Asian Elephant in Kalakad - Mundanthurai Tiger Reserve (KMTR), southern India

Habitat Usage Pattern and Conservation of Asian Elephant (Elephas maximus) in a Compact Evergreen Elephant Habitat

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Note; Figure3, 16a, 17 and 19 are not from the landscape, but are mean to show an endangered species and the conservation problems of the region)

Preface

Kalakkad - Mundunthurai Tiger Reserve (KMTR) is situated in the southern end of Western Ghats in Ashambu hills, with an area of 895 km^2. It is biologically rich and known for high endemism. The rich forests of the reserve form the catchments for many rivers   and streams. The area is also unique as it has 5 primate species and is the home of the Nilgiri Tahr, a mountain goat endemic to the Western Ghats. KMTR is believed to support about 100 Asian elephants; however their status is not well known.

The main objective of the investigation was to document the status of the Asian elephant, its distribution, movement, migratory routes and habitat management related information across the reserve. The study also demonstrates the value of short term, but rapid surveys in understanding the spatial pattern of distribution of Asian elephant and its habitat usage pattern in this compact evergreen elephant habitat   The survey was carried out meeting experienced research scholars, forest staff and local people and review of earlier studies or information of past elephant sightings, habitat usage pattern, through ground survey of a number of routes (trails) across the reserve,.

This investigation led to develop details such as elephant number, distribution, movement and habitat usage pattern, elephant areas in KMTR and elephant distribution in response to altitude range, food availability and within different ranges of KMTR. Some basic insights on elephant and habitat conservation problems, such as human-elephant conflict, pressures on the forest and the enclaves, hydroelectric projects, tea, coffee and cardamom estates and enclosures within the Reserve were also identified. The document may also become a source of monitoring and comparing the elephant status and conservation issues the species faces in this compact evergreen elephant habitat across the years.

Abstract

The study demonstrates the value of short term, but rapid surveys in understanding the spatial pattern of distribution of Asian elephant (Elephas maximus) and its habitat usage pattern in Kalakad - Mundanthurai Tiger Reserve (KMTR), Western Ghats, southern India. The investigation reviews overall status, distribution, human-elephant conflict and other elephant and habitat related conservation problems in the reserve. The survey was based on the insights of past elephant sightings, habitat usage pattern, through ground survey of a number of routes (trails) across the reserve, meeting experienced research scholars, forest staff and local people and review of earlier studies.

The past elephant census estimated a number of 107 elephants (1991) and 138 (1997) elephants for the reserve. An average group size of 8 (SE: 1.15, CV: 18.7%), ranged from 1 to 23, elephants was predicted for the reserve. Results indicated that the elephant use the habitat uniformly throughout the reserve since encounter rates of elephant signs were found to be similar for most of the routes surveyed. However, the data on fresh dung piles, indicative of elephant presence at any given point of time and space, pointed to a clumped distribution. With respect to habitat use, 60% of elephant signs were recorded in the evergreen forests, 13% in grasslands and 12% in evergreen and reed belts. However, a comparison of dung density indicates a significant difference (p < .0000) across the habitats and the elephant densities appear to be more in the grasslands.

The elevation of the reserve ranged from 40 to 1867 m, however elephant presence was limited to altitudes ranging from 300-1300 m, out of which 90% was restricted to altitudes ranging between 600 and 1200m. Specific knowledge of range wise elephant status and habitat usage was important as some of the ranges have very crucial elephant habitats, and some ranges report human-elephant conflict. All the 7 ranges of the reserve report elephants and the number of their sightings is more in Kodayar and Mundanthurai. Free movement of elephants across ranges could be noticed and for Kadayam the movement of elephants is not direct but through neighboring Kerala State due to the steep nature of the terrain.

Within the park, elephant-human conflict was minimal, however, at the foothills, it was relatively higher. Cattle grazing, forest fire, damage due to timber extraction in the past, developmental activities such as hydroelectric and irrigation projects and presence of human settlements, plantations of tea, coffee and cardamom etc. appear to cause habitat fragmentation and resultant disturbance in the area. Based on the findings on elephant distribution and the existing pressures on the habitat, certain recommendations for management and conservation of elephants within and outside the reserve have been suggested.

Introduction and objectives
The elephants in southern India are distributed in eight distinct sub-regions of the Western and Eastern Ghats (Sukumar, 1989). The populations in southern India are unique in a number of ways. It consists of the largest number of elephants and also has large stretches of contiguous habitat. Many of these habitats have a combination of both large number of elephants and large available area (Sukumar, 1989). The contiguity of many of these habitats (sub regions) and the population is maintained by narrow corridors, while some of their contiguity is broken by a number of hydroelectric projects; highways, agricultural lands and other anthropogenic activities (Sukumar, 1989; AERCC, 1988). Periyar and Agasthyamalai sub-regions, located in the southern Western Ghats are known for their large contiguous habitat with a variety of forest types such as tropical evergreen, semi evergreen, mixed deciduous, grasslands and dry forests. These two sub-regions come under the Periyar-Kalakad Tiger Conservation unit and having an area of about 5000 km^2 of very productive habitat for many species of conservation interest (Dutt, 2001; Melkani, 2001).

The elephant habitat in Agasthyamalai sub region comprising Tirunelveli (southern part) and Kanniyakumari forest divisions of Tamil Nadu, part of Trivandrum Forest division (Kulathupuzha range), Shendurani, Peppara and Neyyar Wildlife Sanctuaries (Figure 1) of Kerala covers an area of 2400 km^2. More than 75% of the area in this region comes under evergreen forest (Dutt, 2001) and an approximate number of 100 to 150 elephants are estimated for this entire region (Melkani, 2001). The current study is significant, as not many surveys or studies on elephants and their status have been conducted in this region prior to this survey. Secondly, there is no compact evergreen forest elephant habitat in southern India other than this. The main purpose of this study was to demonstrate the value of short term, but quick surveys in understanding the spatial pattern of distribution, and habitat usage of the Asian elephant in this compact evergreen elephant habitat and little explored KMTR. The reserve has 7 administrative ranges, viz., Ambasamudram (Ambai), Papanasam, Mundunthurai, Kadayam, Upper Kodayar, Kalakkad and Thirukarungudi. The survey also document the status of the Asian elephant, its distribution, movement, migratory routes and habitat management related information across the administrative ranges of the reserve. Information on range wise elephant status and habitat usage was important as some of the ranges are very crucial for elephants, and some ranges report human-elephant conflict.

Survey area
Locations and Geography KMTR is situated in the Ashambu Hills of the southern Western Ghats (southern India), with an area of 895 km^2 (537 km^2 is core zone) lying between 8º 25' and 8º 53' N and 77º 10' and 77º 35' E. The elevation ranges from 40 meters to 1867 meters above sea level. The hill slopes are steep with rugged and undulating terrain intercepted by deep gorges and ravines. The soil type in the upper reaches is clay loam to sandy loam; outer slopes have reddish yellow or sandy loam. The climate is dry, humid and hot at the lower levels, but cooler at elevations of 500 m msl and above. Temperature ranges between 24° C and 44° C. It receives rainfall from both southwest (May-August) and northeast monsoons (October- December), but more from

the northeast and the rainfall varies from 750 to 3000 mm (Kant, 1994; Parthasarathy, 2001).
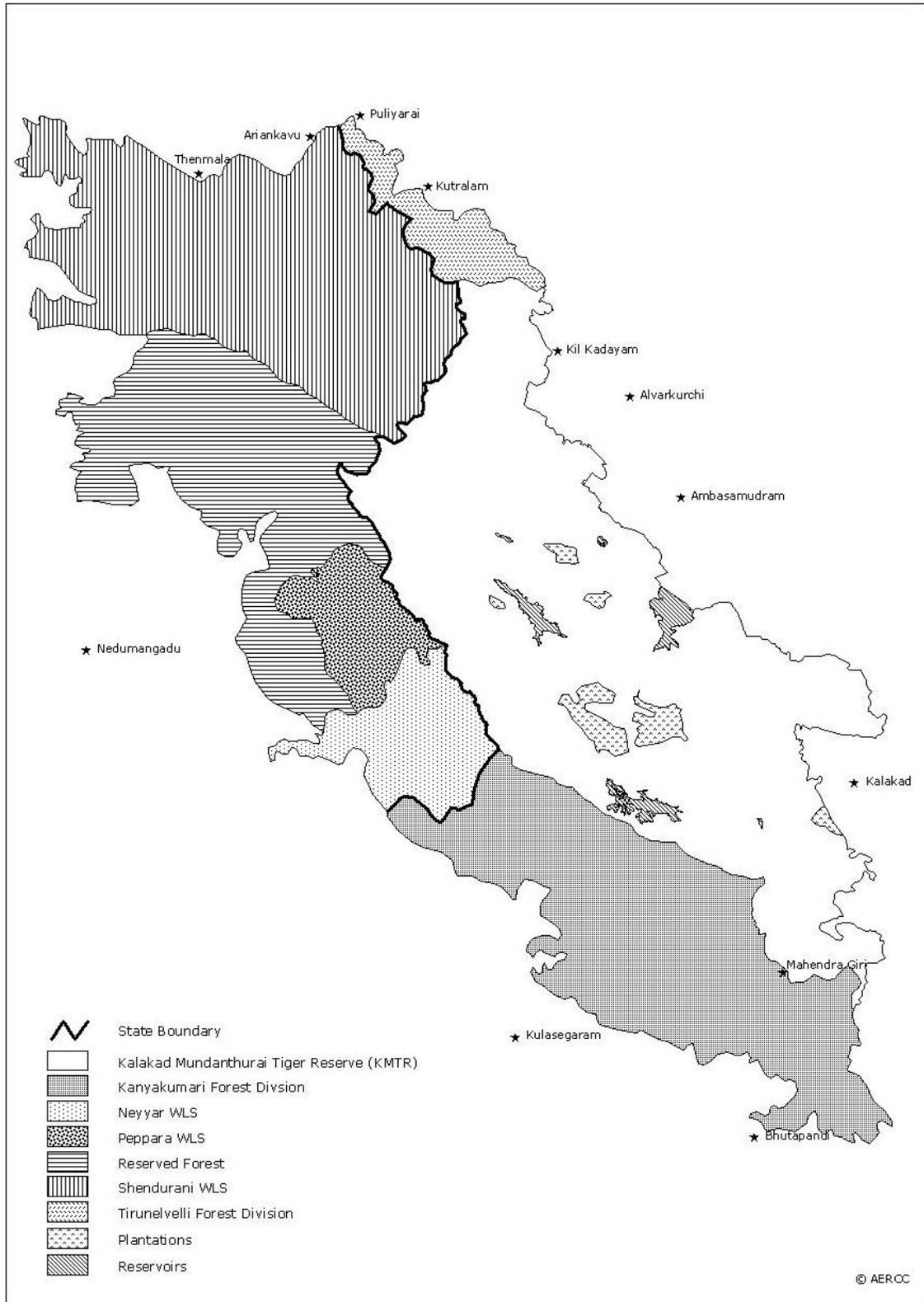
Figure 1: Location of KMTR in Agasthyamalai Sub- region

Three distinct seasons can be identified for the reserve, the northeast monsoon extend from September to December, followed by the dry during January to May and the southwest monsoon period from June to August (Karthikeyan et al., 2001). The reserve is called a River Sanctuary because of the presence of many streams and rivers (Johnsingh, 2001) The major river, Tambarabarani and its tributaries flow eastward through the reserve and the 12 other rivers flowing within the reserve and are also a perennial water source for irrigation, hydroelectric projects and the 4 taluks in Tirunelveli district, southern India. There are a number of reservoirs and swampy areas found here.

Figure 2: Evergreen forests of KMTR

Flora and fauna and human communities

West Coast tropical evergreen forest, sub-tropical montane forests, Tirunelveli semi-evergreen forest, southern moist-mixed deciduous forest, dry teak and deciduous forests and scrub forest are the major vegetation types in the reserve. Tropical riparian fringe forest, Ochlandra reed brakes, and grassland at low and high altitudes are the other habitats found here *(*Parthasarathy, 2001*; Ganesh, et al., 2001; Ramesh, et al., 2001*).* KMTR is biologically rich and known for its unique endemism (Dutt, 2001; Melkani, 2001; Johnsingh, 2001;Ganesh, et al., 2001; Ramesh, et al., 2001). The endangered and Western Ghats'endemic mountain goat (Figure 3) the Nilgiri tahr (*Hemitragus hylocrius*) is found here. Lion Tailed macaque (*Macaca silenus*), Nilgiri langur (*Trachypethicus johni*) Bonnet macaque (*Macaca radiata*), Common langur (Semnopithecus *entelus*) and Slender loris (*Loris tardigradus*) are the 5 different primate species found here (Dutt, 2001; Johnsingh, 2001; Sunderraj and Johnsingh, 2001). Kani tribes are the major inhabitants of the region, with about 120 families living here in 5 Kani settlements. There are about 150 villages

Figure 3: Nilgiri Tahr; an endangered and endemic to Western Ghats

(with 30,000 households and a population of 0.1 million) belonging to different human communities, located in a belt within 5 km of the edge of the reserve, stretching for about 200 km distance. Out of these 22-30 % are located close to the forest (Melkani, 2001; Kant, 1994).

Survey Methodology

A review of earlier studies or surveys on elephants and habitat was done through literature searches and by interviewing researchers. Forest Department records provided very useful information of many aspects of elephant management. Based on the literature review, past elephant sightings and habitat usage patterns, a number of survey routes (trails) were identified (Figure.4). One observer and field tracker(s) walked (Figure 4b) these routes and a total of 24 routes were surveyed on foot during the beginning of the northeast monsoon season (mid-September to mid-October). Whenever elephant signs (track, dung, feeding and other signs) were located, time of sightings, location, altitude, forest type, number and the status of the sign (fresh or old) were recorded.

While walking, a uniform pace was maintained to calculate the sighting intervals (in minutes) of each signs. Observations of elephant signs were restricted to a width of 1 m on either side of the survey route to calculate the area scanned for each route. At

Figure 4b: Survey team (forest staff and local trackers) exploring the landscape for the habitat and elephant habitat usage survey

regular time intervals (30 minutes), tree species were identified for associating with the forest types surveyed. Villages, enclosures and other human establishments along the boundary and within the reserve were visited for information on past and current elephant sightings, elephant visits to village to damage crops and other elephant related information. The number of trails surveyed varied across the ranges and the selection of trails for each range roughly matched the total area of the range.

The percentage of trails covered in Mundunthurai range was the highest (33%) followed by Kalakadu and Kodayar (25% for each), Trirukarangudi range (8%) and Kadayam and Ambai (4%). Except for Papanasam range the survey was carried out in all the ranges. Only elephant dung piles were considered for data processing, as dung piles were very prominent and easy to locate in the field. It is known that elephants defecate 13.33

times/day (Varman, et al., 1995) and the chances of missing them in the field are less compared to missing out the other signs.
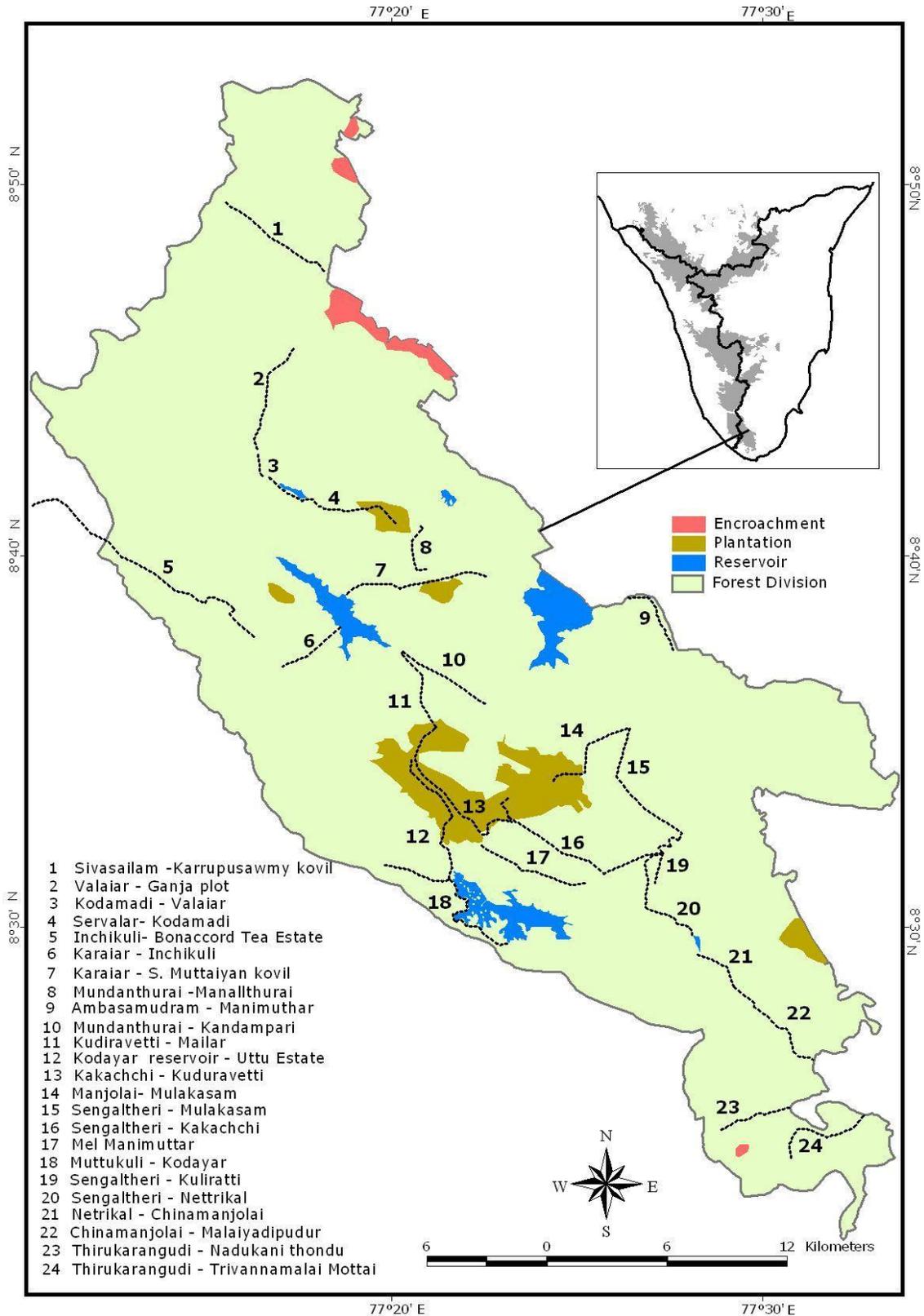
Figure 4: Elephant habitat survey routes in KMTR.

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It is important to note that, the effort needed to locate other signs were very high and this was also related to the dryness, wetness or other factors associated with the terrain of the route surveyed. Encounter rate of dung piles was calculated by dividing the total distance covered by the number of dung piles encountered for each route. The frequency of occurrence of elephant signs was calculated through sighting interval. Based on the administrative divisions (range) different sub regions were identified and encounter rate and sighting intervals were calculated for each sub-region. Except for the Papanasam range, the survey was carried out in all the ranges.

Comparison of dung pile encounter rate and sighting interval were made across the routes and regions. The spatial data was incorporated into GIS software (ArcView 3.2a). The maps of the study area, survey routes and other topographical features were digitised. Survey routes were considered to be independent of each other. For each route, the encounter rate data (of dung piles) was analysed and results were incorporated to develop the patterns of habitat usage and distribution.

A vegetation map (Ramesh, et al., 2001) of the area was used to look at patterns in encounter rates with respect to different vegetation types. The computer program software Statistica 5.5 (StatSoft, Inc., 2001) was used for carrying out statistical tests data processing, Shapiro Wilk's W test was used to test the normality and Spearman Rank Correlation was for testing the correlation between encounter rate of dung piles and their sighting interval. X^2 test used to test the observed and expected values for different habitats

Results
Elephant status, number, distribution, movement and habitat usage pattern
The approximate number of elephants in the reserve comes from two censuses carried out in years 1991 and 1997. The 1991 census estimated 107 elephants (0.11 elephants/km^2) and in 1997, 138 elephants (0.15 animals/km^2) were counted.

The increase in the number of elephant across two estimates could be due actual increase in the number or due to differences in manpower used or the methods followed. It is also possible that as the reserve is a part of contiguous forest complex, movement of elephant across the reserves could also have increased the number.

There were 27 sightings of elephants for various years accounting for an average group size of 8 (sample size (N) = 27, Standard Error (SE) = 1.15, % Coefficient of Variation (CV) = 20) individuals. The group size of elephants sighted ranged from 1 to 23 and the most frequently seen numbers were 1, 2, 5, 7 and 8. More than 15 elephants in a group were seen only once, indicating that the group size of elephants in this reserve is relatively small.

There were frequent sightings of adult males and calves indicating scope for a growing population. According to reports of direct sightings, except in January, August and September (Table 1), elephants are sighted through all the months in this reserve.

Combining the information of both direct sightings and indirect evidence, it is possible to assume that elephants use the reserve through the year.

Main elephant areas in KMTR:
The survey identified following main areas and routes used by elephants to move within, across or out side the regions of the reserve.

1. Kannikatti-Enjikuli-Pambar-Kuduravatti-Mailar-Kandamparai-Manimuthar-Mulakasam-Sengeltheri-Kakachi-Nalumukku-Kuduravatti.
2. Valayar-Kandamparai-Kannikatti-Enjikuli-Pambar-Varataiyar Kuduravatti.
3. Sengeltheri-Thalaianai-Karunkalkasam-Sengeltheri or Kandamparai to Mundanthurai.
4. Sambulimukku (on the mailar road)-Pulianjolai, Perappannaoothu-Gundar-Sorimuthanarkoil-Kullanodai-Manalthurai-Mundal.
5. Sorimuthanarkoil, Banatheertham to Enchikuli, Kannikati Kalivarpul (Kerala-Tamilnadu border)-Bonacara estate.
6. Kannikati-14 beat-Kandamparai-Valayar to Kerala (Kulathu pulza).
7. Sengaltheri-Kularatti estate-Multalar-Mullakasam-Manimuthar.
8. Kerala-Kultrilam-Noondi Mangadu estate-Kadeyam range-14 beat- Kanikatti-Agastyamalai-Kalivarpullu-Aduppukalmottai.
9. Keripari-Nadukanithoundu-upto Akilandampillai estate.
10. Kakachi-Nallumukku-ottu-Police repeater station-Kodayar reservoir-Muthukulaivayal-Keripari.

Dung encounter rates in survey routes and elephant density for the reserve
During the elephant and habitat survey, 24 different routes with an average of 13 km (N = 25, SE =1.25, % CV = 9.7) per route were sampled. The survey covered a total distance of 316km and a total of 643 dung piles, with average of 26.7 (N = 24, SE = 6.09, % CV 23) dung piles per route and 2.01 (N= 24, SE = 0.4, % CV 19.9) piles/km.

Studies show dung pile encounter rates for prime elephant habitat of mixed deciduous scrub forest combination (Sukumar, 1989) is 15.5 dung piles/km and elephant density of 1.74 animals/km^2 (Varman, et al., 1995) and for evergreen habitat 8.7 dung piles/km and density of 0.35 animals/km^2 (CES, 2001). Comparison of these results with that of the reserve indicates that encounter rate of the dung piles for the reserve is very low.

High dung decay rate or very low elephant density could lead to low encounter rate of dung piles in a given habitat. In KMTR it could be assumed that the low encounter rate may be primarily due to the low elephant density, which could be 7.6 to 4.28 times lower than that of the prime elephant and evergreen habitats respectively. Based on this assumption, the reserve could support a relatively low density of 0.1 to 0.2 elephant/km^2.

Distribution and habitat usage pattern of elephants in KMTR
The survey routes covered most regions (northern, southern, eastern and western extremes of the reserve) and the result of encounter rate of dung piles/km showed that the habitat usage pattern of elephants was uniform throughout the reserve. Among all the

routes surveyed, 88 routes encountered dung piles and 71 % of these routes encountered 1 to 2-dung piles/km and there was not much of a variation around the mean for these routes (Mean 1.57, N = 15, SE = 0.13, % CV 9).

It should be noted that mean encounter rate for all the routes was 2.0 and there was a wide variation around the mean (N = 24, SE = 0.5, % CV 19.9). These results suggest that the elephants use habitat uniformly and as the survey covered most parts of the reserve, the result of equal habitat usage pattern could be extrapolated for the entire reserve.

The sighting interval of encountering dung piles varied across routes and on average of every 14.5 (N = 24, SE = 4.6, % CV 32) minutes of walk dung pile was encountered. In some routes the sighting interval of dung piles was very wide (95 minutes). The result was comparable to the intensity of usage pattern of elephants in a given route.

However, as the Shapiro – Wilk's W test for normality suggest that the distribution of encounter rate and sighting interval was not normal (p < 0.001), a nonparametric correlation was carried out and it was found that there was no significant correlation between the encounter rate and sighting interval (r = 0.0193, p = 0.927, Figure 5).

With reference to habitat usage pattern for individual routes, Kodamadi -Valaiar route encountered more dung piles/km (8.8/km) followed by Kudirravetti to Malilar (7.7/km), Manjolai - Mulakasam (5/km) and Servalar -Kodamadi (3/km). In the Chinnamanjolai - Malaiyadipudur, Karaiar-Sorimuttaiyan Kovil and Tirukarangudi-Tiruvanna Malai Mottai routes no dung piles were encountered.
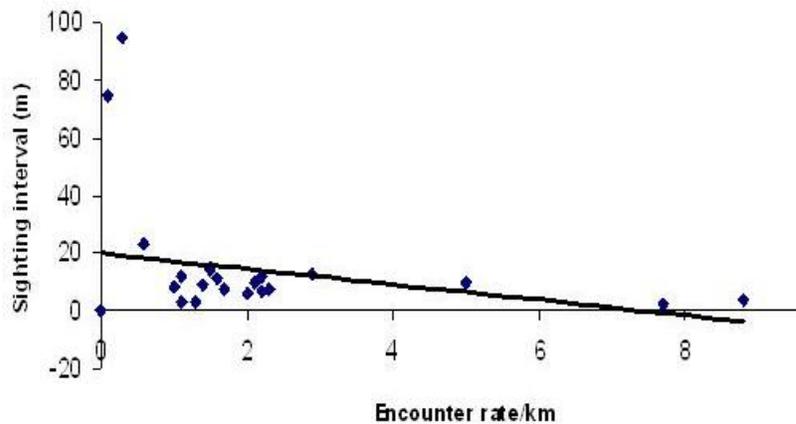
Figure 5: Encounter rate vs sighting interval

The survey estimated an average encounter rate of 0.09 (N= 24, SE 0.04, % CV 48) fresh dung piles/km and 0.1 (N= 24, SE = 0.04, % CV 38) 2-week-old dung piles /km. Encounter rate of one-month-old dung piles was 0.29/km (N= 24, SE = 0.07, CV 26) and 0.27 (N = 24, SE = 0.07, % CV 27) for very old dung piles/km. Fresh dung piles were

encountered only in eight routes (Figure 6) while 2-week-old dung piles were noticed only on six routes.
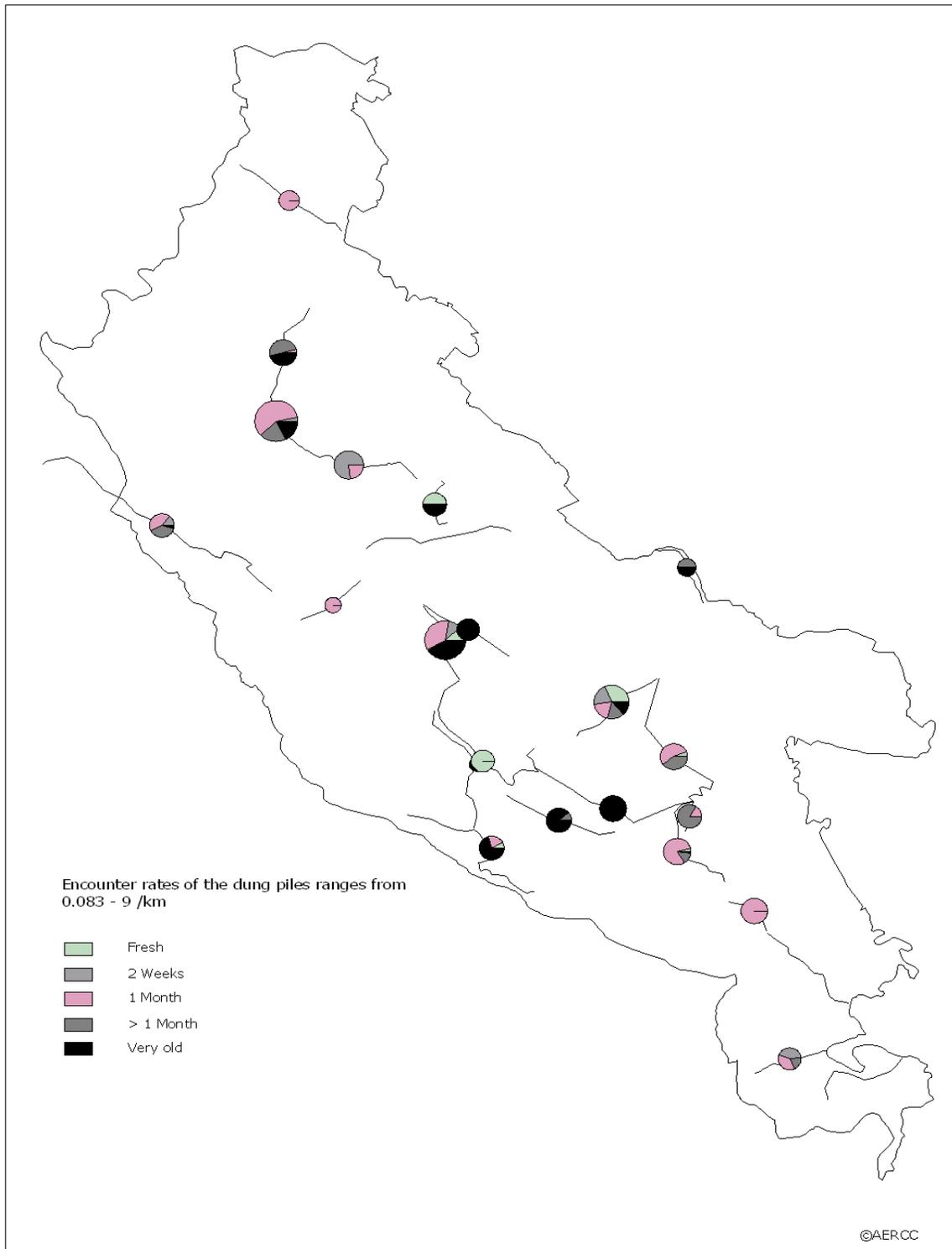
Figure 6: Encounter rate of dung piles for the survey routes in KMTR

This may indicate that even though elephants use most of the reserve throughout the year, at any given point of time they restrict themselves to a small proportion (30%) of the area. A pattern of clumped distribution of elephant was noticed from the survey, as most of the fresh dung piles encountered were from one region of Kodayar.

Dung encounter rates in each habitat type:
The survey also provided data on the dung pile encounter rate for each habitat type (Figure 7).
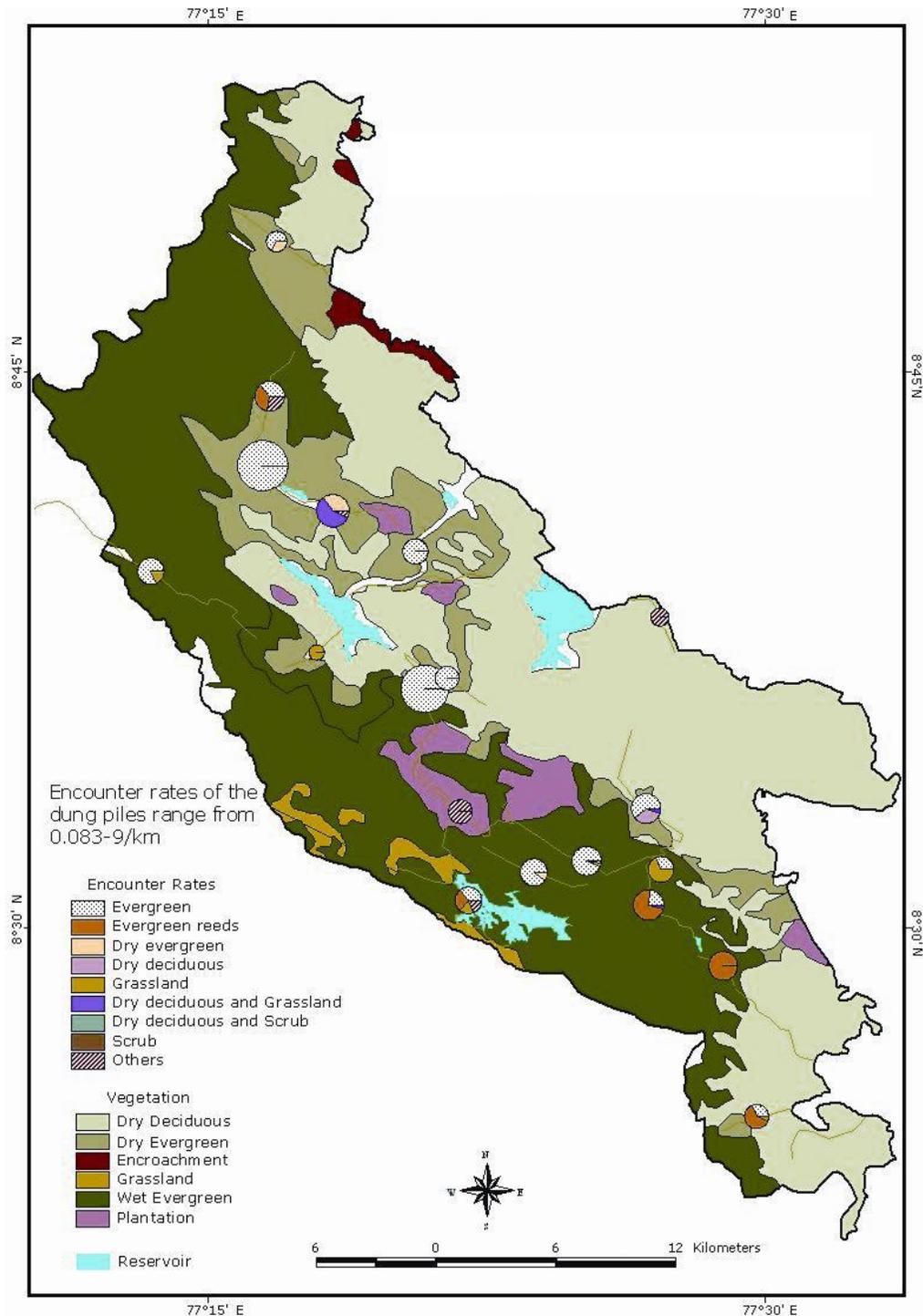
Figure 7: Encounter rate (per km) of dung piles in vegetation types in the KMTR

Among all the dung piles encountered, 60 % of them were from the evergreen habitat, while grasslands encountered 13% and evergreen and reed belts 12%. Mean encounter rate of dung piles also was significantly more in evergreen forest (N= 24, Mean = 1.1, SE = 0.5, % CV 41). More dung piles appearing in evergreen forest could be due to the habitat of KMTR being predominantly evergreen, and out of 24 survey routes, 18 of them (75%) had evergreen forest.

This pattern could also be due to the decay rate of dung piles; that is in some habitats the decay rate could be very slow and dung piles remain for longer periods due to the habitat having more closed canopy forests. Wherever, the combination of evergreen and reed belts along with *Caryota urens* (common name: *Koondapani*) and *Arenga wightii* (common name: *Alapanai*) are found, the dung encounter rate and density was high, suggesting a preference of elephants towards the microhabitats. However, as the data was processed in proportion to the habitat size (for major habitat types), the grassland was used more than its availability (Figure 8) and there was a significant difference (p < .0000) in habitat usage pattern and the calculated elephant density for grassland was more than 0.32 elephant/km^2, for evergreen it was only 0.04 elephant/km^2 and for dry deciduous forest as low as 0.0019 elephant/km^2.
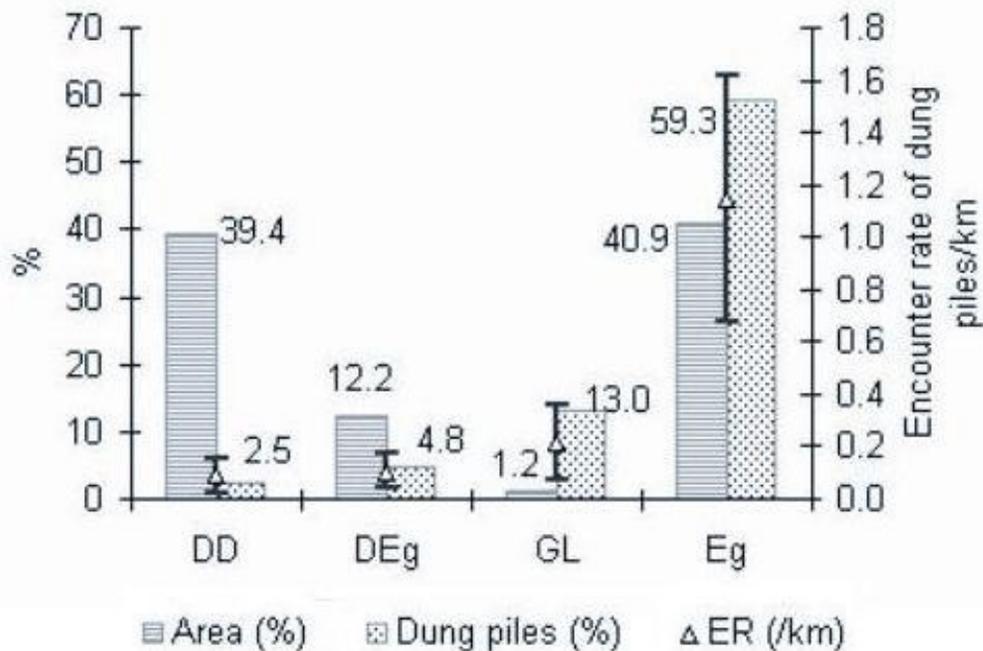
Figure 8: Encounter rate, percentage of dung piles and area for different habitats in the KMTR

Dung encounter and altitude
The elevation of the reserve ranges from 40 to 1867m, but dung piles were sighted only in the altitude range of 300 to 1300m, a large percentage of which were seen in the range of 600-900m (60%). Ninety percent of dung sightings were in the range of 600–1200m.

The evergreen and reed belts start at an altitude of 600 meters and this could explain the reason for more dung piles encountered above 600 meter.

Number of dung piles sighted below 600 and above 1200m was very low (Figure. 9). Elephants rarely use habitat below 300m (foothills) and above 900m (the habitat becomes open grassland and deciduous vegetation and in some regions at this altitude, the terrain is very steep).
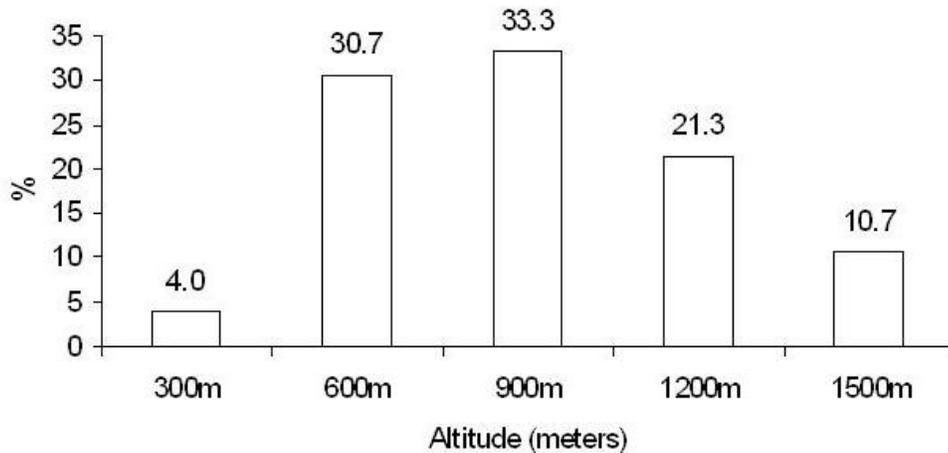
Figure 9: Dung piles sighted across the altitude of the KMTR

Elephant distribution in response to food availability
It was previously known that the habitat in KMTR could support only a small population of elephants. This is due to low abundance of elephant food plants and high variance in their spatial and temporal distribution. The main food sources are reeds and grasses that occur in patches of low density and are widely separated from one another and do not provide enough food for the elephants. The evergreen area (700 m) has reed patches and other elephant food species such as *Calamus sp, Mallotus phillipinensis* and *Helictres isora*. The deciduous forest and grasslands of the slopes and the foothills have *Grewia tiliaefolia, Dendrocalamus strictus, Borassus flabellifer, Phoenix* and *Buchannia*. These food species are also distributed in patches. Therefore the elephants move extensively from one patch to the other.

Secondly, except in Mundanthurai plateau and a few lower regions (Singampatti ex-jamin), most of the areas in the reserve are steep and precipititious with many valleys rising to the peaks. This pattern has a major impact on the movement of elephants and not allowing them to descend into the valleys. They are therefore restricted mostly to the upper reaches. Elephants do come to the foothills, but mainly to feed on the cultivated crops in villages and also for the *palmyra* palm (*Borasus flabelifer*) trees (grown naturally or planted to demarcate the forest boundary along the foothills).

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Elephant distribution in different ranges of KMTR

The survey provided basic information on elephant distribution in different administrative ranges of the reserve. It was understood that, information on range-wise usage (Figure 10) was important, as some of the ranges are very crucial for elephants while some ranges reported human-elephant conflict.
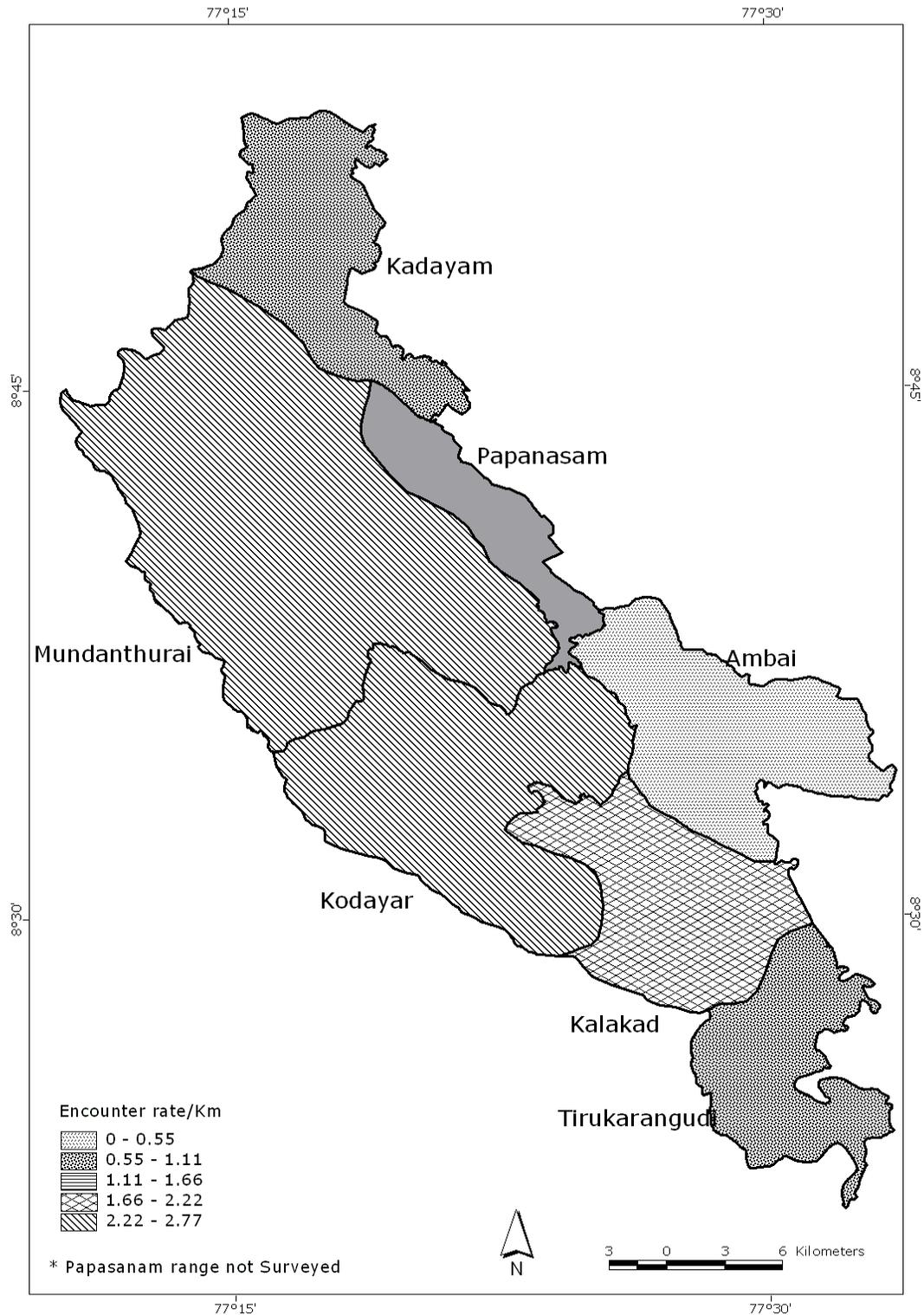
Figure 10: Encounter rate of dung piles in different administrative range of the KMTR

All the 7 ranges of the reserve report elephants and the number of elephant sightings was higher in Kodayar and Mundanthurai. This is due to availability and abundance of elephant food plants, and their varying geographical and seasonal distribution. Free movement of elephants across most ranges was apparent, except in Kadayam where their movement is not direct but through the neighbouring State of Kerala due to the steep terrain. Kodayar region encountered more dung piles (2.77/km) followed by Mundanthurai (2.39/km) and Kalakad (1.77/km). The encounter rate (0.25/km) and frequency occurrence (every 95 minutes) of dung piles were very low for Ambai range (Table 3; Figure 10).

Mundunthurai

Based on elephant distribution, this region can be classified into three parts; the area around Karayar reservoir, Mundunthurai plateau and the higher reaches (Figure 11). Within Karayar region, four Kani settlements such as Enchikulai, Periyamailar, Chinnamailar and Kattalamalai estates are located, among them, Enchikulai, Periyamailar and Katlamalai have elephant problems during the rainy season (November and December). Based on the direct and indirect evidences and interviews with the locals it is revealed that elephants use Karayar and the adjoining region from July to December.

Elephants are reported in Manalthurai, Mundal, Karaiyar road, Servalar, Thailar odai of Mundunthurai plateau. The Mundunthurai plateau has an area of 50-60 km^2 of dry deciduous vegetation with tall grass, considered to be ideal elephant habitat.

However, the area is small (only 6% of the park) and not connected to areas with similar forest types. The area has a low elephant density. Secondly,

Figure 11: Forest cover available for elephants in higher reaches of Mundunthurai

habitat from Sorimuthanurkoli to Manimuthar dam is known for firewood collection. Woodcutters from Ambasamudram and V.K Puram use this region. The area is also known for heavy cattle grazing and the cattle from Sengampatti and adjoining villages come to this area. Elephants use Mundunthurai plateau during January to March and the largest elephant group seen in this region was 23 animals. The Valayar, Kodamadi and adjoining areas of the higher reaches, are known for their regular elephant presence. The rich *Ochlandra* reed brakes make this habitat prime elephant areas and they reportedly use this part throughout the year.

Kalakkadu

Elephants come down to Kalakkadu from Mundunthurai through Banatheertham, Kandamparai to Kalakkad, and they are reported only in rainy season. The elephant areas in Kalakkadu are Sengaltheri, Kovapatti, Kuluratti, Multalar, Mulakasam, Nettrical and Kakachi. From Sengeltheri elephants move to Karungalkasam and they are reported here from December to January. The swampy grassland patches within the Netrikal dam and Chinnamanjolai estate area attracts a number of elephants to this region. But no elephant signs have been reported from Chinamanjolai to Mailadipudur region. It appears that if the area is very steep and has only grassland with a few scattered trees; elephants may not use such habitat.

Figure 12: Forest habitat available for elephants in Sengaltheri region of Kalakadu

Kodayar

Elephants in Upper Kodayar region are mainly found in Muttukuli, Kudaravetti, Kakachi and Nallumukku and Ottu tea estates. Elephants use the estate region regularly and one of the reasons for elephants frequently using tea estate areas could be due to the area being dominated by *Ochlandra* reed brakes, which adjoins the tea estates. Elephants that visit villages such as Potal, Singampati, Papankulam during summer use this region. However towards the foothills, close to Manimuthar dam area, no record of elephants or their signs have been reported. The habitat near Kodayar reservoir has swampy grassland, *Ochlandra* reed brakes and evergreen forest and is considered to be another well-known area for elephants.

Kadayam

Elephants enter the Kadayam region from the Kerala side. The nearest place in KMTR to come to Kadayam is Amburveli, but elephants from Chinnapullu (Kodamadi) cannot come to Amburveli as the place is very steep. So they enter Kerala and from there they come to Kadayam. Elephants from Kerala come via Kadayam to Sivasailam and Talamalai boundary. In Kadaiyam range, elephants were reported in only two places of the foothills, Govindaperi and Sivasailam (Bangalakudiyirrupu). Elephants are known to use the region from, Alwarkuruchi peak to Karruppusamy kovil to Kallar River and to foothills (near Kadana reservoir), particularly to visit the villages during January and February. They do not use the foothills of this range regularly.

Ambai

Elephants are seen in Singampatti forest beats 1,2 and 3, Kulundumamarai forest beat and Thekkuveeranallur forest beat. All these 5 forest beats are in the foothills near the Manimuthar dam in Ambai range. Elephants come from Mulakasam and the route they follow is Mulakasam, Kathodai mottai, Nakarichan odai, Othapanai and Elumbachaiar (Mardamkasam). Elephants come to foothills and villages through Keerakaranthoundu (saddle). The saddle adjoins Vadagari beat of Kalakadu range. From the saddle the elephants come to Elumbachaiar. During rainy season between December and January elephants use this region. The habitat within the foothill region is very dry (Figure 13), but villages with their cultivation of banana, paddy, sugarcane and coconut, along with old palm tress along the boundary attract elephants towards villages. However, they visit only few villages.

Figure 13: Forest type and status in the foot hill regions of Ambai Range

Figure 14: Forests in foot hill regions of Trirukarangudi region

Trirukarangudi

Elephants from Keeripari, (Alagiapandiyapuram range of Kanayakumari) via Naduganithondu (saddle) reach higher reaches of Thirukarangudi region. From Naduganithoundu up to Agailandampillai Kadu (private estate) elephants are reported, and beyond this point towards the foothills (Anaiadithambiran temple) no elephants are reported. From the saddle to the estate, the path is negotiable and the habitat is rich with deciduous forest (Figure 14) on foot hills and reeds in higher reaches. Other hill ranges such as Thrivannamalai mottai, and Nadugani mottai are adjoining the saddle but are very steep.

There is a possibility that, elephants from Nattrikal and Chinnamanjolai come to Naduganithoundu.

Elephant and habitat conservation problems in KMTR
The survey provided information on the number of elephants and habitat related conservation problems. It was also observed that, elephant conservation problem such as human-elephant conflict and elephant death due to poaching or due to conflict is not much. However the habitat related problems are severe and need to be addressed effectively. The number of civil activities undertaken in the past has brought down the quality of the reserve. Forest exploitation for irrigation and power projects, severe cattle grazing pressure, frequent fires, road construction and uncontrolled encroachments along the foothills have caused severe damage to the reserve. There are 150 villages with the households of 30,000 in a belt of 5 km stretching for 200 km. Twenty two - 30 % of them (with the human population of about 0.1 million) are close to the forest. There are a notable number of people reside within reserve in the work sites, staff colonies of State Electricity Board, and private estates (Figure 8). This experiences a moderate to very high biotic interference; particularly the fuel and other forest resource needs of the villages in the fringes are very high (Melkani, 2001; Dutt, 2001).

Human-Elephant Conflict
The major aspect of conflict arises from the fact that the movement of elephants towards the foothills and the conflict due this is relatively severe. The movement towards the foothills (Figure 15) is due to the changes in the weather condition, food and other resources or disturbance caused by people or for the palm tress, planted to demarcate the forest boundary or grown naturally along the foothills. In the past 25 years, only recently (since 1995) have the elephants started visiting the villages. This is also due to the villagers removing most of the palm trees for fuel.

In these villages elephants are reported during the crop harvesting seasons and on average 20 (SE = 4) cases of crop raiding/year are reported. There are settlements within the reserve and the human elephant conflict appeared to be low, only villages located on the foothills

Figure 15: Elephant habitat towards human habitations in foot hills, a source of conflict between human and elephant

have elephant problem. Elephants use mostly the upper reaches and come down to the foothills during December to May and the conflict is more in areas under Ambai range. Since 1995, three human deaths have taken place due to elephant attack in the reserve.

Elephants are reported to visit the settlements for 2-3 months, especially during the northeast monsoon season. According to the local villager, elephant groups of 10, 5, 2, 3, and sometime single animals are reported. They come for crops such as banana (*Musa paradiasica*), jackfruit (*Artocarpus heterophyllus*), arecanut (*Areca catechu*), tapioca (*Manilhot esculentm*), pineapple (*Ananas cosmosus*) and coconut (*Cocos nucifera*). Elephants damage banana, tapioca and coconut the most. No effective control methods have been taken so far except chasing the elephants by using firecrackers. It was observed that, these settlements have primitive wooden fences to prevent animal entry. Crop damage is relatively low and no human death due to elephants is reported in the settlements located within the reserve. This may be due to the low density of elephants within the reserve or due to the habitat contiguity with enough food, water and other resources available within the forest itself.

Elephant deaths:

Information on number of elephants found or use the reserve helps in understanding the status of elephants in the reserve, their growth and death rates. No specific or scientific information on number and status of elephants is available for the reserve. This is due to no scientific study or survey on elephant carried out earlier or earlier surveys have only basic information on elephant number and the deaths (due to natural or man-made causes) and it is also not clear how accurate this information is. However, based on this information, from 1993 to 1998, 4 elephants (only males) have died, two due to natural causes, one after capture by tranquilizing and the other by poaching in Singampatti beat 11. No arrest of culprits or detection of tusks was made.

Pressures on the forest
Cattle Grazing:

The major problem associated with the settlements within and out side the reserve is the livestock (Figure 16a). This problem mainly arises from villages located close to Papanasam RF, Singampatti ex-jamin and Kalakad RF of the reserve. From these

| Figure 16a: livestock moving towards forest for grazing | Figure 16b: Denuded status of forest due to cattle grazing and other disturbances |

villages, it is estimated that nearly 5000 cattle units are dependent on the forest. Due to heavy grazing, the lower hills in the forest have been denuded (Figure 16b) and are devoid of any grass for grazing. Tender seedlings are destroyed by trampling and damage is caused to the roots by the heavy hooves of the cattle. Grazing has caused soil compaction resulting in the reduction of water percolation and loss of topsoil and run off (Melkani 2001; Dutt 2001).

Forest fire:
Along with grazing, forest fires are known to be set frequently by the cattle grazers also have reduced the quality of the habitat. Nearly 4-5% of the habitat is burnt (Figure 17) every year. If we take into account the actual fire prone areas of the reserve, and then the proportion of habitat burnt for these regions would be very high. It is felt that the external damage caused by man, due to cattle grazing and fire, keeps the forest from reaching a stable stage. From the entrance of Mundanthurai right up to the lower dam camp, the terrain is rough with huge

Figure 17: Forest status after forest fire

rocky outcrops, unsuitable for animals (Kant 1994; Melkani 2001;Dutt 2001). Combination of forest fire, cattle grazing and other human activities were responsible for such a status.

Timber extraction:
The reserve has a very long history of timber extraction and from 1891, some parts of the reserve were worked on a regular basis. Kannikatti zone was subjected to light selection felling with the trees being used as sleepers, especially Mesua species, in 1927. Kodamadi area was subjected to selective felling to preserve the catchment areas of Tambaraparni, Servalar and Manimuthar. Timber cum fuel working coupe worked on contract till 1975 in Mundanthurai plateau and Sivasailam forest.

The extracted areas were planted with teak and softwood. The failure of the plantation increased the demand for fuel and cattle grazing here. The whole of Singampatti forest (see Figure 18 for its location) was under the *jamindars* (traditional feudal landowners, who were appointed administrators of the area) and they had control till the upper reaches of the Tambaraparni River. With the abolition of the *jamin* in 1952, the ex-jamin forest was taken over. These forests were badly damaged due to repeated cutting, felling and
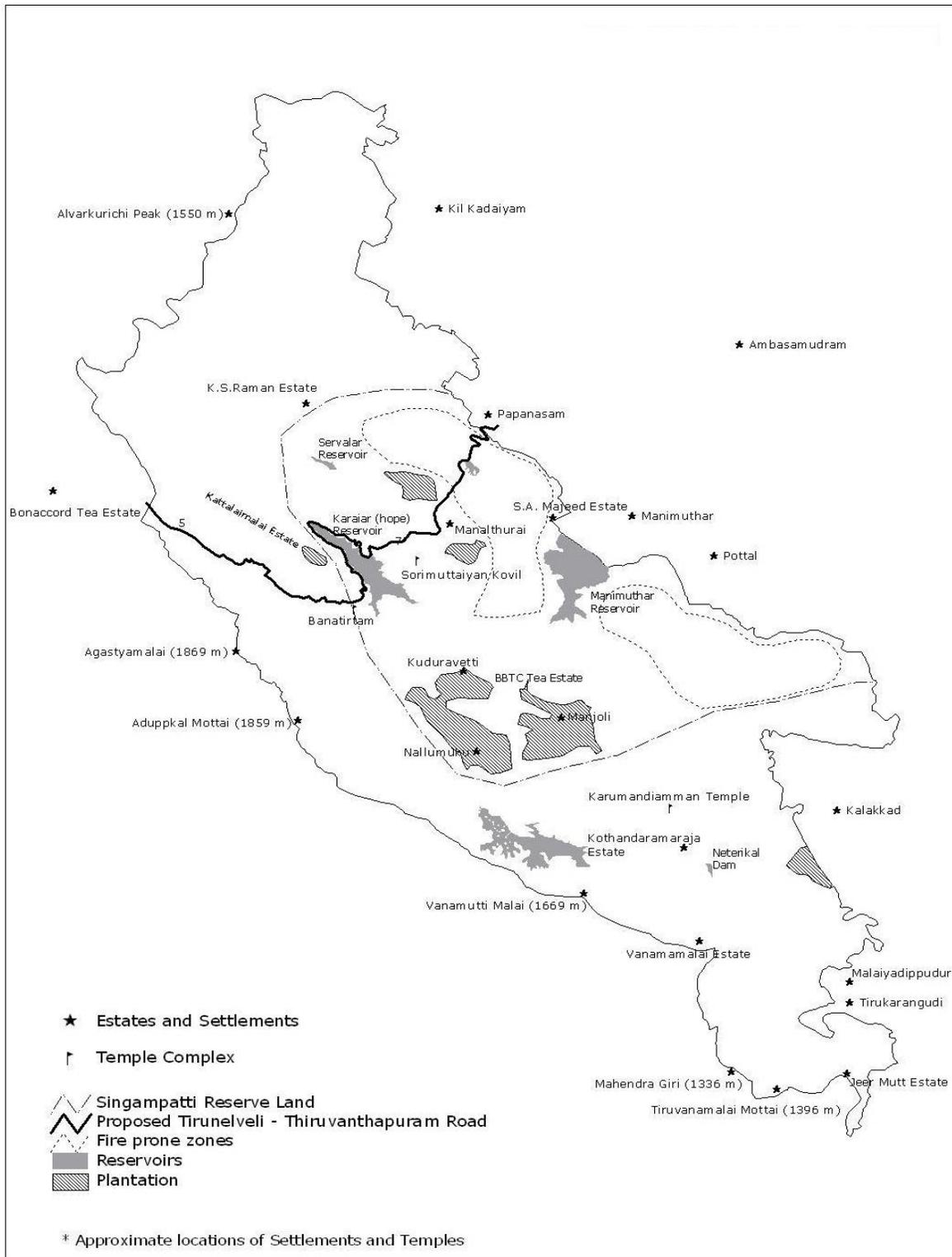
Figure19: Map showing different conservation issues of KMTR

The map contains the following labels:

- Alvarkurichi Peak (1550 m)★
- ★ Kil Kadaiyam
- ★ Ambasamudram
- K.S.Raman Estate
- ★ Papanasam
- Servalar Reservoir
- Kattalaimalai Estate
- ★ Bonaccord Tea Estate
- 5
- S.A. Majeed Estate
- ★ Manimuthar
- Karaiar (hope) Reservoir
- ★ Manalthurai
- ★ Pottal
- Sorimuttaiyan Kovil
- Manimuthar Reservoir
- Banatirtam
- Agastyamalai (1869 m)★
- Kuduravetti
- BBTC Tea Estate
- Aduppkal Mottai (1859 m)★
- Manjoli
- Nallumuku
- Karumandiamman Temple
- ★ Kalakkad
- Kothandamaraja Estate
- Neterikal Dam
- Vanamutti Malai (1669 m)★
- Vanamamalai Estate
- Malaiyadippudur
- ★ Tirukarangudi
- Mahendra Giri (1336 m)★
- Jeer Mutt Estate
- Tiruvanamalai Mottai (1396 m)★

Legend:

★ Estates and Settlements

Temple Complex

Singampatti Reserve Land
Proposed Tirunelveli - Thiruvanthapuram Road
Fire prone zones
Reservoirs
Plantation

* Approximate locations of Settlements and Temples

over grazing by the jamin cattle. After being declared as a Tiger Reserve, no coupe was allowed to operate and forty years after taking over, the area has still not recovered completely (Kant 1995, Melkani 2001, Dutt 2001).

NTFP Collection:
Up to 1980, NTFP collection was allowed in the reserve and later only the local tribes were involved in the collection. Before 1981 the Forest Department collected honey and it was sent to Lac factory in Madurai in Tamil Nadu. Currently the collection of NTEP is not permitted; however there is seasonal illegal collection of mango (*Mangifera indica*), cane (*Calamus sp.*), kundrikam (*Canarium strictum*), wild tubers and other Non-Timber Forest Products by people who live within and out side the reserve. This illegal collection has severe negative impacts on the biomass of the reserve (Melkani 2001, Dutt 2001).

Tourists and Pilgrims:
The area attracts many local visitors as it has many rivers, waterfalls and temples. The temple festivals bring several thousands of pilgrims into the reserve particularly during 2 days (Adi Amavasi and Matu Pongal festivals) of the year, to visit Sorimuttaiyan Kovil and Bana tirtam in Mundanthurai range and Karumariamman temple at Sengeltheri and Nambi Kovil of Kalakadu range. The Adi Amavasi festival brings about 0.5 million people over a short period of time. Littering the places with food and other material, depending on the forest for fuel wood, biomass depletion, accidental forest fires, transporting domestic animals for slaughter, all these activities have significant negative effect causing considerable damage and disturbance to the habitat (Kant 1994, Melkani 2001).

Enclaves, hydroelectric projects, tea, coffee and cardamom estates and enclosures:
There are a number of enclaves located within the reserve, comprised of 4 electricity camps *(for *t*wo hydroelectric projects, 9 irrigation projects and 7 reservoirs), Bombay Burmah Trading Corporation (BBTC), 4 temple complexes (see figure 18 for their locations) and 19 patta lands and 5 tribal settlements coming within the limits of the reserve. BBTC, covers an area of 3391 ha (lease expires on 11-02-2027) with tea (Figure 19), coffee, cardamom and eucalyptus. The estate

Figure 19: Tea cultivation within the reserve

employs some 5000 people; there are 200 families with 1000 people living in the fringes

of evergreen forests, causing a notable damage to the rainforest. Kattalaimalai, (Figure 19) the second largest estate with an area of 1271 ha of prime moist deciduous forest, located within the reserve, due to its commercial timber logging (until recently) activities prime lowland and moist deciduous forest of the region is severely affected. The estate activities not only disturb the forest but also fragment corridors of many species.

Cardamom leases were granted in 1941 and a total of 40 cardamom blocks with an extent of 490 acres came into being with lease period being 25 years. During 1979, the Government banned the renewal of all cardamom blocks within the sanctuary. So far 35 cardamom blocks have been resumed by the Forest Department and five more are under operation on lease.

All these estates, cardamom blocks and patta enclosures are located inside the reserve (most of the area is inaccessible) and it is very difficult to monitor their movement and the disturbance they cause to the forest (Kant 1994; Melkani 2001; Dutt 2001).

Other disturbances:
The Tamil Nadu Electricity Board (TNEB) is contemplating on a number of power projects in the evergreen segment in higher altitudes (Core zone). The road to Triruvanthapuram, via Mundanthurai-Kannikatti goes through the core zone. Attempts to kill elephants for tusks have been taking place at the border of Kanniyakumari and Kerala State. Due to inadequate supervision and staff, ganja (*Cannabia sativa*) cultivation, woodcutting and smuggling, and other illegal activities are taking place. Nearly 400 such cases have been reported for the years 1996 and 1997 (Kant 1994, Melkani 2001,Dutt 2001).

Conservation goals
Elephant food mapping: Elephant presence and movement is noticed throughout the year in some parts of the reserve. However, how many elephants are there, what attracts them and how they use the habitat is not clearly known. Elephant food species distribution and mapping (along with identifying the stage of the dung piles) on the paths regularly used by elephants would give an indication as to how elephants use the habitat.

Monitoring of elephant sightings: Wherever elephants are sighted, their number, age and sex classification, microhabitat and other behavioral observations have to be noted. Getting the cooperation of the tea estate people is also necessary to fulfill the objectives. Places like Kakachchi, Nalumukku, Kudiravetti and Manjolai have regular elephant movement. Estate people, or the staff of the Tamil Nadu Electricity Board (TNEB), who visit rainfall station (located within the reserve) could give more information on their number, movement and other related details.

Patrolling: The park management has to concentrate more on policing and it should be treated as a significant component of habitat management (Dutt 2001). Patrolling of elephant habitats is very important as illegal activities like ganja cultivation and collection of forest products, which are regularly reported, are disturbing the movement of elephants directly or indirectly. For example, the three-ganja plots visited near Valaiar

had more of reed belts and prime water resources. Of all the places visited, the areas from Kodamadi to Valaiyar and Valaiyar to 3 ganja plots had the maximum number of dung piles. Dung density i**s** very high here. The clearing of reed (favorite food of elephants) belts and diversion of water for ganja cultivation would severely affect the elephant movement. The Department needs to take some measure to control or patrol and monitor these areas.

Monitoring or acquiring private estates and settlements: Allowing estates and settlements to operate deep inside the forests and not monitoring their activities would lead to several illegal activities being undertaken by the estate people or supported by them. Documenting the current internal and external pressures from settlements located within and out side the reserve is a major concern. Predicting biomass resource demand and use of local communities and developing strategies to counter the degradation of elephant habitat should be given major priority. Ali & Pai (2001) suggest that if current land use of these settlements would not benefit the surrounding forest, acquisition must be considered as an option.

Ranking estates and some settlements being sites for endemic/rare species, damage to the ecosystem, watershed functions and other criterions (Ali & Pai 2001), Kattalaimalai estate located within the reserve, suits to a high-ranking value and it has be acquired. It was also informed that keeping the estate people inside the forest also had some advantages as they provide information on the movement of people from outside. If the estate people are not disturbing the forest much and their presence in very remote areas prevents the entry of outsiders, then they should be allowed to stay. This would help the Department, given the less manpower and resources to monitor these interior and unapproachable areas.

Man power and other facilities: To start with, the Forest Department (FD) has very less manpower. It is noticed that illegal activities like ganja cultivation, etc., usually take place in areas where the terrain is very tough, unapproachable, infested with leeches and take several hours and kilometers to reach, needing camping facilities. Good manpower is needed to stop or control any illegal activity that is noticed. The staff posted in these areas are not interested in taking up the job as these areas are remote, and the staff currently posted here do not have enough facilities, such as, raincoats, field equipment, boots, ammunition, etc.

The establishing of temporary camps in these areas, with the FD and other conservation agencies providing food and other resources to the watchers and above all motivating the FD staff would facilitate better protection of these remote areas. Habitat along the foothills, particularly in Ambai range is very dry and has extensive biotic pressure. In the foothills of this range, an irrigation canal runs along the boundary. If a barrier is constructed along the canal, it would improve the habitat quality. It would prevent many problems including cattle entry and elephant entry to human habitation, and forest fires, which are known to be set by the villagers.

Beyond KMTR: Conservation of elephants and its habitat in KMTR cannot be considered in isolation and any aspect of elephant management should be based on the surroundings and the quality of the habitat available for elephants in the adjoining areas of KMTR. The

KMTR is a part of a compact unit of sanctuaries such as Neyyar, Peppara and Shendurani (of Kerala State) across the political border, buffered by Kanniyakumari, Thirunelveli (of Tamil Nadu State) and Trivandrum (of Kerala State) Forest Divisions. A comprehensive understanding of elephants within this unit is very important. Apart from this, connecting the link between this compact unit (currently Ariankavu Pass of the Shencotah Gap – Figure 20- separates this unit) and the remainder of the north of Western Ghats (to Periyar sub-region) would provide a much larger habitat for elephants.
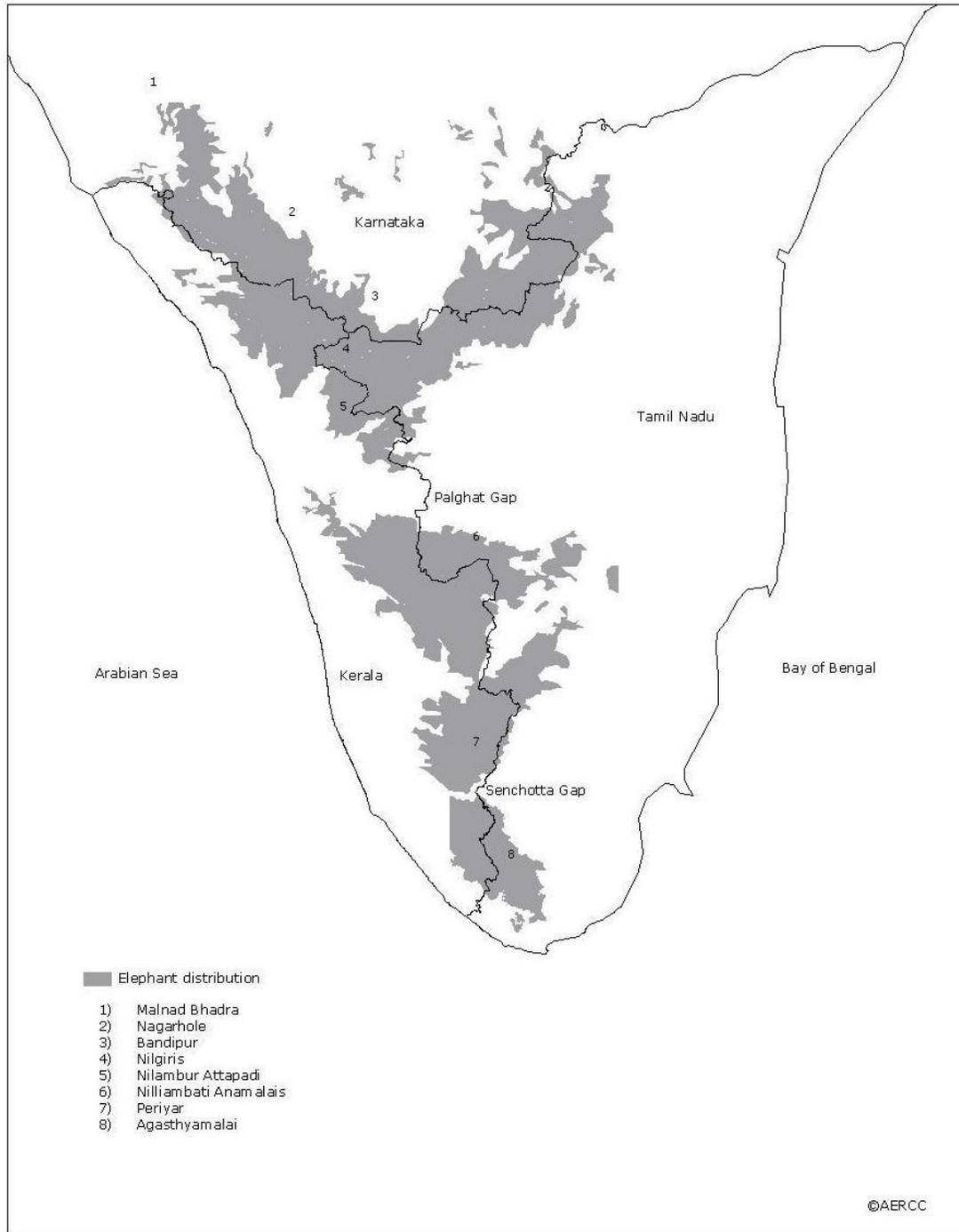

Figure 20: Elephant distribution in southern India, the location of Agastyamalai Sub region and Senchotta Gap

Conclusion
This survey carried out, even though for a short period of time (a month) has provided a collective knowledge of the species, the habitat and its usage pattern. The survey results indicate that elephants use the habitat uniformly and at any given point of time they have a clumped distribution and restrict themselves to altitudes ranging from 300 to 1300 m (60% to 600-900m). The reserve experiences a moderate to marginally high biotic pressure; however some part of the habitat (within KMTR) is intact and has a long-term conservation value for the species.

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Table 1:
Elephant sightings through direct and indirect sightings in KMTR for various months

S.No	Region	Direct sightings			Indirect sightings
		Number of elephants	Month of sighting	Age-Sex Classification	Month of Sighting
1	Mundanthurai	12	July	-	January, February, May, August
		18	-	-	September, October, December
		23	-	-	-
		1	-	Adult male	-
		10	November	-	-
		5	-	-	-
		2	-	-	-
		3	-	-	-
		20	May-June	-	-
		1	-	-	-
2	Kalakad	10-15	February	-	July, August, September, October
		7	July	-	November, December.
		5	March	2 calves	-
		4	June	-	-
3	Kodayar	11	October	-	-
		7	October	-	-
		5	March	2 calves	-
		11	June	3 calves	-
		2	April	Adult male	-
		1	March	Adult male	-
		2	-	-	-
		7	-	-	-
		8	-	-	-
		10	-	-	-
4	Ambai	7-8	-	-	-
5	Kadayam	12	-	-	October
		8	-	-	-
6	Tirukarngudi	-	-	-	August

- Data not available

Table 2: Route surveyed, distance covered, number of dung piles encountered and number of dung piles found for different habitats in KMTR

				Number of dung piles in forest types								
Route	Forest Type	Dist	No. Dung	Eg	Eg+Rd	DEg	Dd	Gl	Dd+Gl	Dd+Sc	SC	Ot
Sengaltheri – Kakachchi	Eg	21	45	42	0	0	0	2	0	0	0	1
Mel Manimuthar	Eg&Ri	16	27	24	0	0	0	0	0	0	0	3
Kodamadi – Valaiar	Eg&SEg	14	123	123	0	0	0	0	0	0	0	0
Kudiravetti – Mailar	Eg&DEg	9	69	69	0	0	0	0	0	0	0	0
Valayar – Ganja plot	Eg&Eg+Rd	13	28	10	10	0	0	0	0	0	0	8
Kodayar reservoir – Uttu Estate	Eg,Eg+Rd&Gl	20	32	17	9	0	0	2	0	0	0	4
Inchikuli - Bonaccord Tea Estate	Eg,Eg+Rd&Gl	24	37	30	0	0	0	7	0	0	0	0
Muthukuli – Kodayar	Eg,Eg+Rd&Gl	23.5	36	13	10	0	0	6	0	0	0	7
Tirukarangudi – Nadukani thondu	Eg,Eg+Rd,Dd& Sc	14.5	16	5	10	0	0	1	0	0	0	0
Sengaltheri – Neterikal	Eg,Eg+Rd&Dd+ Gl	21.5	50	12	36	0	0	0	2	0	0	0
Karaiar – Inchikuli	Eg,SEg& Gl	12	1	0	0	0	0	1	0	0	0	0
Sengaltheri – Kuliratti	Eg,Dd&Gl	13.5	19	6	0	0	0	13	0	0	0	0
Sivasailam –Karrupusawmy temple	Eg,DEg,Tp,Dd& Sc	10	6	4	0	2	0	0	0	0	0	0
Neterikal – Chinnamanjolai	Eg,SEg,Eg+Rd& Gl	2	4	0	4	0	0	0	0	0	0	0
Sengaltheri – Mulakasam	Eg,SEg,Dd& Gl	15	33	20	0	0	11	0	2	0	0	0
Manjolai- Mulakasam	Eg,SEg,DEg,DD &Ri	15	75	0	0	20	1	50	2	2	0	0
Kakachchi – Kudiravetti	Eg,Te&Pl	3.5	4	0	0	0	0	0	0	0	0	4
Mundanthurai – Kandampari	Eg&Dd	6	6	6	0	0	0	0	0	0	0	0
Servalar- Kodamadi	Eg,Tp&Dd	9	26	0	0	9	0	0	15	0	0	2
Tirukarangudi – Trivannamalai Mottai	Dd&Sc	15	0	0	0	0	0	0	0	0	0	0
Mundanthurai - Manalturai	Dd&Sc	3	4	0	0	0	4	0	0	0	0	0
Karaiar –S.Muttaiyan Kovil	Dd,Tp & Sc	13	0	0	0	0	0	0	0	0	0	0
Ambasamudram – Manimuthar	Dd,Tp & Sc	8	2	0	0	0	0	0	0	0	0	2
Chinnamanjolai – Malaiyadippudur	MDd	15	0	0	0	0	0	0	0	0	0	0
Total		316.5	643	381	79	31	16	82	21	2	0	31
%				59.3	12.3	4.82	2.49	13	3.3	0.31	0	4.821

Dist = Distance covered, No.Dung = Number of Dung Piles.

Forest Types: SEg: Semi Evergreen, Eg: Evergreen, DEg: Dry Evergreen, Eg+Rd:Evergreen+Reeds, Dd:Dry deciduous, Gl: Grassland, Dd+Gl: Dry deciduous + Grassland, Dd+Sc; Dry deciduous + Scrub, Sc: Scrub, Ot: includes mixed deciduous, teak plantation, tea estate and plantation

Table 3: Distance covered, number, encounter rate and sighting interval of dung piles for different management zones of KMTR.

S.no	Range	Dist	No.D		Er
1	Ambai	8	2	0.25	
2	Kalakad	88	151	1.72	
3	Kadyam	10	6	0.6	
4	Kodayar	87	241	2.77	
5	Mundanthurai	94	225	2.39	
6	Tirukarangudi	14.5	16	1.1	

Dist: Distance covered, No. D: Number of dung piles, Er: Encounter rate (expressed as number of dung piles/km)

Appendix 1: Route surveyed, distance covered, number of dung piles encountered, encounter rate, sighting interval and encounter rate of dung piles of different stage in KMTR.

S.no	Route	Dist Km	No D.P	Er /km	Si M	F Er	2W Er	1M Er	>1m Er	Vo Er
1	Kodamadi – Valaiar	14	123	8.8	3.6	0	0	0.59	0.2	0.18
2	Kudiravetti – Mailar	9	69	7.7	2.7	0.1	0.1	0.36	0.01	0.41
3	Manjolai- Mulakasam	15	75	5	10.1	0.3	0.2	0.19	0.16	0.13
4	Servalar- Kodamadi	9	26	2.9	13.1	0	0.8	0.23	0	0
5	Sengaltheri – Neterikal	21.5	50	2.3	7.7	0	0	0.8	0.14	0.02
6	Sengaltheri – Mulakasam	15	33	2.2	6.8	0.1	0	0.55	0.39	0
7	Valaiar – Ganja plot	13	28	2.2	11.8	0	0	0.04	0.5	0.46
8	Sengaltheri – Kakachchi	21	45	2.1	10.1	0	0	0	0	1
9	Neterikal – Chinnamanjolai	2	4	2	6.2	0	0	1	0	0
10	Mel Manimuthar	16	27	1.7	7.9	0	0	0	0.11	0.89
11	Kodayar reservoir - Uttu Estate	20	32	1.6	11.1	0.3	0	0.03	0	0.69
12	Inchikuli- Bonaccord Tea Estate	24	37	1.5	14.1	0	0.1	0.43	0.38	0.05
13	Muthukuli – Kodayar	23.5	36	1.5	14.8	0.1	0	0.22	0	0.69
14	Sengaltheri – Kuliratti	13.5	19	1.4	8.8	0	0	0.16	0.84	0
15	Mundanthurai – Manalturai	3	4	1.3	3	0.5	0	0	0	0.5
16	Tirukarangudi – Nadukani thondu	14.5	16	1.1	12.2	0	0.4	0.38	0.19	0
17	Mundanthurai – Kandampari	6	6	1	8.6	0	0	0	0	1
18	Sivasailam –Karrupusawmy temple	10	6	0.6	23.3	0	0	1	0	0
19	Kakchachi – Kudiravetti	3.5	4	1.1	3	1	0	0	0	0
20	Ambasamudram – Manimuthar	8	2	0.3	95	0	0	0	0.5	0.5
21	Karaiar – Inchikuli	12	1	0.1	75	0	0	1	0	0
22	Chinnamanjolai – Malaiyadippudur	15	0	0	0	0	0	0	0	0
23	Karaiar –S.Muttaiyan Kovil	13	0	0	0	0	0	0	0	0
24	Tirukarangudi – Trivannamalai Mottai	15	0	0	0	0	0	0	0	0
	Total	317	643	2	14.5	0.1	0.1	0.34	0.17	0.31
	Mean	13.2	26.8	2	14.5	0.1	0.1	0.29	0.14	0.27
	SE	1.26	6.1	0.5	4.61	0	0	0.07	0.05	0.07

Dist = Distance covered (km), No.D.P = Number of dung Piles, Er = Encounter rate/km
Si = Sighting interval (in minutes), F: Fresh dung piles, 2W: 2 weeks old, 1M; one month old, >1m: More than one month old, Vo: Very old.

Kalakkad and Mundanthurai Tiger Reserve (KMTR), situated in the southern end of Western Ghats in Ashambu hills,   is biologically rich and known for its endemism and the rich forests of the reserve are the catchments for many rivers and streams. There is no compact evergreen forest elephant habitat in southern India other than KMTR. The study demonstrates the value of short term, but rapid surveys in understanding the spatial pattern of distribution of Asian elephant (Elephas maximus) and its habitat usage pattern in the Reserve. The current study is significant, as not many surveys or studies on elephants and their status have been conducted in this region prior to this survey.