besides the effects of spatial correlation. More detailed analysis including spatial regression is being carried out.

Swamp areas in the middle of vast extensions of tea habitat are important feeding grounds for elephants on their movement on the Valparai plateau. In picture: Step-ear herd in Karamalai tea estate.

Secondary vegetation in riverine habitats is an important source of food and water for elephants in the plantation landscape of the Valparai plateau. In picture: Mayuri of Monica herd with her calf in a riverine habitat.

Rainforest fragments in the middle of tea are the only refuges for elephants on the fragmented mosaic of the Valparai plateau. In picture: Pannimade rainforest fragment along the Sholayar river system, a major corridor for elephants on the plateau.

Chapter 3: Behaviour of elephants in human dominated landscape of the Valparai plateau

Introduction

In Asian elephant range countries, about 20% of the human population lives either in or near natural forests that are congenial for elephants (WWF 2000). The wide-ranging movements of elephants frequently create opportunities for contact and conflict with people and the long-term survival of elephants may depend on their ecological and behavioural adaptations to changed conditions in altered habitats. Of the 25 'biodiversity hotspots' in the world, the Western Ghats of India and Sri Lanka hotspot faces elevated risks due to rapid growth of human population (Cincotta *et al*. 2000).

An often overlooked aspect in human-elephant conflict studies is the role of elephant behaviour and response to humans, which is important in population management and conflict resolution in human-dominated habitats (Anthony and Blumstein 2000, Sukumar 2003). It is now widely recognized that such behavioural investigations are integral for the management of wild populations (Quader 2005, Singh and Kaumanns 2005). Behavioural study of elephants is essential for two reasons in plantation dominated fragmented landscape of the Valparai plateau. One, unlike in most other places where crop depredation is the main reason for conflict, elephants in the Valparai plateau do not raid crops but damage store houses where rice and other lentils are stored. This necessitates investigation of proximal factors that influence behaviour of elephants. Second, frequent encounters between elephants and humans may influence behaviour repertoire of elephants due to constant harassment of elephants by people and may create negative attitude in people. This kind of situation may aggravate human-elephant conflict which in turn may lead to undesirable consequences on both sides. Thus behavioural understanding of elephants in human-altered habitats has far-reaching conservation implications for elephants in terms of where, when, and how to initiate conflict mitigating measures. In this project, preliminary analysis was carried out to study the impact of human presence and human activities on behaviour of two elephant herds. More detailed analysis on behaviour of identified elephants in Monica and Step-ear herds will be carried out later.

Objectives

This chapter deals with behavioural responses of elephant herds in order to:

1) Study the general behavioural activity of elephants in the Valparai landscape matrix, and
2) Investigate behavioural responses of elephants to human presence and activities.

Methods

Preparation of ethogram

Two herds were observed over a period of three months to understand their behavioural responses to human presence and activities. An ethogram was prepared based on behavioural observations of elephants. These behaviours were assigned to three categories in the ethogram such as self directed, feeding, and social behaviours. The general behavioural activity of elephants and their responses to humans were categorised into six sub-categories under social behaviour. These were contact, play, avoidance, alert/warning, assurance, and offensive behaviours. A detailed description of behaviours and symbols used in the study is given in the ethogram (Appendix 1).

Individual identification of elephant herds

All individuals in the two focal herds were identified based on multiple characteristics such as physical markings including holes, lumps, cuts, shape of tusks, position of physical markings, individual behaviour, and position of young within the herd (Moss 2001). These two elephant herds were named as Monica and Step-ear herds.

Behavioural responses of elephants to human presence and activities

Behavioural observations were carried out by using standard behavioural techniques. Scan sampling (Altmann 1974, Lehner 1996,) with an interval of 15 minutes was used on randomly chosen identified individuals in each elephant herd. Data recorded during scans included date, individual identity, age-sex class, activities (such as feeding, locomotion, passive, and social behaviour), habitat, immediate surrounding habitat within 200 metres, identity of nearest neighbour, distance from nearest neighbour, distance of humans, number of people around, distance of nearest human colony, and distance of nearest forest fragment. Sampling effort was distributed in a manner designed to maximise the number of individuals that could be observed and to spend approximately equal duration of time in the wet and dry seasons on each elephant herd. Observations were made from a distance of 50 metres from elephants from available cover (or rarely over my shoulder while running full tilt away from elephants!) in order to eliminate or reduce the impact of observer on behaviour of elephants.

Results

General behavioural activities

Of the total 961 scan records of the Monica herd has shown high percent of major activities such as feeding in riverine habitat, movement in tea, resting in *Eucalyptus* and low percent of feeding in E*ucalyptus*, movement in Eucalyptus and riverine habitats (Table 3.1). On the other hand, alert, assurance, and avoidance behaviours such as turn away, placing trunk over young ones by adults, move away, stretching ears etc., in response to human presence and human activities increased to 14.6 % and 11.8% respectively in tea and swamp surrounded largely by tea. Other behaviours such as self directed behaviours are high in *Eucalyptus*. Behavioural observation of elephants could not be carried out in rainforest fragments due to poor visibility of elephants.

The Step-ear herd showed similar pattern to Monica herd with high percent of feeding in riverine vegetation and movement in tea but resting in swamp. Alert, assurance, and avoidance behaviours are high in tea (27.5%). Play by young ones (juveniles and calves) is high in coffee habitat (16.8 %) as compared to other habitats.

Table 3.1. Percentage of scan records in various behavioural activity in different habitats.

Habitat	Feeding	Movement	Resting	Play	Self-directed	Alert	Assurance	Avoidance
Monica herd								
Riverine vegetation	56.2	8.8	15.9	3.5	7.1	4.7	0	3.8
Eucalyptus	43.0	8.0	23.0	2.5	14.0	7.0	0	2.5
Tea	47.5	14.6	17.7	0	5.7	7.6	1.3	5.7
Grassland	54.5	12.7	13.6	8.2	6.4	1.8	1.8	0.9
Swamp	54.2	11.1	7.8	9.8	5.2	7.2	1.3	3.3
Total	52.4	10.4	16.6	4.3	7.9	5.7	0.6	3.7
Step-ear herd								
Riverine vegetation	64.4	16.0	4.3	4.3	4.8	2.7	1.1	2.7
Eucalyptus	53.1	10.1	13.4	6.1	8.4	5.6	0.6	2.8
Tea	27.9	23.5	16.2	1.1	2.8	14.0	1.7	12.8
Swamp	41.1	22.4	17.8	2.8	6.5	5.6	1.9	1.9
Coffee	43.2	11.6	7.4	16.8	7.4	10.5	0	3.2
Total	47.1	16.7	11.6	5.5	5.7	7.1	1.1	5.1

Elephant behaviour and human density

Behaviour of elephants in relation to the number of people in their vicinity was investigated to estimate the impact of humans on general elephant activity patterns. Alert, assurance, and avoidance behaviours were groped into one agitation behaviour category. Play and self-directed behaviours were grouped into others category. The Monica herd did not show any discernible pattern of change in behaviour in relation to number of humans in the vicinity, except for a slight trend of decrease in resting behaviour (Figure 3.1). In contrast, for the Step-ear herd human density appeared to clearly influence the behaviour of elephants. There was a gradual decrease in feeding (54.8%, 47.9%, and 38.1%), movement (19.4%, 16.1%, and 16.3%), resting (11.3%, 12.9%, and 8.1%) especially in the higher density (11-50 people) category (Figure 3.1). On the other hand, there is a trend of increase in agitation behaviour (0.0, 7.7%, and 12.5%) with increase in the number of people in the vicinity.

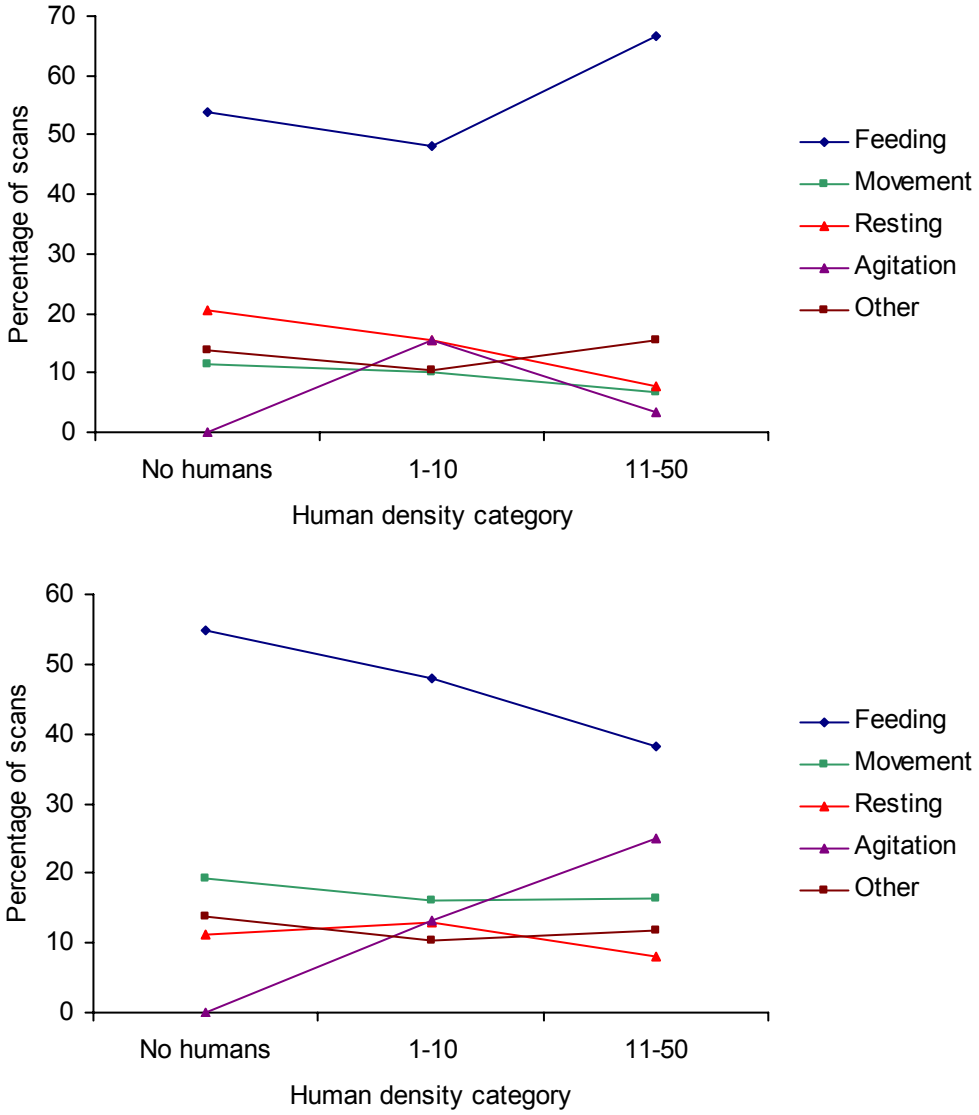

Figure 3.1. Behaviour of elephants in relation to human density on the Valparai plateau. Upper panel: Monica herd; lower panel: Step-ear herd.

Elephant behaviour and human distance

Behaviour of elephants in relation to distance to nearest humans was recorded for the following categories: <30 metres, 31 – 50 metres, >50 meters, and no humans. Along this

gradient, the Monica herd showed increase in feeding (25% to 54%), movement (1.8% to 11.5%), and resting (14.3% to 20.6%) behaviour, with a corresponding decrease in agitation behaviour (48% to 0%). For the Step-ear herd, there is a gradual increase in feeding behaviour from 48% to nearly 60% and decrease in agitation (22% to 0%) as human distance category increases. However, there was an overall increase in percentage in movement (9% to 14%) and resting (7% to 11%) behaviours.

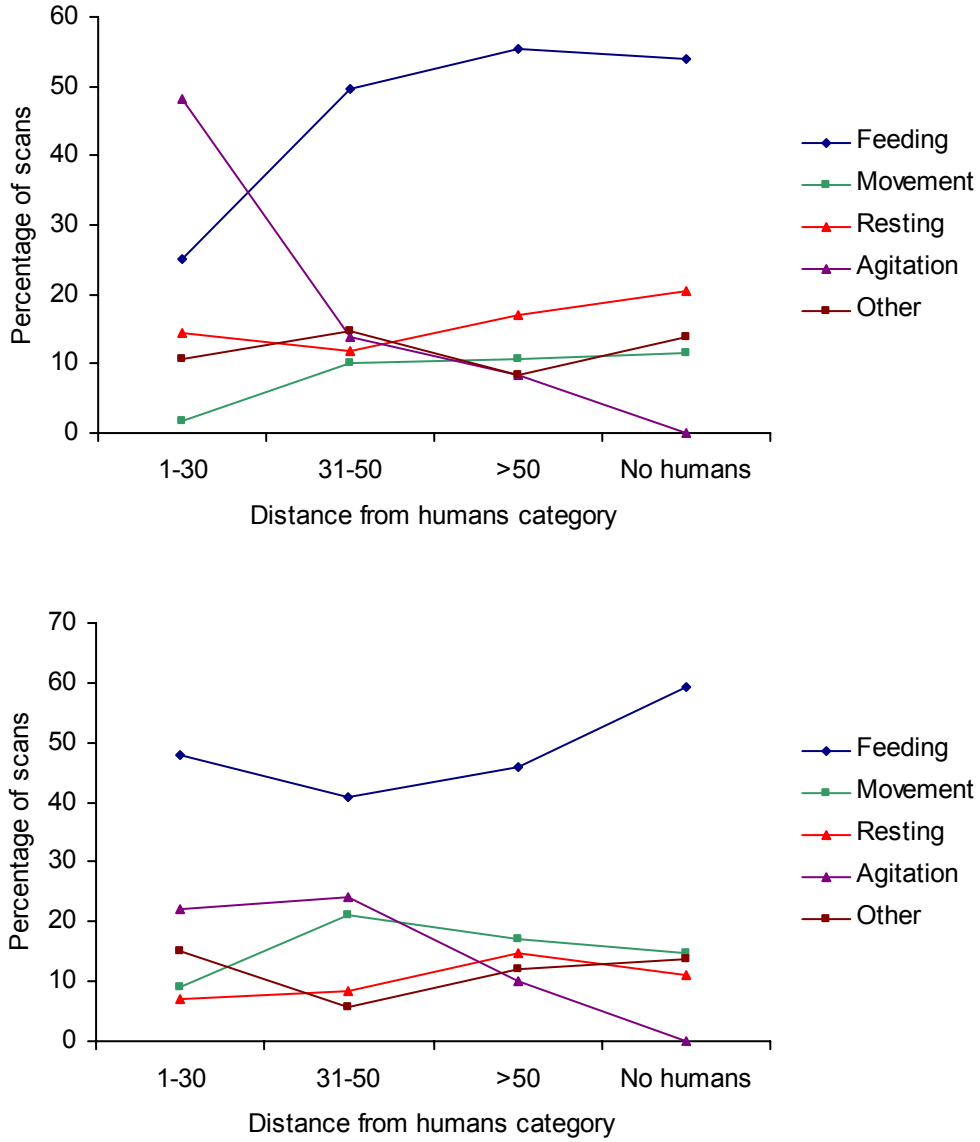

Figure 3.2. Behaviour of elephants in relation to human density on the Valparai plateau. Upper panel: Monica herd; lower panel: Step-ear herd.

Discussion

Understanding the relationship between elephant activity and movement patterns, and the configuration of the different landscape elements is suggested as an important area of investigation in human-elephant conflict resolution (Hoare 1999). In the Valparai plateau, wide distribution of human habitations, high density of humans, and regular movement of elephants warrants an understanding of the behaviour of elephants and their responses to human presence and human activities. In this chapter, I investigated the general behaviour

patterns of Monica and Step-ear herds and their responses to people. This study also indicates behavioural differences of Monica and Step-ear herd in the conflict prone Valparai plateau.

There is considerable variation in general behaviours such as feeding, movement, and resting in different habitat types by both herds. However, behaviours such as alert, avoidance, and assurance behaviours are high in tea and swamp habitats. Tea, a dominant crop in the Valparai region involves intensive human activity, elephants have to negotiate long distances in tea habitat often results in encounters with humans while moving between forest fragments. This amounts to high incidence of alarm behaviour in elephants. In human-dominated landscapes like the Valparai plateau where humans and elephants have to coexist, determining thresholds beyond which elephants are not substantially affected by human presence is a primary requisite to promote coexistence between people and elephants.

In both herds, behaviours such as resting and movement decreased and agitation behaviours increased as number of people increased from one to fifty. However, human density did not show negative effect on feeding behaviour in Monica herd, whereas feeding behaviour in Step-ear herd gradually reduced in relation to increase in human density. This implies that less than 10 people may have reduced impact on agitation behaviours and may not have a negative effect on feeding, movement, and resting behaviours.

Both herds showed increase in feeding, movement, and resting behaviours and decrease in agitation behaviours as distance to humans from elephants increased. This is clearly apparent when people maintain a threshold distance of over 30 metres. Therefore it is suggested that less than 10 people (preferably <5 people) maintaining a distance of more than 30 metres (preferably >50 metres) is desirable to minimise undesirable effects on elephant behaviour such as disruption of foraging and resting, and increase in irritability due to people's presence.

Behaviour of elephants needs to be considered to manage human-elephant conflict on the plateau. When it is inevitable for people to chase elephants away from human colonies, such activities should consider movement direction of elephants, distance of elephants from colonies, the amount of harm caused to elephants due to undesirable human activities such as bursting crackers and using large trucks close to elephants. Studies indicate that elephants have good memories and are quick learners. If elephants are not disturbed when they are away from colonies, elephants tend to differentiate between places where they are disturbed and where they are likely to be left undisturbed. Such steps may increase chances of avoiding human colonies by elephants on the Valparai plateau.

Step-ear herd in a logged *Eucalyptus* plantations beside a main road is a common sight for people on the Valparai plateau

Chapter 4. Human-elephant relationships and conflicts on the human dominated landscape of the Valparai plateau

Introduction

Human-elephant conflict is considered to be one of the major threats to the long-term conservation of elephants in Asia and Africa and has been the focus of much research (Africa: Thouless 1994, Lahm 1996, Hoare 1999, Sitati *et al.* 2003; Asia: Blair *et al.* 1979, Sukumar 1990, Nath and Sukumar 1998, Williams *et al.* 2001, Madhusudan 2003). Understanding the causes of conflict is a prerequisite for devising appropriate conflict mitigation and conservation measures. Studies of Asian elephants (*Elephas maximus*) report several possible causes for human-elephant conflict such as interspersion of forest and cultivation in fragmented landscapes (Sukumar 1990, Singh *et al.* 2002.) In southern India, large scale conversion of forests to monoculture plantations, agriculture, and developed areas, has drastically reduced and fragmented Asian elephant habitats (Santiapillai and Jackson 1990). Our earlier one-year study (Kumar *et al.* 2004) on elephants on the Valparai plateau indicated that several elephant herds moved across the plantations using rainforest fragments, *Eucalyptus* patches, and riverine habitats. This study also addressed spatial and temporal distribution of human-elephant conflict over one-year and suggested suitable mitigation measures to local managers. However, this chapter deals with specific individually identified two elephant herds which range within the Valparai plateau for a substantial part of the year and their conflicts with people in the plantation areas.

Objectives

1. To study spatial and temporal pattern of human-elephant conflict on the Valparai plateau, and
2. Suggest remedial measures for human-elephant conflict to enhance coexistence of elephants and humans on the Valparai plateau.

Methods

Information on conflict incidents were collected while tracking of elephants, reported by informants, and field assessment of conflict incident at damage site. Each conflict incident record carries information on date, month, season, herd identity, time, estate name, place identity such as ration shop, labour line, bungalow, habitat, surrounding habitat within 200 metres, people reaction such as whether animals were chased or not chased by people, distance of human settlement, distance of nearest fragment, and GPS location. Assessment of damage was carried out by collecting information on details of items damaged such as number of tiles, number of wooden reapers, door latches, quantity of materials such as number of sacs of rice, weight of lentils and other ration items etc. Extent of damage to building was calculated by visual measurement property. Cost of damage to property was estimated by collecting information on market price of items damaged and labour costs involved to repair items lost. More than one conflict incident in one night within 100 meters from a conflict site is considered as one incident. Since conflicts occurred during the night time, I followed elephant path from conflict place to recognise the identity of herd which caused the damage.

Results

Spatial pattern of conflicts

In total, 114 conflict incidents were recorded during May 2004 – April 2005 of which seven incidents did not result in any monetary loss as they were damages to abandoned buildings. A total of 107 conflict incidents amounted to an estimated monetary loss of Rs. 256,301 (US$ 5,825) over the above period. This excludes compensation (Rs. 100,000) paid by the state

Forest Department for one human death in the month of October 2004. On average, there was a loss of US$ 54/incident/year. Nearly 86% of conflicts occurred in tea habitat and only 14% of incidents occurred in coffee (Figure 4.1).

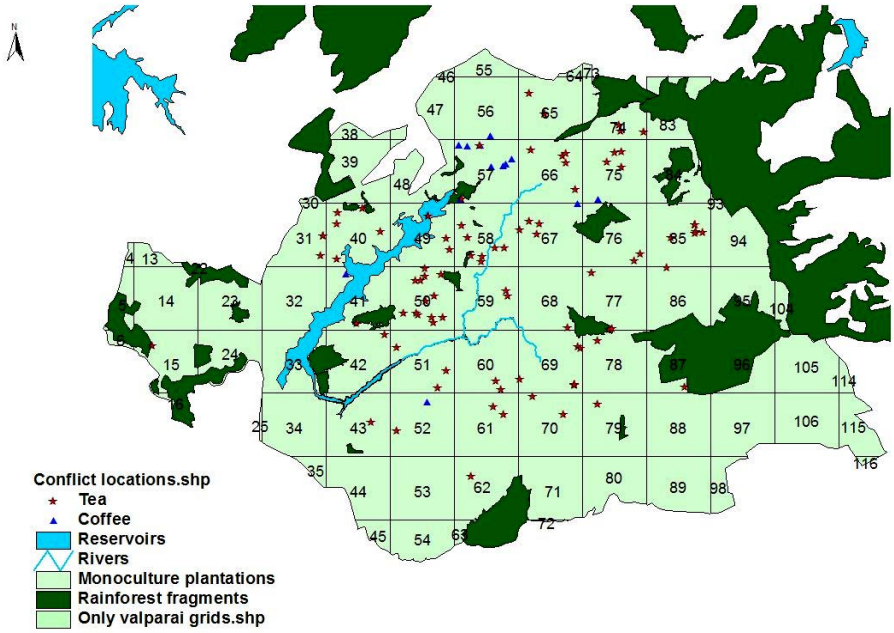

Figure 4.1. Distribution of conflict incidents on the Valparai plateau indicating location within tea and coffee plantations.

Most conflict incidents were in the centre of the Valparai plateau. Of the two herds, the Monica herd caused nearly 66% of total conflict incidents, Step-ear herd caused 31%, and rest were caused by an adult male and a peripheral herd (Pigtail herd). Nearly 50% of total loss (US$ 2,945) and 60% of total conflict incidents (65) occurred at or close to human habitations (Figure 4.2). Also, 42% of property loss (US$ 2,460) and 40% of total incidents

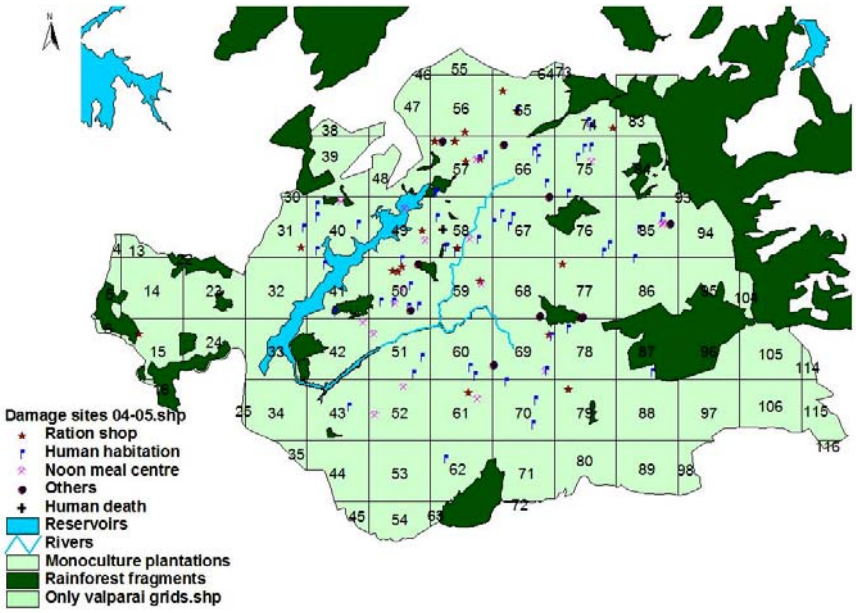

Figure 4.2. Distribution of conflict incidents on the Valparai plateau indicating different kinds of conflict or damage.

were at ration shops and noon-meal centres. The high incidence of conflicts by elephants close to human habitation is due to the frequent presence of ration shops and noon-meal centres close to or within the residential places. During the dry and wet seasons, 43% and 67% of conflicts occurred on the plateau. However, there seems to be no significant difference in spatial distribution of conflicts between seasons on the plateau.

Temporal pattern of conflict

Temporally, two peaks were observed in the pattern of conflicts and resultant monetary cost of damages. The first peak was around June and September and second peak was noticed between November and March, except for February when only three incidents occurred. During these two peak periods a total of 99 incidents amounted to 90% of damage on the plateau. Minimum number (3) of conflict incidents occurred in February which amounted to a loss of Rs. 452 (US$ 10) and maximum conflicts (19) was noticed in November, but high cost of damage Rs. 42,089 (US$ 957) was due to just four conflict incidents in July.

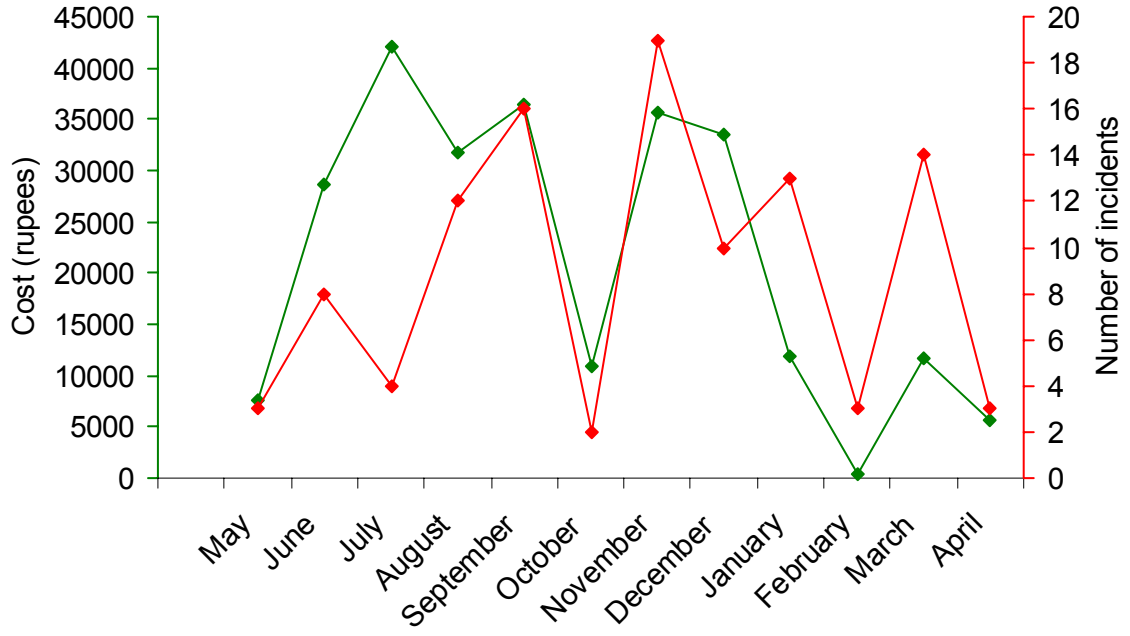

Figure 4.3. Temporal pattern of conflict incidents (red) and monetary costs (green) due to elephants on the Valparai plateau (May 2004 to April 2005).

Discussion

Our earlier study (Kumar *et al.* 2004) on Asian elephants revealed that the plantation landscape on the Valparai plateau is regularly used by three herds apart from several peripheral herds which operate in the fringes of the plateau bordering surrounding protected areas. Monica and Step-ear herds caused damage to property over the plateau with high concentration of conflicts in the centre of the plateau, an area with fewer forest fragments. This once again validates our earlier study findings. On the Valparai plateau, conflict is mainly due to elephants damaging buildings where food grains such as rice, lentils and other provisions are stored. The total monetary loss due to elephant herds in the Valparai plateau during the study period was estimated to be around Rs. 256,301 (US$ 5,825) which is significantly lower (US$ 14,625) than the loss to property during 2003-04 (Kumar *et al.* 2004). This could be attributed to environmental factors such as good monsoon since 2004 after three years of continuous drought in the Valparai region as well as preventive measures taken by companies following the previous study.

However, other peripheral herds and the third elephant herd (Pigtail herd) that move regularly in the southeast part of the plateau would not have contributed to the huge difference in loss of property (personal observations). During this study more residential places were damaged by elephants as compared to our previous study. This requires an immediate and cautious approach to minimize damages to residential places. The reasons that could be attributed to damage to residential places include the distribution of ration shops and noon meal centres on the Valparai plateau. Our previous study in the year 2003-2004 indicated that most damages were caused to ration shops and noon meal centres and very few damages were reported to residential places. Most of ration shops and noon meal centres are located either very close to residential places or found inside human colonies resulting in more damages to houses on the plateau. Steps such as immediate shifting of ration shops and noon meal centres to isolated buildings away from colonies, and better storage facilities have to be implemented in order to avoid close encounters with elephants and casualties to humans.

Conflict incidents and damage to property due to elephants were noticed throughout the year on the plateau. However, there are two peaks, one between June and September and second peak between November and March were noticed during the study period. This entails more concentrated efforts are required to be carried out during these months to reduce human-elephant conflict on the plateau. Apart from trip-wire alarm system, protection of selected buildings with solar/electric fence, installation of elephant warning signals to communicate the presence of elephants to people in order to reduce direct encounters between humans and elephants.

Presence of ration shop in human habitations may cause damages to residential places (In picture: Ration shop along with housed damaged by Monica herd in one of the Tata coffee estates of the Valparai plateau).

Harassment of elephants may promote aggressive behaviours, lose fear of people and increase human-elephant conflict (In picture: Step-ear herd is being chased by bursting crackers in Karamalai estate).

Conclusions and recommendations

1) Elephants preferred natural vegetation habitats such as rainforest fragments and riverine vegetation along major rivers. Retention and improvement of these habitats can play an important role in providing food and also facilitate movement of elephants through the plantation landscape with minimal encounters with humans.
2) In areas of few rainforest fragments or absence of natural vegetation, retention of *Eucalyptus* patches is essential for elephant movement and fodder. Loggings of eucalyptus patches will only expose elephants to human's presence and may aggravate human-elephant conflict on the Valparai plateau.
3) Within the range of Step-ear herd on the Valparai plateau, simultaneous clearing of eucalyptus patches will hamper herd movement and may reduce fodder availability because these habitats seem to be alternate resource for Step-ear herd. If these areas are disturbed they might be pushed to raid ration shops more frequently.
4) Sholayar and Nadu ar rivers in the centre of the Valparai plateau is an important corridor for elephants since both herds seem to prefer this riverine system in dry and wet seasons.
5) Active steps need to be taken to inform the people about the impacts of their presence and proximity to elephant behaviour. Local companies, Forest Department, conservation organisations should take the responsibility to inform people and strictly implement a minimum distance of >30 meters (preferably 50 meters) and fewer than ten people watching elephants when they are within the plantation area.
6) Installation of early warning systems such as red light indicators or trip wire to indicate elephant presence will help people who walk back home during late evening hours and at night to avoid direct encounters with elephants.
7) Immediate relocation of ration shops and noon meal centres at least 400 metres away from human habitations is strongly recommended.
8) A better storage of food grains is an alternate method to avoid damages to buildings such as underground storage, and building with protected by power fences.
9) Harassment of elephants will only reduce the fear of people by which human-elephant conflict may increase. Such activities should be strictly avoided.

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Appendix 1

Ethogram of behaviours used in observation of wild Asian elephants during the study.

	Behaviour	Description
I	**Self directed**	
1	Ear flapping	Flapping of ears when animal is resting
2	Resting	When animal is standing or sleeping on the ground
3	Tail swinging	Swinging of tail when animal is not disturbed and during general activities such as feeding, resting, or on movement
4	Trunk swinging	Swinging of trunk when an animal is not alarmed and during general behavioural activities as described above
5	External object manipulation	Manipulating of objects such as twisting branch of a tree or any object in the surrounding environment by young ones
6	Locomotion	Movement of animals from one place to other
7	Digging mud	Removing mud by using legs
8	Mud bath	Throwing mud over body using trunk
II	**Feeding**	
1	Eat	Feeding on vegetation
2	Drink	Drinking water
3	Exploration	Searching surrounding environment for food
III	**Social**	
A	**Contact**	
1	Body contact	More than one animal is in touch with other
2	Proximity	Presence of animal within 3 meters distance
B	**Play**	
1	Contact play	When more than one animal involve in play with each other with a body contact
2	Non-contact play	More than one animal engage in play but there will be no body contact
3	Non-mutual contact play	When one animal involves in play where other animal does not invovle
4	Self play	When animal plays on its own especially with external objects in the surrounding environment
C	**Avoidance**	
1	Look away	When an animal moves its head away from people
2	Turn away	When an animal turn the whole body away from people
3	Show back	When an animal shows its back by facing away from people
4	Move away	When an animal moves away from people
5	Hide	When an animal is covered by others
D	**Alert/Warning**	
1	Stare	Looking straight at the people
2	Freeze	No movement of body parts in a conflict situation
3	Restless movement of trunk	Rapid Movement of trunk when animals agitated
4	Rigorous ear flapping	Rapid movement ears back and forth when people are close
5	Ear stretch	Stretching of both ears wide apart while facing people in the vicinity
6	Smell danger	Smelling human presence by lifting trunk in the

		direction of people
7	Alarm call	Trumpet or *Khi-Khi-Khi* sound made during conflict situations
8	Threat	Rapid movement of legs back and forth when people are in close proximity
9	Redirected aggression	Aggression shown on external objects such as uprooting tea bushes or pulling out tree branches during conflict
E	**Assurance**	
1	Placing trunk over other	Placing trunk over the body or inside mouth of nearby animal
2	Guarding	Guarding of young ones by adults by covering young animals under four legs
3	Grouping	Congregate of animals with close proximity to each other in a conflict situation
F	**Offensive**	
1	Mock charge	A threat by physically moving towards people to chase away within 10 meters of distance
2	Attack/Chase	An intentional physical attack on people by an animal