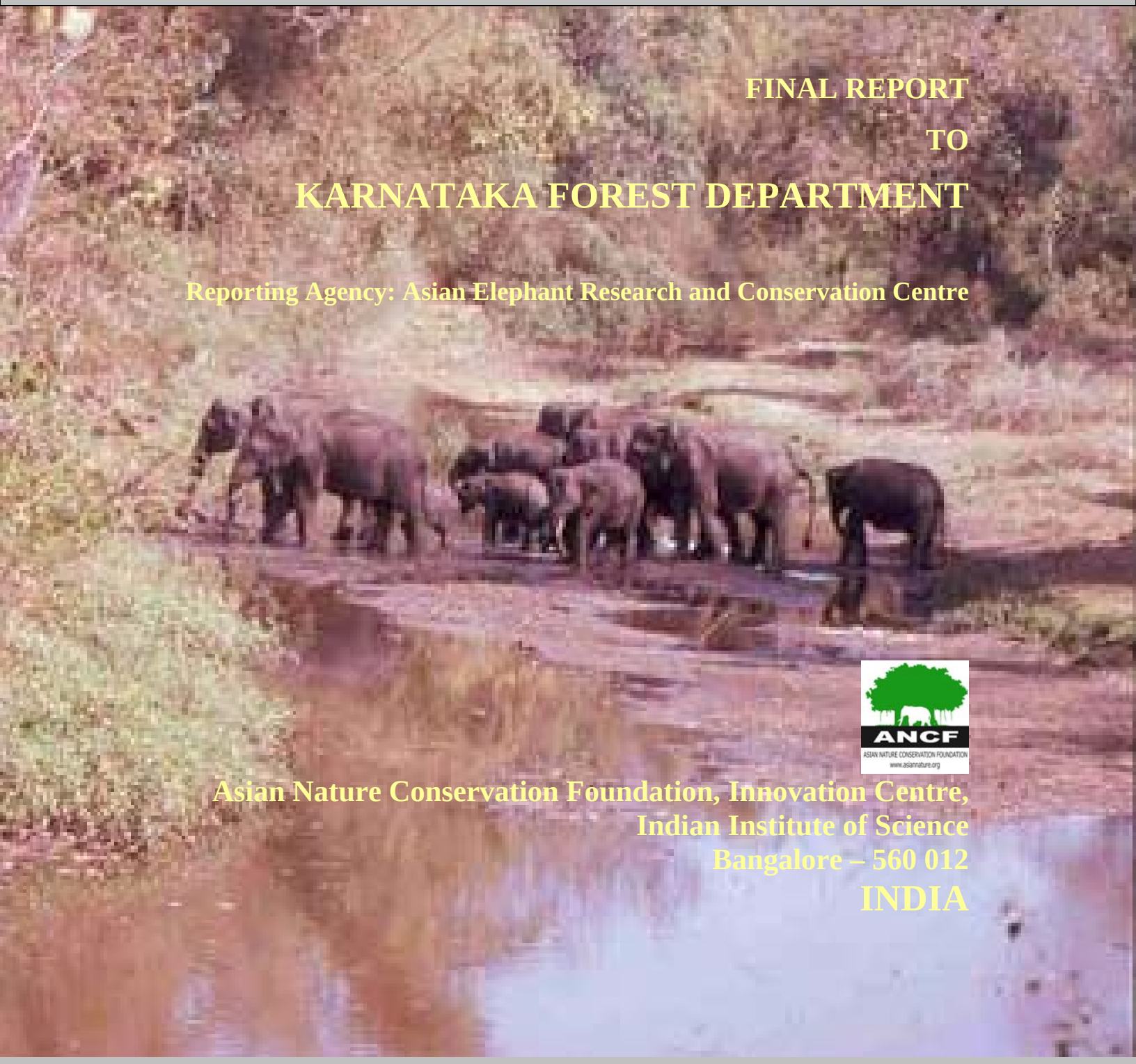
SOUTHERN INDIA ELEPHANT CENSUS 2007



FINAL REPORT

TO

KARNATAKA FOREST DEPARTMENT

Reporting Agency: Asian Elephant Research and Conservation Centre

Asian Nature Conservation Foundation, Innovation Centre,
Indian Institute of Science
Bangalore – 560 012
INDIA

SEPTEMBER 2007

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Report by

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ACKNOWLEDGEMENT

This report was prepared at the request of the Karnataka Forest Department to assist them in conducting the synchronized elephant census among the southern states during May 2007. We thank the Shri A. K. Varma, IFS, for offering ANCF this opportunity to compile the 2007 elephant census data, and Shri I. B. Srivastava IFS for his continued interest.

We also thank the Deputy Conservators of Forests from elephant-bearing forest divisions of Karnataka for providing logistical support to the technical teams during the census programme.

We thank Mr. Thomas Mathew, Executive Director, Asian Nature Conservation Foundation, Indian Institute of Science, Bangalore for his critical inputs to the report.

We acknowledge Mr. R. Arumugam (WWF India), Mr. B. Ramakrishnan (Wildlife Trust of India), Mr. A. Madhusudhan and our colleagues Mr. Surendra Varma, Dr. C. Arivazhagan and Mr. Mukti Roy for extending their valuable technical support in executing the census programme.

CONTENTS

I. INTRODUCTION

A synchronized elephant census was carried out in May 2007 by the southern Indian states under the auspices of Project Elephant, Government of India. Field data were collected between 7th and 9th May 2007 in the four southern states of Karnataka, Tamil Nadu, Kerala and Andhra Pradesh. At the request of the Chief Wildlife Warden, Karnataka, the Asian Elephant Research and Conservation Centre (AERCC), a division of the Asian Nature Conservation Foundation (ANCF), provided the initial training to field staff on field census methods, and also undertook the task of analyzing the data for various forest divisions in the state.

Project Elephant Directorate has recommended that two methods, a direct method (such as random block count) and an indirect method (such as dung count through line transects), could be used for estimation of elephant density and population size. In addition, we felt that a waterhole count for population structure, as was done during the census of 2002 and 2005, would be appropriate under forest conditions. A one-day workshop on elephant census techniques was organized on 27th April 2007 at Bandipur Tiger Reserve, for officers (CF, DCF and ACF) from all the elephant-bearing Forest Divisions of Karnataka by the AERCC in collaboration with the Karnataka Forest Department. During the workshop, detailed presentations and discussions took place on the relevance of three (sample block count, line transect dung count and waterhole count) methods, the rationale behind them and their applicability in a given division. Sampling design for different forest divisions and the proposed data analyses were also discussed. About a week prior to the commencement of the census operations, the field staff from most of the forest divisions were trained on various methods with special emphasis on line transect dung count, age-sexing elephants, etc. As per the decisions taken, block counts were conducted on 7th May, waterhole counts on 8th May and line transect dung counts on 9th May 2007 in all the elephant divisions of Karnataka. During the census operations, the major elephant-bearing divisions such as Bandipur, Nagarahole, BRT, Cauvery, Kollegal, and Bhadra were each supported by a researcher from AERCC.

II. METHODS

2.1. Sample block count

The forest division was taken as the unit of sampling. Elephants were counted within sample blocks selected randomly across the entire division. Between 30% and 50% of the beats were randomly selected and designated as census blocks on the compartment map of the division. These sample blocks were of unequal size and varied from 2 to 24 km^2; this depended on the size of the compartments or beats within each division and constraints of logistics with respect to number of staff available for the field operations. In 73% of the cases, the sample blocks were <10 km^2. A team of two forest staff along with 1-2 volunteers perambulated each sample block as thoroughly as possible on the day of the enumeration and recorded all elephant sightings. When possible, the sex and age class of the elephants seen were also recorded. Age and sex classifications were carried out using a key described in the section below on waterhole count. To arrive at estimates of mean elephant density, number of elephants and statistical confidence limits for each forest division, the sample block count data were analyzed for each forest division separately using the formula provided by Lahiri-Choudhury (1991, see below).

The number of elephants in the state was estimated by two methods:

(1) All the sample blocks (n = 411) from 19 forest divisions where elephants were enumerated during the block count survey were pooled together for analysis using the same formulae mentioned below, given that the number of sample blocks per unit area and total sampled area for various forest divisions was roughly the same across the state.

(2) In this method, the mean population size and 95% confidence intervals (upper & lower limits) for the state were arrived at by summing up the individual estimates for the 23 forest divisions.

Formula used for the statistical estimate of population density, numbers, upper and lower confidence limits for sample blocks of unequal area (Source- Lahiri-Choudhury 1991)

y_{ij} = No. of elephants in the j^{th} sample quadrat of the i^{th} stratum.

x_{ij} = Area in sq.km. of j^{th} sample quadrat of i^{th} stratum.

n_i = No. of sample quadrats in the i^{th} stratrum.

$y_i = \sum_{j=1}^{n_i} y_{ij}$ = Total no. of elephants in the sample quadrats of the i^{th} stratum.

$x_i = \sum_{j=1}^{n_i} x_{ij}$ = Total area of sample quadrats of the i^{th} stratum.

X_i = Total area of the i^{th} stratum.

$(Y_i/x_i) \times X_i$ = Estimate of total no. of elephants in the i^{th} stratum.

$\frac{Y_i}{x_i} \times 100$ = Estimate of elephant density in the i^{th} stratum.

$\sum_{i=1}^{6} \frac{Y_i}{x_i} X$ = Estimate of total no. of elephants in all the strata = estimate of total elephant population.

$v_i = \frac{X_i^2}{n_i(n_i-1)} \sum_{j=1}^{n_i} \frac{(y_{ij}-y_i)^2}{(x_{ij}-x_i)^2}$ = Estimate of the variance of total elephant population estimate of i^{th} stratum.

$\sum_{i=1}^{6} v_i$ = Estimate of the variance of total elephant population estimate for all strata.

$\sqrt{v_i}$ = Standard error of the estimate of total elephant population of the i^{th} stratum.

$\sqrt{\sum_{i=1}^{6} v_i}$ = Standard error of the estimate of total elephant population of all strata.

2.2. Line transect dung count method

In each forest divisions, line transects (Burnham *et al*. 1980) were laid in those blocks where the block count was undertaken. In each sample block a transect of length 2 km was laid across an altitudinal gradient where feasible and walked once to enumerate dung piles. On sighting dung piles, the perpendicular distance of the pile from the line and the degradation stage of the dung pile were recorded. The line transect dung count data were used to estimate dung density using computer programme ***Distance Version 5*** and this dung density was converted into elephant density through ***Monte Carlo simulations*** using the programme ***GAJAHA Ver. 2.0*** by incorporating elephant defecation rate and elephant dung decay rate. In the absence of specific data for the Karnataka elephant populations, the defecation rate (16.33 dung piles/day and SE = 0.8) calculated by Watve (1992) in Mudumalai Wildlife Sanctuary (Tamil Nadu), and a decay rate of 0.0097 dung piles/day (SE = 0.002) as calculated by Varman *et al.* (1995) also at Mudumalai were used in the present analysis. The following formula was used in the dung count calculation (Barnes & Jenson 1987).

$$E = \frac{Y \times r}{D}$$

E = Density of elephants

Y = Density of dung

r = Daily rate of dung decomposition

D = The number of dung piles deposited/elephant/day

2.3. Population structure from waterhole counts and block counts

2.3.1. Waterhole count

Water sources such as streams, rivers and waterholes were chosen within or close to the randomly chosen compartments or blocks in each division to record the population structure of elephants under conditions of good visibility. Observations were made on the

elephants visiting these points by teams sitting on a tree, *machaan* or hide. These data were collected on 8th May 2005. During this period all elephants visiting the waterhole were sexed as being male or female.

In order to construct the age structure of the population, elephants were classified into four major age classes based on their heights - *i.e*. calf (<1 yr old; <120 cm height), juvenile (1 yr to 5 yrs old; 121 -180 cm), sub-adults (5 yrs to 15 yrs old; 181 - 210 cm for female and 181 - 240 for male) and adults (15 yrs; >210 cm for female and >240 cm for male) based on shoulder height as suggested by Sukumar *et al*. (1988). Individuals were recorded as 'Unidentified' if they could not be categorized into a specific age and sex.

2.3.2. Block count:

During the sample block count, apart from recording the number of elephants within the sample block, the age and sex of all animals seen were recorded when possible. Age/sex classification was done as described for the waterhole count. Aging and sexing elephants is easier at waterholes than while carrying out block counts where visibility is often poor due to dense undergrowth. However, this was carried out in order to have a larger sample size in some of the divisions that have low elephant densities.

III. RESULTS AND DISCUSSION

3.1. Elephant population size

3.1.1 Block count method

The census was carried out in 23 forest divisions in Karnataka (**Table 1**). A total of 1912 elephants was recorded by the survey teams during block counts within the 23 forest divisions. The data were analyzed both by pooling the sample blocks state-wise, as well as analyzing them division-wise and summing up. The state-wise analysis estimated a mean population of 4,219 elephants with a lower (95%) confidence limit of 3808 and an upper limit of 4,629 individuals. The division-wise analysis and summing up came up with a mean estimate of 3,935 elephants (2,677, lower and upper 5,196 - 95% confidence limits).

The present estimates for the state are comparable with that of 2005 estimate made by summing up the divisional estimates (4347 range from 2375 to 6784 elephants – **Appendix I**) but considerably lower as compared to 5800 elephants estimated during the census of May 2002 (**Appendix II**). Such differences in the estimate of elephants for the state may not necessarily reflect any significant population size reduction overall in the region but could also be due to shifts in spatial distribution of elephants between May 2002 and May 2007; a factor mostly influenced by inter-annual variation in climatic conditions. It is worth mentioning here that the rainfall was significantly lower during 2002 as compared to 2007 across the region. The elephants from Karnataka also range into adjoining forest divisions of Kerala and Tamil Nadu. Thus, for wide ranging species like elephants, a comprehensive assessment at population or landscape scale covering the forest divisions of contiguous elephant habitats in various states is essential to understand any fluctuations in the population size within a state or region. For example, in Kerala the estimated total number of elephants was 3850 during 2002 and it decreased marginally (3565 elephants) in 2005 and in 2007 the number rose drastically to 6068 elephants. Similarly Tamil Nadu also experienced considerable fluctuation between the three estimates (from 3052 elephants in 2002, it rose to 4015 elephants in 2005 and decreased

Table 1: Elephant population estimated using sample block count for the forest divisions of Karnataka during May 2007.

S. No.	Division	Elephants sighted	No. of blocks [area sampled, km^2]	Mean elephant density/ km^2	Division area km^2	Estimated mean elephant population	95% CL	
							LCL	UCL
1	Bandipur	486	57 [438.48]	1.1	906.3	1005	741	1268
2	Nagarahole	300	36 [326.44]	0.9	643.4	591	395	787
3	BRT WLS	331	49 (309.72)	1.08	540.0	581	417	745
4	Bhadra WLS	106	30 [158.97]	0.6	492.3	331	210	452
5	Cauvery WLS	129	22 (235.33)	0.6	519.0	285	163	406
6	Kollegal	136	47 (608.37)	0.2	1222.0	273	194	352
7	Virajpet	41	34 [95.5]	0.4	337.0	159	105	213
8	Bannerghatta	87	9 [61.33]	1.4	104.0	148	105	191
9	Mysore [T] *	34	5 [57.18]	0.59	176.7	105	34	208
10	Hunsur [T]*	54	7 [39.5]	1.37	71.4	98	54	117
11	Mandya	24	4 [44.5]	0.53	96.9	52	29	75
12	Brahmagiri	19	10 [97.6]	0.19	181.0	35	27	44
13	Dandeli WL	3	29 [182.07]	0.02	894.5	15	9	20
14	Hassan	13	4 [172.7]	0.08	249.6	23	14	25
15	Chikmagalur *	7	10 [59]	0.12	59.0	7	7	12
16	Madikeri - WL	2	14 [77.1]	0.03	197.7	5	2	8
17	Madikeri [T]$^{\$}$	16	16 (45.47)	0.26	373.2	98	47	149
18	Bangalore Rural$^{@}$	115	26 (353)	0.33	353	115	115	115
19	Nugu WLS$^{@}$	9	2 (20.32)	0.4	20.32	9	9	9
20	Koppa	0	0	0	??	0	0	0
21	Karwar	0	0	0	??	0	0	0
22	Haliyal	0	0	0	??	0	0	0
23	Yellapur	0	0	0	549	0	0	0
	Total for the State^{+}	**1912**	**411 [3381. 58]**	**0. 57**	**7437. 25**	**4205**	**3800**	**4610**
	Total for the State$^{!}$	**1912**	**411 [3381.58]**			**3935**	**2677**	**5196**

* In divisions where LCL figures were less than the elephants counted during sample block count, the number of elephants counted during the block count is treated as LCL.

$^{\$}$ Of the 37 blocks sampled, block sizes are given only for 16 blocks, which also vary widely from 15 - 0.1 km^2 and appear as approximate sizes.

$^{@}$ Total count

$^{+}$ Pooled data of 19 forest divisions (excluding Koppa, Karwar, Haliyal and Yellapur Forest Divisions where no elephants sighted)

! Total for the state has been arrived by adding the figures of all the forest divisions.

to 3867 elephants in 2007). Therefore, it is possible that a drop in elephant numbers in Karnataka may have been due to their movement into adjoining habitats of Kerala and Tamil Nadu during May 2007. It is also possible that changes in visibility between years due to climatic conditions has influenced the estimates of elephant numbers by the block count method. For instance, the visibility during 2002 was much higher because of lower

rainfall and lesser vegetation growth, while during 2007 the undergrowth was much denser as a result of higher than normal rainfall during 2006. Undercount of elephants is therefore distinctly possible during the 2007 census.

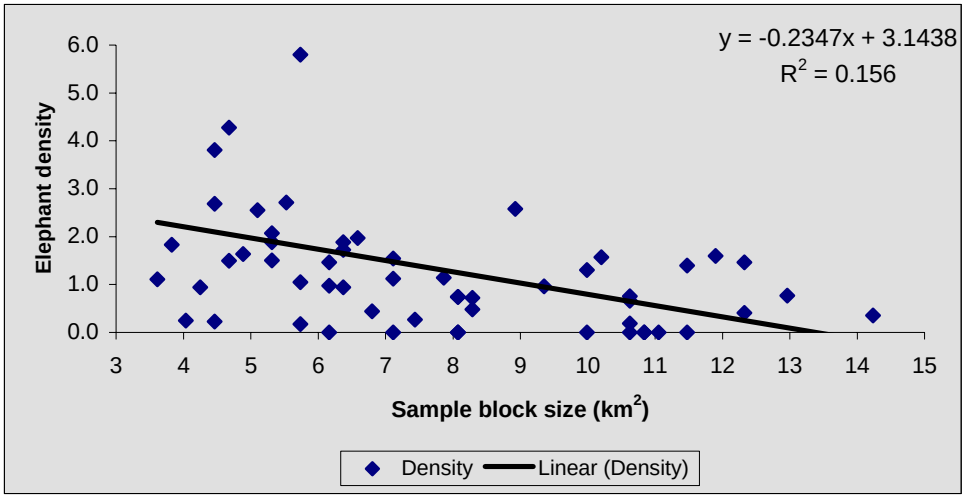
Influence of sample block size on detection rate

Another important drawback in the block count estimate was sample block size. Considering the field situation (visibility) and feasibility (hilly nature of elephant habitats), it was suggested that a smaller sample block size of 4-5 km^2 be used for the block count method. However, the sample blocks of many of the forest divisions were significantly larger than the size recommended, which is likely to result in undercount of elephants within the sample blocks by the survey team. For example, the mean, minimum and maximum block sizes used in some of the important elephant bearing forest divisions are shown in **Table 2**. It is unlikely that sample blocks larger than 4-5 km^2 areas would have been perambulated thoroughly without underestimating the number of elephants found within the block. In support of the above statement, the estimated elephant densities in relation to sample block sizes (**Fig. 1**) show a decline in the density with increase in sample block size, with relatively higher number recorded or densities of elephants estimated in sample blocks up to 4-5 km^2, indicating that the survey team is less likely to locate and record all the elephant groups in the larger-sized sample blocks.

Table 2: Some observations on the sample block count carried out during May 2007

S. No.	Division	Remarks from sample block count
1	Bandipur Tiger Reserve	Raw data with exact block size provided but it is mentioned that only 80-90% of the block area may have been covered by the enumeration team. So we have taken this as 85% (mean of 80-90%) of the block size sampled. **Mean block size = 7.7 km^2** (varied from 3.6 –14.2 km^2).
2	Nagarahole NP	**Mean block size = 9.07 km^2** (4.4 to 20 km^2)
3	BRT WLS	**Mean block size = 6.3 km^2** (3.9 – 9.9 km^2)
4	Kollegal	**Mean block size = 12.94 km^2** (2-24 km^2)
5	Cauvery WLS	**Mean block size = 10.7 km^2** (3.4 – 20.4 km^2)
6	Bhadra WLS	**Mean block size = 5.3 km^2** (4 – 6 km^2)
7	Bannerghatta NP	**Mean block size = 6.8 km^2** (5.5 – 10 km^2)
8	Madikeri Territorial	Of the 37 blocks sampled, block sizes are given only for 16 blocks, which also vary a lot from 15.0 to 0.1 km^2. All the block sizes seem to be approximate.

Figure 1: Relationship between sample block size and estimated density of elephants (data from Bandipur Tiger Reserve). ($P < 0.05$, $R^2 = 0.156$)



3.1.2. Line transect dung count method

The detailed analyses carried out for dung count data from various forest divisions are shown in **Table 3**. Multiple analyses were carried out for most of the forest divisions with different levels of cutoff of perpendicular distance in the model. Analysis with smaller AIC (*Akaike Information Criteria*) as suggested by the programme *Distance* was used to select the appropriate cutoff (analysis) for each division. For most of the divisions, the density results obtained from dung count do not match with the sample block count density figures. This can be partly expected because the dung count could reflect the average density of elephants over the previous 3-4 months of the census operations, while the direct count reflects the density on the day of the census. The other possible reason for the overestimation in dung count could be steady state assumption. In some areas especially during dry season or areas with low rainfall lower decay rates result in dung pile deposition rate exceeding the dung decay rate and thus steady state assumption does not hold. To avoid such a situation, it is appropriate to carry out the dung count twice a year covering both wet and dry season and take the mean of these two estimates. Further it is also essential to estimate the dung decay rates covering various habitat types with different rainfall regime so as to precisely estimate the population size. In the absence of

such data, we used dung decay rate data collected from Mudumalai Wildlife Sanctuary about 10 years back.

Table 3: Elephant population estimated using the line transect dung count method in various Forest Divisions of Karnataka during May 2007

Division	Details of analysis			Elephant density /km^2			Total Area	Estimated population size		
	T. length covered (km)	Cut off (m)	Dung density (km^2)	Mean	LCL	UCL		Mean	LCL	UCL
Bandipur TR	104	14	1971	1.2	0.69	1.8	906.3	1069	625	1604
Nagarahole NP	80	14	3316	2.0	1.1	2.9	643.4	1267	733	1872
BRT WLS	78.16	14	688	0.4	0.22	0.63	643.4	257	142	405
Bhadra WLS	52.9	16	3488	2.1	1.2	3.1	492.3	1024	581	1511
Cauvery WLS	47.8	16	1606	0.96	0.54	1.53	519	498	280	794
Kollegal	112	18	674	0.4	0.24	0.61	1222	489	293	745
Virajpet	58	14	299	0.18	0.1	0.23	337	61	34	78
Bannerghatta	44	15	1919	1.1	0.69	1.81	104	114	72	188
Mysore	10	12	787	0.46	0.25	0.75	176.7	81	44	133
Hunsur	15	14	2211	1.32	0.75	2.05	71.4	94	54	146
Mandya	8	22	4291	2.6	1.05	4.6	96.9	249	102	446
Brahmagiri	20	16	1467	0.9	0.5	1.4	181	163	91	253
Dandeli	58	15	253	0.2	0.1	0.2	894.5	134	89	179
Hassan	34	7.5	132	0.08	0.04	0.12	249.6	20	10	30
Chikkamagalur	14.8	8	466	0.28	0.13	0.43	59	17	8	25
Madikeri WL	27.95	18	606	0.36	0.19	0.56	197.7	71	38	111
Madikeri	62	16	361	0.21	0.12	0.33	373.2	78	45	123
Bangalore Rural	52	16	422	0.25	0.11	0.44	353	88	39	155
Haliyal	174	10.8	5.3	0.003	0.001	0.006	1166	3	1	7
Koppa	28	7	241	0.14	0.06	0.26	??			
Total	**1081**						**8686**	**5780**	**3280**	**8807**

In total, using the dung count method a mean of 5780 elephants have been estimated for the 19 forest divisions, which is higher than the estimate from the sample block count by ~ 1500 elephants. In the dung count method some of the forest divisions such as Nagarahole NP, Bhadra WLS, Cauvery WLS, Kollegal FD, Mandya FD, etc showed elephant densities far higher (~100%) than the sample block count method.

3.2. Elephant population structure

Overall, 3445 elephants were counted during the sample block and waterhole counts in 23 forest divisions. Of this, 2404 elephants (70%) were age-sexed and the rest were either unidentified (*n* = 76) or not aged (*n* = 965). The highest number of elephants was counted at Bandipur Tiger Reserve (*n* = 965) but for all these individuals sex alone was recorded and age-class details were not recorded except for calves. Age-sex compositions of these 2404 elephants show that 52% of the population consisted of adults and the rest (48%) by younger classes of sub-adults, juveniles and calves (**Table 4**). The percent composition of adult segment (52%) in the population arrived at from 2007 census data is lower compared to 2005 census data (nearly 60% see **Appendix III**). However, there appears to be some misclassification of age classes in the census data. For example, age structure estimated by a more scientific study (Arivazhagan and Sukumar 2005) in Nagarahole National Park has shown that the adult, sub-adult, juvenile and calves comprised 43.5%, 26.3%, 22.7% and 7.4% of the elephant population, respectively. In comparison the 2007 census data of Nagarahole NP showed considerable variation in age structure (51% adult, 19.6% sub-adult, 14.7% juvenile and calf 14.7%) in age structure. Even the elephant population in Periyar Tiger Reserve, Kerala, with a significantly lower birth rate compared to Nagarahole has only 48.4% of individuals in the adult segment (Arivazhagan and Sukumar 2005). Therefore it is very unlikely for either Nagarahole (with relatively high birth rate) or the entire Karnataka region to have an adult segment greater than 50% of the population.

Table 4: Percentage of various age and sex classes of elephants during sample block and waterhole counts in various Forest Divisions of Karnataka during May 2007 (*n* = 2404)

Age class	Age structure (%)			Sex ratio M : F
	Male	Female	Total	
Adult	16.8	35.3	52.0	1: 2.1
Sub-adult	4.5	15.1	19.5	1: 3.4
Juvenile	4.4	9.7	14.1	1: 2.2
Calf	7.2	7.2	14.4	1: 1.0
Total	**32.8**	**67.2**	**100**	**1: 2.0**

Sex Ratio:

Overall male to female ratio for all the divisions together was 1:2.0 (**Table 4**). However, when we look at the sex ratio of various age classes there are only marginal differences that may not reflect the real situation. For example, among adults the male to female ratio was 1:2.1, while the skew increases to 1 male for every 3.4 females at the sub-adult stage and drops to 1:2.2 for the juveniles.

It is unlikely that elephant populations would have such patterns in sex ratios considering that the elephant is a polygynous species where sex ratio at birth is expected to be equal and may begin skewing towards females gradually with increasing age. Therefore, skew is expected to be higher at the adult stage than in the sub-adult and juvenile segments. In Asian elephants we also have to consider the human factor (ivory poaching), which can be expected to selectively remove adult and sub-adult males (tuskers) from the population, and thus the skew is expected to be even higher than the natural condition in the adult class as compared to sub-adult or juvenile classes. In a population where ivory poaching pressure is relatively low as in northeastern India (Sukumar *et al*. 2003), because of the high proportion of tuskless males (*makhnas*), the sex ratio among adults is about 1:2.5 to 1:3 (male to female). As southern India has experienced much higher poaching pressure than northeastern India (Sukumar 2003), Karnataka is unlikely to have a sex ratio of 1:2.4 among adults as the census figures show.

Overall, there appeared to be some misclassification of adult females as sub-adults. Thus we find records of female herds without adult females but with sub-adult females, juvenile females and calves (*e.g.* Bannerghatta). Similarly, sub-adult males also seem to have been misclassified as adults, as the total number of sub-adult males counted [*n* =107] was significantly lower than adult males [*n* = 403] across the state. Adult males mostly live a solitary life. However, not all solitary males are adults, because sub-adult males (around 10-14 years) often temporarily move away from maternal herds before their permanent dispersal and adulthood; there are also chances of permanent dispersal at late sub-adult stage (about 12-14 years). Further, it is possible to misclassify a sub-adult male as an adult male when a sub-adult male is alone, as there are no adult animals for comparison while aging. Such misclassification of adult females as sub-adult females and of sub-adult males as adult males biases the results towards a more equal sex ratio than is likely.

Table 5: Sex ratio of elephants estimated by research projects carried out in Nagarahole National Park during 2001 – 05 (Source: Arivazhagan and Sukumar 2005).

Age-class	**Nagarahole - 2001**	**Nagarahole - 2002**	**Nagarahole - 2003**	**Overall**
	Male : Female	**Male : Female**	**Male : Female**	**Male : Female**
Adult	1 : 4.8	1 : 6.6	1 : 5.9	1 : 5.8
Sub-adult	1 : 1.1	1 : 1.4	1 : 1.2	1 : 1.2
Juvenile	1 : 1.1	1 : 1.2	1 : 1.3	1 : 1.2

IV. RECOMMENDATIONS FOR FUTURE CENSUS PROGRAMMES

Some of the issues related to census methodology and technical capacity requirements that may need to be addressed in preparation for future census programmes are listed.

Sample Block Count

- In comparing the data for sample block sizes with their respective estimated elephant densities (sighting) it is seen that highest density of elephants is recorded for sample blocks of size ranging from 4 –5 km^2. The estimated densities start declining gradually with increases in sample block size beyond the abovementioned range (Fig. 1). This result suggests that block sizes of 4-5 km^2 would be optimal for being covered effectively by a single survey team without missing out elephants in a sample unit. The probability of detecting and enumerating all the elephants in sample blocks of sizes above 5 km^2 would decrease with an increase in block size resulting in underestimation of elephant numbers. Prior to the census operation it was suggested that a 4 km^2 sampling area would be appropriate for each sample block. However the data shows that the number of sample blocks above 5 km^2 in size surveyed accounted for about 65% of total sample blocks surveyed across all the forest divisions. Therefore, it is likely that the sample block count in the 2007 Census underestimated the population size of elephants for the state. Importance needs to be given to this vital component in future census programmes to improve accuracy of census figures.

Coverage Area and Staff Strength

- There is a feeling among FD officers that 40-50% of the total area of each forest division must be covered in the census programme. In actual practice it is not possible to cover such a large area with the available manpower and infrastructure. For example in Bandipur, out of 900 km^2 of total area, to cover 40-50% of the total area using sample block sizes of 5 km^2 would require 72 – 90

sample blocks to be surveyed. However the total number of sample blocks actually covered range between 38 and 59 in the past synchronized elephant censuses since 2002. Thus it is not realistic with existing resources to cover 40-50% area in each forest division. Any attempt to do so with present staff strength without keeping in view the need for smaller sample block sizes will result in underestimation of elephant population size.

Line Transect Dung Count Method

- Although there has been some improvement in the quality of data collected by the Line Transect Dung Count during 2007 census, as compared to earlier censuses in 2002 and 2005, there is still need for considerable improvement to obtain reliable estimates. From the data it is evident that most of the important forest divisions such as Nagarahole BRT, Bhadra, Cauvery etc yielded elephant density estimates significantly higher or lower than the sample block count method. Intrinsic problems in the methodology such as the accuracy of the 'steady state assumption' and the lack of accurate estimates for dung decay data for the concerned forest divisions could contribute to a lack of precision. However other sources of error include infringement of the basic conditions for the use of line transects (*e.g.* only dung piles seen from the line by the observer to be recorded, accurate estimation of perpendicular distances from the line transect, avoidance of rounding off of perpendicular measurements etc) by field level staff due to lack of experience could also result in inaccurate estimates. Although Karnataka harbours the major share of the elephant population of southern India and deserves special importance, no targeted training programmes have been conducted for the field staff unlike in Tamil Nadu and Kerala. It is therefore essential that all field level staff need to be exposed to new methods like the line transect method through a special training programme.

- Carrying out the dung count method during the month of May is not ideal, as it is a transitional period between the dry and wet seasons. Because the 'steady state assumption' for the dung may not hold in such a transition period, it would be desirable to carry out the exercise in the middle of dry and wet seasons. Further it is important to move ahead from the present exercise of one time a year to at least twice a year (one time each in the dry and wet seasons) so as to obtain a reliable estimates with better understanding of seasonal influence on the dynamics of elephant dung piles in the system and on the distribution pattern of elephants.

Population Structure Data Collection

- Since the 2002 synchronized elephant census, the quality of the data on population structure has shown no improvement indicating a major lack of experience among field staff. The sex ratio for the state is female biased more in sub-adults than in adult, which is unlikely given the filed realities. The estimated age structure and sex ratios for the important elephant bearing forest divisions during census programmes are also not comparable with that of the figures reported by scientific studies. This aspect of the census also demands systematic training of staff. It would be ideal to train a selected number of skilled staff from each forest division in population structure data collection.

- A systematic collection of population structure data by trained staff on a regular basis (when they go for routine field perambulation) together with the recording of accurate annual mortality data would greatly help achieve more detailed and accurate demographic analyses including the assessment of natality, mortality, fecundity and so on.

General suggestions

- The Synchronized Census needs to be conducted at regular intervals. Unfortunately the periodicity has not been maintained in the past. The first one

was conducted in May 2002, the second one after an interval of three years in May 2005 and the third one after a two year gap during May 2007. An interval of three years (or ideally a four year period) would be appropriate for long living animals like elephants with wider inter-calving interval (4-6 yrs).

V. APPENDICES

Appendix I: Elephant population estimated using sample block count for the forest divisions of Karnataka during 2005 synchronized elephant census.

S. No.	Division	No. of elephants sighted	No. of blocks [area sampled, km^2]	Mean elephant density/ km^2	Division Area km^2	Estimated population size	95% CL	
							LCL	UCL
1	Bandipur	459	38 [459]	1.34	906.32	1217	825	1610
2	Nagarahole	328	21 [262]	1.25	643.36	804	459	1149
3	Bhadra WLS	135	10 [124.4]	1.09	492.3	534	178	891
4	BRT WLS *	173	NA [207.7]	0.83	583.67	486	173	1052
5	Virajpet	60	28 [60]	0.88	337	297	142	332
6	Cauvery WLS	202	36 [236.6]	0.85	510.5	445	255	636
7	Kollegal	49	66 [398.5]	0.12	1145	151	114	188
8	Madikeri [T]	26	12 [131]	0.2	373.22	75	32	116
9	Bannerghatta *	52	4 [73.5]	0.71	104	74	52	160
10	Hunsur [T] *	16	4 [22.2]	0.72	142.7	16	16	114
11	Madikeri - WL	26	8 [82]	0.32	197.66	63	16	110
12	Hassan *	42	13 [140.22]	0.3	249.6	75	42	222
13	Bangalore Rural*	29	8 [84.12]	0.34	84.12	29	29	51
14	Mysore [T] *	11	4 [67.42]	0.16	131.52	17	11	47
15	Brahmagiri	7	5 [53.69]	0.07	181	13	6	21
16	Chikkamagalur **	8	16 [NA]	NC	??	8	8	8
17	Mandya *	7	4 [85.4]	0.08	96.9	8	7	18
18	Dandeli *	5	59[346.09]	0.02	894.53	26	5	37
19	Belgaum	2	84 [NA]	-	1448.82	2	2	2
20	Karwar *	2	62 [455.5]	0.004	1421.78	6	2	19
21	Shimoga	1	NA		826.6	1	1	1
22	Haliyal	0	147 [359]	-	1421.78	0	0	0
23	Yellapur	0	100[??]	-	548.8	0	0	0
24	Koppa	0	46 [NA]	-	??	0	0	0
25	Bangalore Urban	0	1 [11.8]	-	??	0	0	0
26	Sirsi	0	60 [NA]	-	??	0	0	0
	Total	1640			12741.2	4347	2375	6784

* Divisions where LCL figure was towards minus side due to poor sample size or non-availability of block sizes, number of elephants sighted during the block count is shown as LCL.

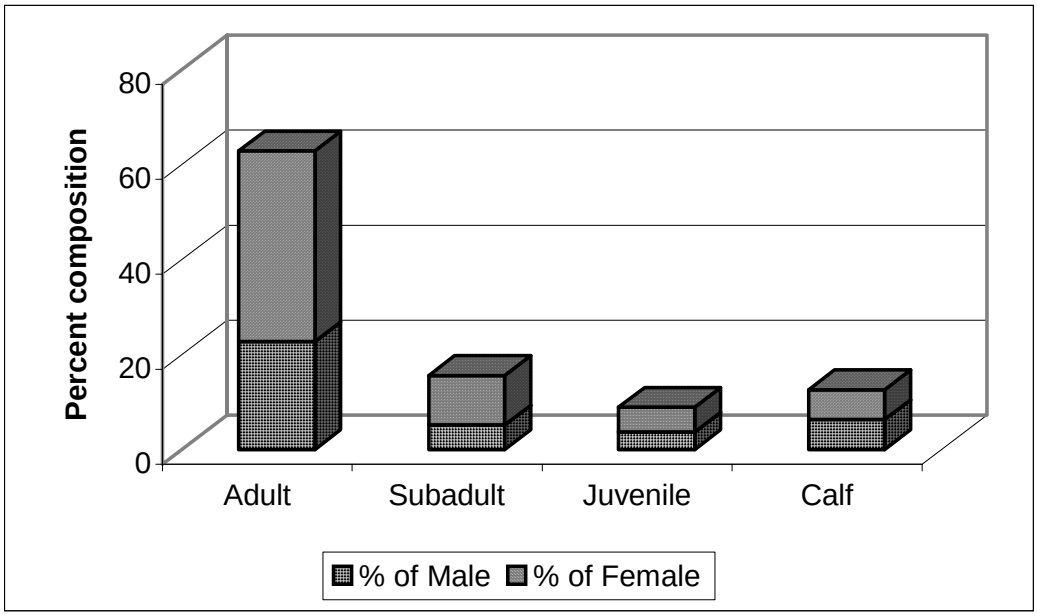
** Block sizes and total area of the division of the division not available

Appendix II. Elephant population estimated using block count method for various divisions in Karnataka during 2002 synchronized elephant census.

S. No	Division	No. of blocks sampled	No. of elephants counted	Total area km^2	Mean density and range of elephant numbers			Mean number of elephants
					Mean (number / km^2)	LCL	UCL	
1	Bandipur TR	59	843	874	2.26	1469	2487	1975
2	Nagarahole NP	57	555	642	1.78	842	1439	1143
3	Cauvery WLS	29	369	510.5	1.58	509	1109	807
4	BRT WLS	42	240	560.35	1.06	411	774	594
5	Kollegal	19	29	1145	0.31	190	518	355
6	Bhadra WLS	37	106	492.46	0.61	204	401	300
7	Brahmagiri WLS	13	32	181	0.65	50	184	118
8	Madikeri TT	36	42	373.32	0.23	64	105	86
9	Hunsur TT	8	33	104	0.7	18	126	73
10	Mysore	12	72	104	0.65	49	87	68
11	Bannerghatta NP	9	53	104	0.68	21	121	71
12	Hassan	2	27	384.8	0.22	27	85	56
13	Virajpet	34	25	336.96	0.15	33	68	51
14	Madikeri WL	11	24	197.66	0.25	18	81	49
15	Nugu WLS	3	25	32.32	0.82	12	41	27
16	Dandeli	34	3	834.74	0.02	11	23	17
17	Karwar	11	3	338.22	0.05	6	28	17
18	Belgaum	61	10	1448.82	0.015	21	22	22
19	Mandya	5	14	??		14	14	14
20	Chikamagalur	58	5	??		5	5	5
21	Haliyal	27	Nil	1165.9	NS	-	-	-
22	Yellapur	4	Nil	548.48	NS	-	-	-
	Karnataka	571	2510	10378.5	0.67	3974	7718	5848

LCL = Upper Confidence Limit, UCL = Upper confidence Limit
NIL – No sighting of elephant
?? – Block sizes and Total area of the Division not mentioned
TT – Territorial, WLS – Wildlife Sanctuary
WL – Wildlife Division, NP – National Park, TR – Tiger Reserve

Appendix III: Age structure of elephants recorded in various forest divisions of Karnataka during the 2005 synchronized elephant census (includes data from sample block and waterhole counts - *n* = 2030)



The very high % of adult class compared to other classes indicates that there could be misclassification of sub-adult class as adult class and also juveniles as calves.

PHOTO PLATES OF CENSUS PROGRAMME

Photo plate 1: Views of census team in preparation and on field surveys at Bhadra Wildlife Sanctuary and Bandipur Tiger Reserve

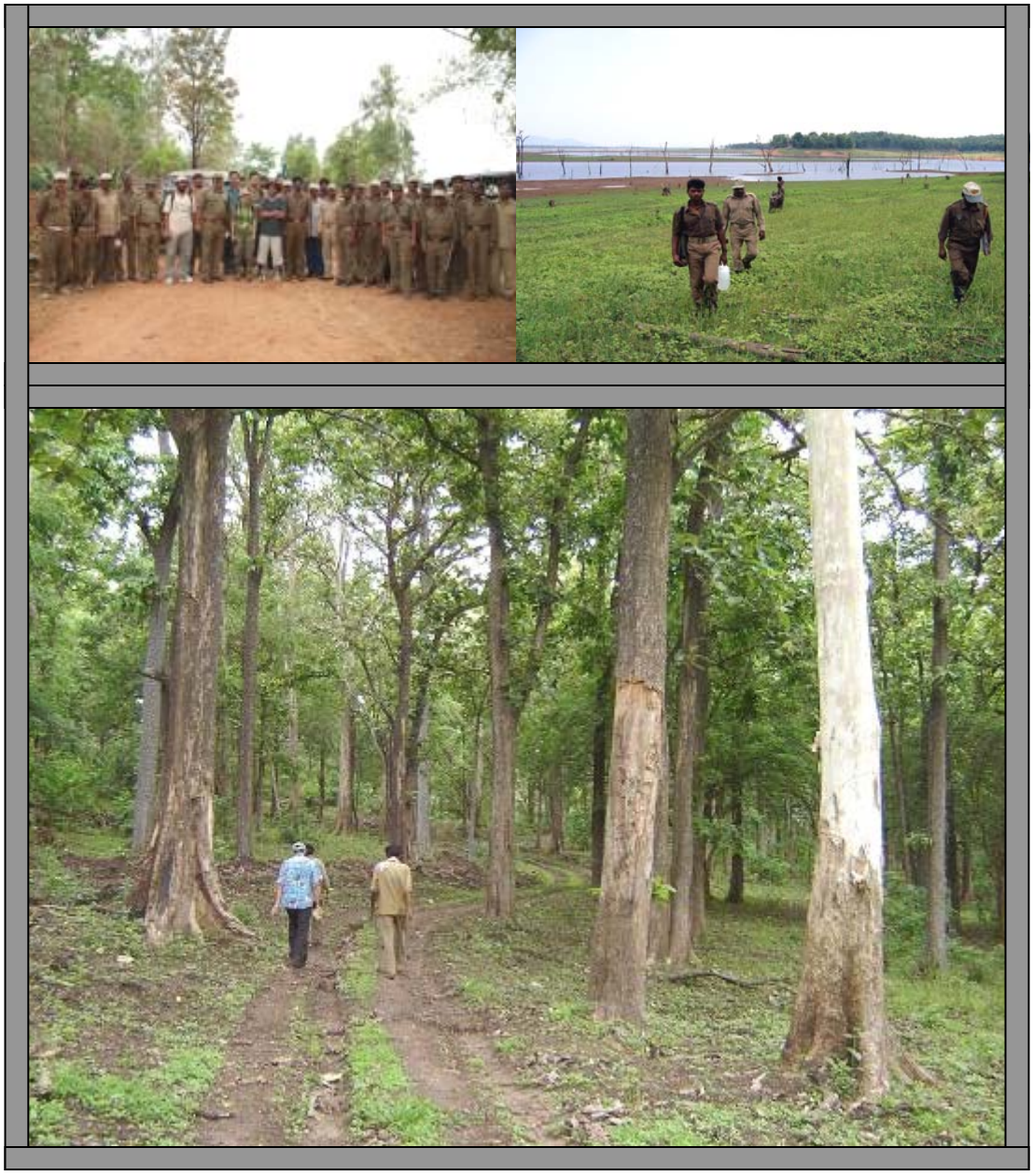


Photo plate 2: Views of elephant herds sighted in the waterhole at Bandipur Tiger Reserve during waterhole count

Photo plate 3: A small herd of elephants sighted in a swamp (*vayal*), a preferred microhabitat within the moist deciduous forest of Bandipur Tiger Reserve (top) and an adult bull sighted near the backwater area of Bhadra Wildlife Sanctuary (bottom)

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