

Assessment of occurrence and abundance of large mammals, birds and woody plants in Bannerghatta National Park, Karnataka

Technical Report



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Karnataka Forest Department
Government of Karnataka



Sálim Ali Centre for Ornithology
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**Submitted to
Karnataka Forest Department
Bannerghatta National Park, Bengaluru**

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Kumara, Saptha Girish and Murugesan

Chapter 1

Introduction and methods

Introduction

Increase in the human population all over the world, especially in the tropical countries, has caused loss of vegetation cover and potential habitats, which in turn has affected animal distribution. Furthermore, it has resulted in an uneven and highly clumped distribution of animals (Myers et al., 2000). Habitat loss due to human activities is the leading cause of species extinction (Pimm and Raven, 2000). Along with habitat destruction, game hunting and poaching of wild animals have also contributed to uneven distribution of animals as well as species extinction. Awareness regarding the effect of human interference on natural processes has led to the development of conservation and management strategies in order to retain and restore the remaining wildlife and habitats. For the past hundred years also, there has been an accelerated loss of wildlife, especially of the mammalian species, in India. Although a few steps have been initiated from time to time to protect wildlife, it was only in 1972, that a comprehensive act was promulgated (Wildlife (protection) act, 1972). One of the most significant outcomes of this act was the declaration of a large number of Wildlife reserves, Wildlife Sanctuaries and National Parks (Bisht, 1995), which are collectively known as the Protected Area Network today.

The preparation of any conservation action plan requires at the very least basic information on the importance of the given ecosystem including biodiversity, ecological and conservation status of species, distribution patterns and identification of critical area for each important species, evaluation of existing threats and solutions for resolving or reducing them. Despite the fact that many parks have been created in the country, the baseline data on species availability, abundance and distribution for even the major taxonomic groups are not available, thus the population monitoring and conservation efforts suffer. Such data is available only for some charismatic species or for areas with such species, but many other parks are being highly ignored from documentation and management effort. Bannerghatta National Park is one such protected area which requires detailed inventorying of different taxonomic groups.

Nagarahole-Nilgiris-Eastern Ghats elephant reserve in South India is one of the important conservation areas for elephants (*Elephas maximus*) in India with a minimum population estimation of about 6300 elephants in an area of 12,000 km². This reserve extends from the Brahmagiri hills in the north, Nilgiris in the south, and Eastern Ghats in the east in the states of Karnataka, Tamil Nadu, and Kerala, including few elephant herds in Andhra Pradesh (Asian Elephant Research and Conservation Centre, 1998). Bannerghatta National Park is part of this forest complex and one of the important areas for elephant conservation (Alva, 1994). Many anecdotal records of bird watchers and naturalists report presence of large number of mammal species and about 250 species of birds. However, systematic exploration has not been attempted in the park to document the occurrence of major taxonomic groups except for studies on various aspects of elephants and human-elephant conflict (Anand et al., 2009; Srinivasaiah, 2010). Towards this end, we explored and documented the occurrence and abundance of woody plants, birds and large mammals in the Bannerghatta National Park.

Bannerghatta National Park

Bannerghatta National Park lies between 12° 34' -12° 50' N and 77° 31' -77° 38' E, with an area of 104.27 sq. km. in the Bengaluru district (Fig. 1.1). Altitude varies from 740 to 1034 m asl, temperature from 20 to 35°C, and average annual rainfall is about 900 mm and is spread across eight months from April to November, the park receives maximum rainfall between August and October (Fig. 1.2). The park has mostly dry deciduous forests and thorny scrubs, with patches of moist deciduous forests along the streams. The park can be considered as the western tip of Eastern Ghats, and can *be* expected to have many elements of Eastern Ghats. The park is highly irregular in shape and measures a maximum of 26 km in length from north to south and the width varies between 0.3 and 5 km from east to west (Rajeev, 2002). Geographically, the park is contiguous with Tali Reserved Forest of Tamil Nadu state to the South-East and with Bilikal Reserved Forest of Karnataka state to the South-West. This further connects to the larger patch of forest of Cauvery Wildlife Sanctuary and Nilgiri biosphere reserve. By and large, the park has scrubs and deciduous forests, and moist deciduous and riparian vegetation along the valleys and streambed. A small quarter of the

northern part of the park has been developed as a Biological Park to attract people and for education purposes.

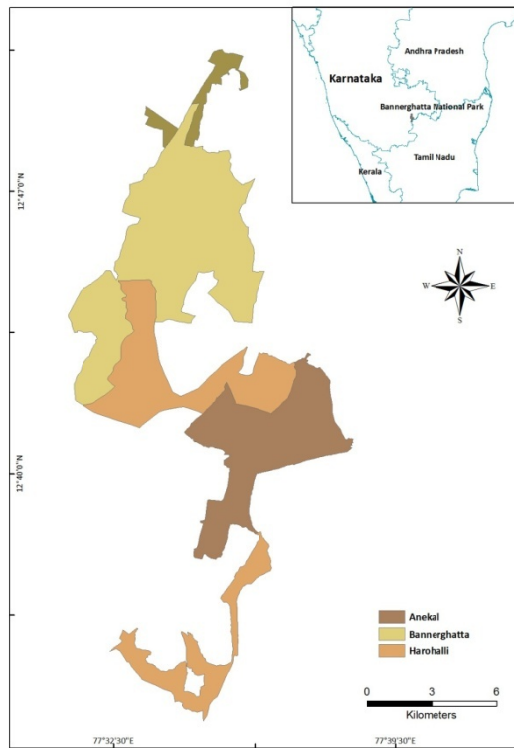


Figure 1.1 Map of the Bannerghatta National Park

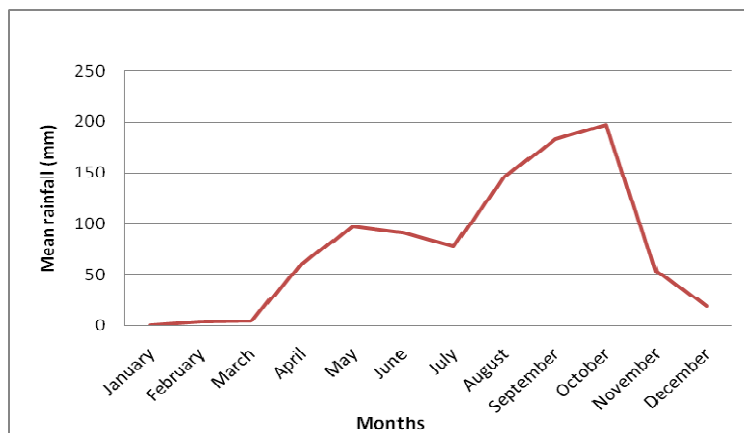


Figure 1.2 Mean monthly rainfalls for the period of 1991-2001

People in and around BNP

The park is surrounded by 117 human settlements within 5 km of the buffer zone from the boundary and 5 settlements within the park (Anand et al., 2009). Majority of the community is illiterate and belongs to the economically weaker sections of the society. Major source of income of these people depends on agriculture and to some extent on daily wages. Many quarries and sand mines are also found around the park, and local people work in these quarries and sand mines on daily wages.

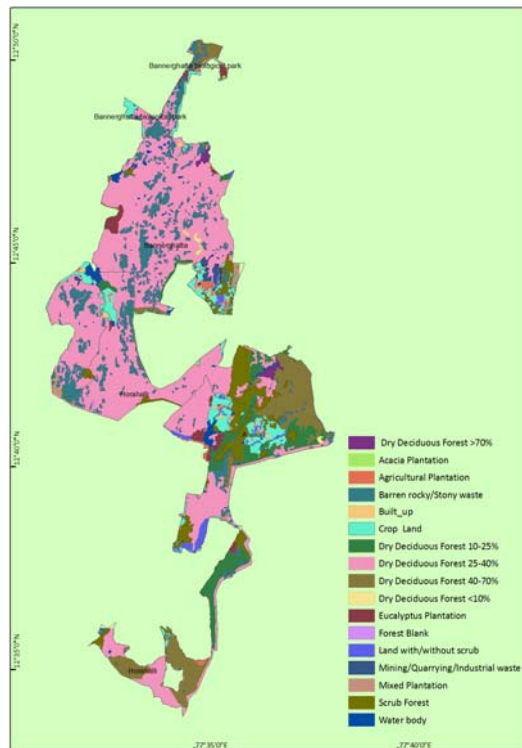


Figure 1.3 Vegetation map of the Bannerghatta National Park

Research in BNP

The BNP is expected to harbor large number of species of various taxa (Lal et al., 1994). BNP being located very close to Bengaluru, many bird watchers and naturalists have been going for birding in the region and have reported sight records of many bird species. Over the period more than 200 species of birds have been documented in BNP, many of which have been sighted rarely. However, no proper information is available on

other taxonomic groups, except the elephant. The census conducted by Karnataka Forest Department during 2007 projects 1.41 elephants per sq. km for the park Bhaskaran et al. (2007), and Anand et al. (2009) reported 0.71 elephants per sq. km. The rate of human-elephant conflict has increased in the last three decades, and was at its peak in the year 2001-2002. An average of two human deaths by elephants and one elephant death by people (may be by electrocution or poaching) was observed in and around the park between 1997 and 2002 (Rajeev, 2002). The recently concluded study by Srinivasiah (2010) highlighted the habitat utilization and spatial segregation between elephants and humans, and its implication value for conservation for BNP. Though BNP is expected to harbor large number of species of various taxonomic groups (Lal et al., 1994), attention has not been paid to document them which prompted us to undertake a short term study to establish a baseline data on occurrence and abundance of woody plants, birds and mammals in BNP.

Methods

The digital map of the park was acquired from the Karnataka Forest Department. A five square kilometer grid was overlaid on the map of the park. A diagonal line was fixed for each grid as a sampling line for the assessment (Fig. 1.4). Circular plots and quadrates were laid at regular interval of 200 m as sampling plots (Fig. 1.5) on the transect line. The required data was collected using these sampling plots. The details on field methods used for each taxonomic group are provided in the respective chapters. Finding the presence of small nocturnal mammals using the conventional methods like transect walk or plot search during the day is just not possible, hence we have also conducted the survey during the night for direct sightings of these animals.

The report: The current chapter (Chapter 1) provides background for the study and also highlights the importance of the study for Bannerghatta National Park. The other three chapters divulge the findings on the occurrence and abundance of woody plants (Chapter 2), birds (Chapter 3) and mammals (Chapter 4).

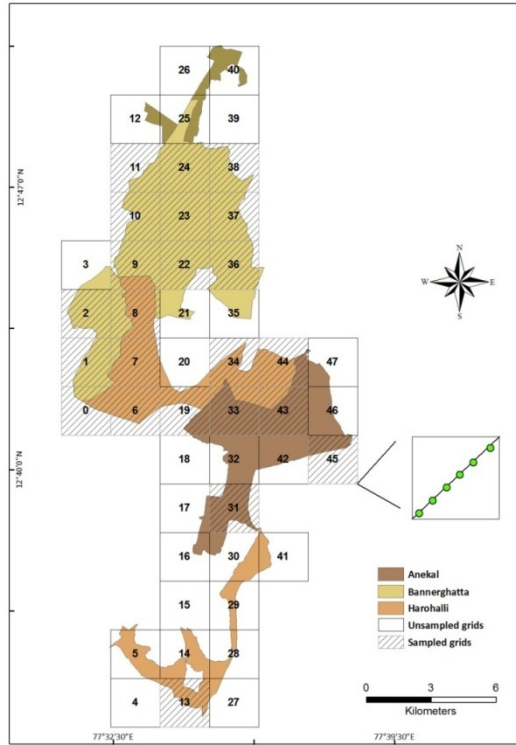


Figure 1.4 Sampling grids in the Bannerghatta National Park

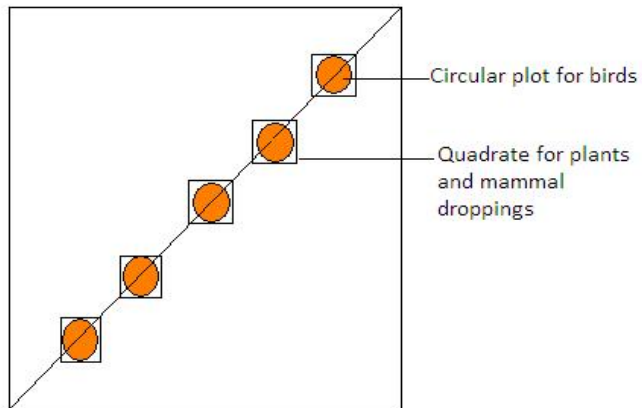


Figure 1.5 Showing the sampling plots (circular plots and quadrates) in the grid

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a. Valley covered by tree canopy at Bannerghatta range., **b.** Water hole at Bannerghatta range.,
c. Bamboo forest at Anekal range



a. Forest cover adjacent to huge granite rock in Bannergatta range.,
b. Water hole at Bannergatta range



Field activities during the survey period



Field activities during the survey period

Chapter 2

Occurrence and abundance of Woody plants in BNP

Introduction

In any ecosystem, the floral structure and composition determines the presence of animal species. Hence an understanding of the vegetation of the area is always important to understand other life forms. Vegetation in tropical countries is under constant threat and is showing drastic change. Since Bannerghatta National Park is narrow linear in shape and has high human density along the border, the vegetation of such condition is under transformation and is also prone to invasion by invasive species. In the present study we establish the existing stand structure of the vegetation of Bannerghatta National Park.

Methods

Vegetation is universally recognized as an integral component of ecosystems, which indicates the effects of changing environmental conditions in an obvious and easily measurable manner and is much important in site evaluation and classification. Hence, careful analysis of vegetation is very important to know the distribution and types of floral components in an ecosystem. For phytosociological analysis quadrat method was used in the present study, since it is the most widely used technique for plant census. Vegetation analysis was done in different habitats of Bannerghatta National Park, Bangalore.

In order to study the trees/woody plants of Bannerghatta National Park in general and to estimate the tree density in particular, quadrates of 25 x 25 m size were laid. A total of 164 such quadrates were laid by representing all the vegetation types during the present study period. Based on the length of the grid and presence of different kinds of vegetation a number of quadrates were laid varying from 5-12. Species with GBH (Girth at Breast Height) > 15 cm were considered as trees/woody species. The GBH of woody trees occurring in the 25 x 25 m plots were recorded and their girth measured at 1.3 m from ground level. For buttressed trees, measurements were made above the buttress as far as possible and for

lianas, 1.3 m from the base of liana stems. For multi-stemmed trees, bole girths were measured separately, basal area calculated and summed. Species encountered during vegetation sampling and surveys were recorded. Taxonomic identification of the species encountered in the field was done consulting the flora of Hooker (1872-97), Gamble (1957), Jain and Rao (1983) and Matthew (1999).

Table 2.1 Calculating quantitative structure and composition of plant communities

| Parameters | Formula adopted |
|-------------------------------|--|
| Frequency (%) | (No. of quadrates in which a species occurred/ Total no. of quadrates studied) × 100 |
| Abundance | Total number of individuals of the species/ No. of quadrates in which the species occurred |
| Density | Total no. of individuals of a given species/ Total no. of quadrates examined |
| Relative density | No. of individuals/ No. of individuals of all species |
| Relative abundance | (Abundance of species × 100) / Sum of all abundances |
| Relative frequency | Number of quadrates occurring/ Total no. of quadrates |
| Basal area | (GBH) ² / 4π |
| Relative Basal area | (Total basal area of Individuals/ Total basal area of all species) × 100 |
| IVI | Relative density + Relative dominance + Relative frequency |
| Family Relative density (%) | (Number of trees in a family/Total number of trees) × 100 |
| Family Relative Diversity (%) | (Number of species in a family/total number of species) × 100 |
| Family Relative Dominance (%) | (Total basal area for all species in a family/Total basal area of all families) × 100 |
| Family Importance Value (FIV) | Σ of Family relative density, diversity and dominance |
| Simpson diversity | D= Σ (n/N) ² |

The vegetation data was analysed to obtain the quantitative structure and composition of plant communities. For understanding the synthetic characters of forest vegetation, the species' richness and diversity of species' in the stands was calculated. The vegetation data was tabulated for frequency, density, abundance, relative frequency, relative density, relative abundance, relative dominance, IVI and composition of plant communities, following Curtis and MC Intosh (1950), Philips (1959). The Shannon-Wiener's index of diversity (H') was calculated using the software 'Species diversity and richness (version 2.65, Colwell, 1994-2004)'. FIV was calculated by using Mori et al. (1983). Table 2.1 provides formulae used to calculate each of the vegetation parameters.

Results

Tree Community Structure

A total of 5766 woody plants, belonging to 153 species (≥ 15 cm GBH), 109 genera and spread over 49 families, in 164 quadrates (25 x 25 m), were recorded in the study area (Table 2.2 and 2.3). The Woody plants community parameters, computed from the data are presented in Table 2.2. Among these, *Anogeissus latifolia* is represented by a maximum number of individuals ($n = 441$), followed by *Acacia chundra* ($n = 343$) and *Shorea roxburghii* ($n = 281$). The highest Important Value Index (IVI) was recorded for *Shorea roxburghii* (16.89), followed by *Anogeissus latifolia* (12.73) and *Acacia chundra* (10.47) (Fig. 2.1). The Shannon-Weiner index of diversity for woody plants community in the study area was 4.2272. The Simpson index of diversity was 0.9766. The mean stand density was 570.67 stems ha^{-2} and the basal area was 44.83 $\text{m}^2 \text{ha}^{-2}$.

Table 2.2 The stand structure of the woody plants in Bannerghatta National Park

| Variables | Value |
|---|--|
| Number of woody species | 153 |
| No. of genera | 109 |
| No. of families | 49 |
| Shannon index (H) | 4.2272 |
| Simpson Index (D) | 0.976617 |
| Stand density (stems ha ⁻²) | 570.67 (stems ha ⁻²) |
| Basal area (m ² ha ⁻²) | 44.83 (m ² ha ⁻²) |
| Number of liana species | 6 |
| Number of Multi-stemmed individuals | 1117 |
| Total number of species | 219 |

Table 2.3 Density and important value index of the woody plants in BNP

| Name of the species | No. of individuals | GBH in m | Density | Basal Area | Relative Basal Area | IVI |
|------------------------------|---------------------------|-----------------|----------------|-------------------|----------------------------|------------|
| <i>Anogeissus latifolia</i> | 441 | 236.88 | 2.69 | 13.86 | 2.95 | 12.73 |
| <i>Acacia chundra</i> | 343 | 228.52 | 2.09 | 15.71 | 3.34 | 10.47 |
| <i>Shorea roxburghii</i> | 281 | 247.66 | 1.71 | 21.25 | 4.52 | 16.89 |
| <i>Ixora arborea</i> | 219 | 152.95 | 1.34 | 10.75 | 2.29 | 8.38 |
| <i>Diospyros melanoxylon</i> | 177 | 79.94 | 1.08 | 3.59 | 0.76 | 6.34 |
| <i>Canthium dicoccum</i> | 163 | 134.74 | 0.99 | 11.09 | 2.36 | 6.33 |
| <i>Ochna obtusata</i> | 156 | 49.65 | 0.95 | 1.43 | 0.30 | 5.42 |
| <i>Syzygium cumini</i> | 153 | 201.93 | 0.93 | 28.77 | 6.13 | 5.63 |
| <i>Wrightia tinctoria</i> | 118 | 104.12 | 0.72 | 11.03 | 2.35 | 4.69 |

| Name of the species | No. of individuals | GBH in m | Density | Basal Area | Relative Basal Area | IVI |
|-----------------------------------|---------------------------|-----------------|----------------|-------------------|----------------------------|------------|
| <i>Buchanania axillaris</i> | 116 | 88.62 | 0.71 | 6.56 | 1.40 | 4.68 |
| <i>Strychnos potatorum</i> | 106 | 90.95 | 0.65 | 8.37 | 1.78 | 4.24 |
| <i>Dalbergia paniculata</i> | 105 | 82.15 | 0.64 | 6.23 | 1.33 | 4.76 |
| <i>Pterocarpus marsupium</i> | 100 | 70.2 | 0.61 | 5.33 | 1.13 | 4.16 |
| <i>Chloroxylon swietenia</i> | 93 | 67.22 | 0.57 | 4.67 | 0.99 | 3.73 |
| <i>Albizia amara</i> | 92 | 96.71 | 0.56 | 9.98 | 2.12 | 3.80 |
| <i>Buchanania lanzan</i> | 92 | 89.52 | 0.56 | 9.56 | 2.04 | 3.83 |
| <i>Flacourtia indica</i> | 90 | 44.33 | 0.55 | 2.34 | 0.50 | 4.12 |
| <i>Naringi crenulata</i> | 89 | 58.02 | 0.54 | 3.56 | 0.76 | 4.03 |
| <i>Erythroxylum monogynum</i> | 86 | 78.46 | 0.52 | 7.18 | 1.53 | 3.96 |
| <i>Polyalthia cerasoides</i> | 83 | 55.58 | 0.51 | 4.06 | 0.86 | 3.44 |
| <i>Santalum album</i> | 83 | 23.97 | 0.51 | 0.59 | 0.13 | 3.67 |
| <i>Azadirachta indica</i> | 81 | 52.2 | 0.49 | 2.97 | 0.63 | 3.45 |
| <i>Terminalia bellirica</i> | 75 | 106.66 | 0.46 | 15.12 | 3.22 | 3.67 |
| <i>Terminalia arjuna</i> | 74 | 102.11 | 0.45 | 13.86 | 2.95 | 3.11 |
| <i>Pongamia pinnata</i> | 73 | 93.37 | 0.45 | 12.79 | 2.72 | 3.33 |
| <i>Boswellia serrata</i> | 70 | 61.64 | 0.43 | 5.59 | 1.19 | 3.23 |
| <i>Holarrhena antidysenterica</i> | 70 | 28.98 | 0.43 | 1.25 | 0.27 | 3.08 |
| <i>Diospyros montana</i> | 68 | 32.12 | 0.41 | 1.63 | 0.35 | 3.58 |
| <i>Syzygium alternifolium</i> | 67 | 69.66 | 0.41 | 7.6 | 1.62 | 2.92 |
| <i>Feronia elephantum</i> | 66 | 54.7 | 0.40 | 4.57 | 0.97 | 3.05 |
| <i>Cassia fistula</i> | 61 | 32.42 | 0.37 | 1.9 | 0.40 | 3.28 |
| <i>Vitex altissima</i> | 61 | 75.33 | 0.37 | 10.06 | 2.14 | 2.98 |
| <i>Maytanus emarginata</i> | 59 | 42.44 | 0.36 | 3.1 | 0.66 | 2.87 |
| <i>Olea dioica</i> | 59 | 42.18 | 0.36 | 3.15 | 0.67 | 2.66 |
| <i>Terminalia chebula</i> | 57 | 35.19 | 0.35 | 2.48 | 0.53 | 2.66 |
| <i>Bauhinia racemosa</i> | 52 | 47.32 | 0.32 | 5.05 | 1.08 | 2.99 |
| <i>Butea monosperma</i> | 50 | 47.45 | 0.30 | 5.28 | 1.12 | 2.81 |
| <i>Diospyros chloroxylon</i> | 49 | 22.42 | 0.30 | 0.98 | 0.21 | 2.34 |
| <i>Terminalia tomentosa</i> | 49 | 50.86 | 0.30 | 4.89 | 1.04 | 2.40 |

| Name of the species | No. of individuals | GBH in m | Density | Basal Area | Relative Basal Area | IVI |
|---------------------------------|---------------------------|-----------------|----------------|-------------------|----------------------------|------------|
| <i>Terminalia crenulata</i> | 46 | 54.22 | 0.28 | 8.33 | 1.77 | 2.48 |
| <i>Phyllanthus polyphyllus</i> | 45 | 28.87 | 0.27 | 1.89 | 0.40 | 2.27 |
| <i>Bassia latifolia</i> | 44 | 39.08 | 0.27 | 3.25 | 0.69 | 2.31 |
| <i>Ficus benghalensis</i> | 44 | 156.29 | 0.27 | 51.56 | 10.98 | 2.88 |
| <i>Schleichera oleosa</i> | 44 | 44.49 | 0.27 | 4.32 | 0.92 | 2.28 |
| <i>Semecarpus anacardium</i> | 44 | 37.89 | 0.27 | 3.1 | 0.66 | 2.36 |
| <i>Albizia odoratissima</i> | 43 | 36.21 | 0.26 | 3.03 | 0.65 | 2.34 |
| <i>Glochidion bourdillonii</i> | 42 | 42.04 | 0.26 | 4.21 | 0.90 | 4.38 |
| <i>Ochna gamblei</i> | 38 | 12.09 | 0.23 | 0.35 | 0.07 | 2.12 |
| <i>Eucalyptus globulus</i> | 37 | 48.26 | 0.23 | 7.61 | 1.62 | 2.01 |
| <i>Premna tomentosa</i> | 36 | 28.04 | 0.22 | 2.08 | 0.44 | 2.12 |
| <i>Bridelia crenulata</i> | 35 | 23.21 | 0.21 | 1.66 | 0.35 | 1.85 |
| <i>Memecylon umbellatum</i> | 35 | 27.76 | 0.21 | 2.23 | 0.47 | 2.34 |
| <i>Lannea coromandelica</i> | 33 | 29.58 | 0.20 | 2.51 | 0.53 | 1.84 |
| <i>Balanites aegyptiaca</i> | 31 | 14.59 | 0.19 | 0.63 | 0.13 | 1.96 |
| <i>Careya arborea</i> | 31 | 35.19 | 0.19 | 4.19 | 0.89 | 1.75 |
| <i>Mitragyna parvifolia</i> | 29 | 27.57 | 0.18 | 2.46 | 0.52 | 1.71 |
| <i>Firmiana colorata</i> | 28 | 29.92 | 0.17 | 3.05 | 0.65 | 1.61 |
| <i>Dalbergia latifolia</i> | 27 | 15.8 | 0.16 | 0.82 | 0.17 | 1.60 |
| <i>Cassia siamea</i> | 26 | 35.9 | 0.16 | 5.22 | 1.11 | 1.53 |
| <i>Stereospermum colais</i> | 25 | 18.11 | 0.15 | 1.28 | 0.27 | 1.64 |
| <i>Dolichandrone atrovirens</i> | 23 | 20.25 | 0.14 | 1.65 | 0.35 | 1.44 |
| <i>Ziziphus xylopyrus</i> | 23 | 14.44 | 0.14 | 0.85 | 0.18 | 1.42 |
| <i>Ardisia solanacea</i> | 22 | 5.4 | 0.13 | 0.1 | 0.02 | 1.94 |
| <i>Sterculia urens</i> | 21 | 27.2 | 0.13 | 3.1 | 0.66 | 1.33 |
| <i>Ficus microcarpa</i> | 20 | 47.22 | 0.12 | 11.35 | 2.42 | 1.37 |
| <i>Memecylon edule</i> | 20 | 15.11 | 0.12 | 1.36 | 0.29 | 1.33 |
| <i>Grewia abutilifolia</i> | 19 | 9.9 | 0.12 | 0.56 | 0.12 | 1.29 |
| <i>Capparis grandis</i> | 18 | 14.27 | 0.11 | 1.79 | 0.38 | 1.22 |
| <i>Cassine glauca</i> | 18 | 17.68 | 0.11 | 1.67 | 0.36 | 1.23 |
| <i>Cordia</i> sp. | 18 | 13.29 | 0.11 | 0.87 | 0.19 | 1.33 |

| Name of the species | No. of individuals | GBH in m | Density | Basal Area | Relative Basal Area | IVI |
|----------------------------------|---------------------------|-----------------|----------------|-------------------|----------------------------|------------|
| <i>Wrightia arborea</i> | 17 | 16.15 | 0.10 | 1.47 | 0.31 | 1.18 |
| <i>Tarenna asiatica</i> | 16 | 8.72 | 0.10 | 0.43 | 0.09 | 1.12 |
| <i>Streblus asper</i> | 15 | 18.26 | 0.09 | 4.02 | 0.86 | 1.23 |
| <i>Alangium salviifolium</i> | 14 | 19.47 | 0.09 | 3.26 | 0.69 | 1.03 |
| <i>Clausena dentata</i> | 14 | 6.86 | 0.09 | 0.34 | 0.07 | 1.05 |
| <i>Ehretia pubescens</i> | 14 | 11.7 | 0.09 | 0.93 | 0.20 | 1.55 |
| <i>Elaeocarpus serratus</i> | 14 | 7.08 | 0.09 | 0.29 | 0.06 | 1.04 |
| <i>Cycas circinalis</i> | 13 | 6.11 | 0.08 | 0.26 | 0.06 | 0.99 |
| <i>Eucalyptus tereticornis</i> | 13 | 14.96 | 0.08 | 1.43 | 0.30 | 1.45 |
| <i>Linociera malabarica</i> | 13 | 7.91 | 0.08 | 0.43 | 0.09 | 1.00 |
| <i>Mallotus philippensis</i> | 13 | 8.57 | 0.08 | 0.59 | 0.13 | 1.22 |
| <i>Phyllanthus emblica</i> | 13 | 7.56 | 0.08 | 0.46 | 0.10 | 0.99 |
| <i>Gmelina arborea</i> | 12 | 11.33 | 0.07 | 0.93 | 0.20 | 1.03 |
| <i>Phyllanthus indofischerii</i> | 12 | 6.95 | 0.07 | 0.36 | 0.08 | 0.94 |
| <i>Ailanthus excelsa</i> | 10 | 11.37 | 0.06 | 1.22 | 0.26 | 0.86 |
| <i>Garcinia gummi-gutta</i> | 10 | 3.29 | 0.06 | 0.1 | 0.02 | 2.73 |
| <i>Randia brandisii</i> | 10 | 5.13 | 0.06 | 0.25 | 0.05 | 1.14 |
| <i>Stereospermum personatum</i> | 10 | 6.08 | 0.06 | 0.35 | 0.07 | 1.14 |
| <i>Tamarindus indicus</i> | 10 | 19.55 | 0.06 | 4.55 | 0.97 | 1.14 |
| <i>Wendlandia lawii</i> | 10 | 6 | 0.06 | 0.32 | 0.07 | 0.90 |
| <i>Adina cordifolia</i> | 8 | 12.16 | 0.05 | 1.57 | 0.33 | 0.76 |
| <i>Erythrina stricta</i> | 8 | 6.8 | 0.05 | 0.57 | 0.12 | 0.82 |
| <i>Holoptelea integrifolia</i> | 8 | 6.53 | 0.05 | 0.67 | 0.14 | 0.73 |
| <i>Maba buxifolia</i> | 8 | 2.21 | 0.05 | 0.05 | 0.01 | 0.94 |
| <i>Milusa tomentosa</i> | 8 | 5.34 | 0.05 | 0.33 | 0.07 | 0.82 |
| <i>Acacia leucophloea</i> | 7 | 3.63 | 0.04 | 0.2 | 0.04 | 0.74 |
| <i>Givotia moluccana</i> | 7 | 11.25 | 0.04 | 1.7 | 0.36 | 0.69 |
| <i>Mangifera indica</i> | 7 | 11.79 | 0.04 | 1.77 | 0.38 | 0.68 |
| <i>Bombax malabaricum</i> | 6 | 6.47 | 0.04 | 0.67 | 0.14 | 0.63 |
| <i>Ehretia ovalifolia</i> | 6 | 5.53 | 0.04 | 0.64 | 0.14 | 0.95 |
| <i>Hiptage benghalensis</i> | 6 | 2.07 | 0.04 | 0.07 | 0.01 | 0.66 |

| Name of the species | No. of individuals | GBH in m | Density | Basal Area | Relative Basal Area | IVI |
|---------------------------------|---------------------------|-----------------|----------------|-------------------|----------------------------|------------|
| <i>Morinda tinctoria</i> | 6 | 3.15 | 0.04 | 0.17 | 0.04 | 0.62 |
| <i>Tectona grandis</i> | 6 | 4.64 | 0.04 | 0.31 | 0.07 | 0.95 |
| <i>Ziziphus oenoplia</i> | 6 | 1.96 | 0.04 | 0.06 | 0.01 | 0.66 |
| <i>Acacia torta</i> | 5 | 2.14 | 0.03 | 0.08 | 0.02 | 0.80 |
| <i>Ficus virens</i> | 5 | 9.56 | 0.03 | 1.89 | 0.40 | 0.58 |
| <i>Pittosporum tetraspermum</i> | 5 | 3.89 | 0.03 | 0.25 | 0.05 | 0.80 |
| <i>Prosopis juliflora</i> | 5 | 7.21 | 0.03 | 0.96 | 0.20 | 0.64 |
| <i>Randia dumetorum</i> | 5 | 3.25 | 0.03 | 0.22 | 0.05 | 0.56 |
| <i>Salix tetrasperma</i> | 5 | 4.08 | 0.03 | 0.3 | 0.06 | 0.80 |
| <i>Acacia farneesiana</i> | 4 | 3.79 | 0.02 | 0.31 | 0.07 | 1.12 |
| <i>Dichrostachys cinerea</i> | 4 | 1.67 | 0.02 | 0.06 | 0.01 | 1.12 |
| <i>Ficus tsjakela</i> | 4 | 8.52 | 0.02 | 1.76 | 0.37 | 0.54 |
| <i>Millingtonia hortensis</i> | 4 | 2.67 | 0.02 | 0.15 | 0.03 | 1.12 |
| <i>Shorea thumbaggaia</i> | 4 | 2.29 | 0.02 | 0.1 | 0.02 | 1.12 |
| <i>Acacia nilotica</i> | 3 | 2.64 | 0.02 | 0.22 | 0.05 | 0.44 |
| <i>Acacia</i> sp. | 3 | 2.79 | 0.02 | 0.21 | 0.04 | 0.85 |
| <i>Chukrasia tabularis</i> | 3 | 2.83 | 0.02 | 0.24 | 0.05 | 0.52 |
| <i>Cochlospermum religiosum</i> | 3 | 4.18 | 0.02 | 0.46 | 0.10 | 0.85 |
| <i>Gardenia obovata</i> | 3 | 2.52 | 0.02 | 0.19 | 0.04 | 0.52 |
| <i>Madhuca longifolia</i> | 3 | 2.96 | 0.02 | 0.4 | 0.09 | 0.44 |
| <i>Melia dubia</i> | 3 | 1.76 | 0.02 | 0.09 | 0.02 | 0.44 |
| <i>Ochna lanceolata</i> | 3 | 1.28 | 0.02 | 0.05 | 0.01 | 0.85 |
| <i>Sapindus emarginatus</i> | 3 | 2.33 | 0.02 | 0.15 | 0.03 | 0.44 |
| <i>Scutia myrtina</i> | 3 | 0.96 | 0.02 | 0.03 | 0.01 | 0.52 |
| <i>Strychnos nux-vomica</i> | 3 | 1.68 | 0.02 | 0.08 | 0.02 | 0.44 |
| <i>Syzygium jambos</i> | 3 | 7.75 | 0.02 | 1.68 | 0.36 | 0.52 |
| <i>Acacia auriculiformis</i> | 2 | 2.15 | 0.01 | 0.19 | 0.04 | 0.58 |
| <i>Breynia vitis-idaea</i> | 2 | 0.45 | 0.01 | 0.01 | 0.00 | 0.37 |
| <i>Bridelia retsua</i> | 2 | 1.25 | 0.01 | 0.08 | 0.02 | 0.37 |
| <i>Capparis sepiaria</i> | 2 | 1.1 | 0.01 | 0.05 | 0.01 | 0.58 |

| Name of the species | No. of individuals | GBH in m | Density | Basal Area | Relative Basal Area | IVI |
|---------------------------------|---------------------------|-----------------|----------------|-------------------|----------------------------|------------|
| <i>Cassine paniculata</i> | 2 | 0.9 | 0.01 | 0.04 | 0.01 | 0.58 |
| <i>Chrysophyllum roxburghii</i> | 2 | 1.6 | 0.01 | 0.11 | 0.02 | 0.58 |
| <i>Drypetes sepiaria</i> | 2 | 1.39 | 0.01 | 0.08 | 0.02 | 0.58 |
| <i>Gardenia gummifera</i> | 2 | 0.58 | 0.01 | 0.01 | 0.00 | 0.37 |
| <i>Helicteres isora</i> | 2 | 1.37 | 0.01 | 0.08 | 0.02 | 0.58 |
| <i>Nothopegia heyneana</i> | 2 | 0.92 | 0.01 | 0.04 | 0.01 | 0.58 |
| <i>Plumeria alba</i> | 2 | 3.41 | 0.01 | 0.49 | 0.10 | 0.58 |
| <i>Randia spinosa</i> | 2 | 1.56 | 0.01 | 0.1 | 0.02 | 0.58 |
| <i>Acacia polyacantha</i> | 1 | 0.63 | 0.01 | 0.03 | 0.01 | 0.31 |
| <i>Albizia lebeck</i> | 1 | 0.46 | 0.01 | 0.02 | 0.00 | 0.31 |
| <i>Allophyllus serratus</i> | 1 | 1.27 | 0.01 | 0.13 | 0.03 | 0.31 |
| <i>Atalantia monophylla</i> | 1 | 0.61 | 0.01 | 0.03 | 0.01 | 0.31 |
| <i>Atalantia racemosa</i> | 1 | 2.36 | 0.01 | 0.44 | 0.09 | 0.31 |
| <i>Casearia tomentosa</i> | 1 | 0.74 | 0.01 | 0.04 | 0.01 | 0.31 |
| <i>Celastrus paniculatus</i> | 1 | 0.2 | 0.01 | 0 | 0.00 | 0.31 |
| <i>Derris scandens</i> | 1 | 0.59 | 0.01 | 0.03 | 0.01 | 0.31 |
| <i>Dolichandrone arcuatus</i> | 1 | 0.64 | 0.01 | 0.03 | 0.01 | 0.31 |
| <i>Ficus tomentosa</i> | 1 | 3.45 | 0.01 | 0.95 | 0.20 | 0.31 |
| <i>Lepisanthes tetraphylla</i> | 1 | 0.76 | 0.01 | 0.05 | 0.01 | 0.31 |
| <i>Schefflera stellata</i> | 1 | 2.6 | 0.01 | 0.54 | 0.11 | 0.31 |
| <i>Ventilago goughii</i> | 1 | 0.34 | 0.01 | 0.01 | 0.00 | 0.31 |
| <i>Viburnum acuminatum</i> | 1 | 1.67 | 0.01 | 0.22 | 0.05 | 0.31 |

Species accumulation curve was estimated using different estimators (Fig. 2.2), which depicts that reaching species accumulation reaching asymptote before 50 quadrat samplings. This shows that the sampled area is adequate and also represents the virtual vegetation of the park. However, few of the estimators projected possible additions of species with increase in effort.

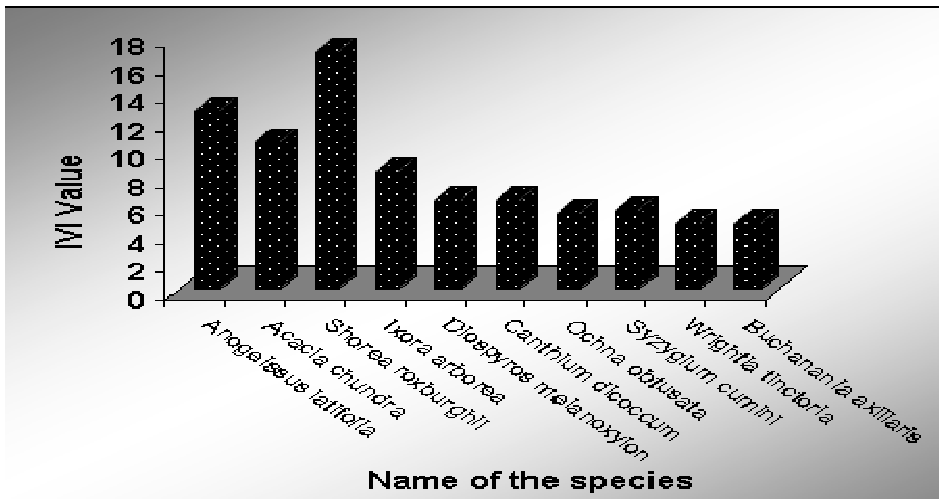


Figure 2.1 Importance value indices (IVI) of the top 10 tree species

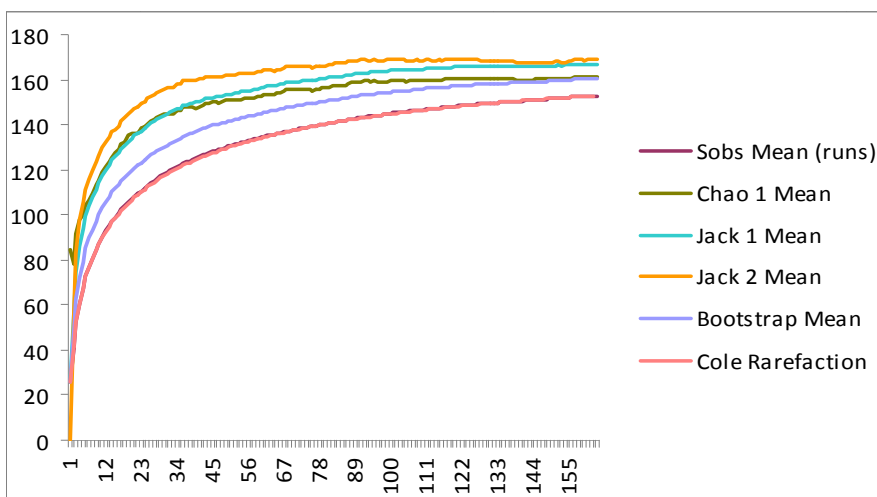


Figure 2.2 Different estimates of species area curve

Stem girth-class diversity, stand density, richness and basal area: The stand density and species richness was observed more in the girth 31-90 cm gbh, however, more basal area was contributed by the girth between 61-120 cm gbh (Table 2.4, Fig. 2.3).

Table 2.4 Occurrence of stand density, species richness and basal area under various girth classes

| Girth class (cm) | Stand density | Species richness | Basal area | Species occurrence rate (species richness/sp ecies density) |
|------------------|---------------|------------------|------------|---|
| 15-30 | 646 | 75 | 2.86 | 0.116099 |
| 31-60 | 1938 | 123 | 33.96 | 0.063467 |
| 61-90 | 1513 | 120 | 65.25 | 0.079313 |
| 91-120 | 729 | 93 | 62.78 | 0.127572 |
| 121-150 | 406 | 84 | 57.97 | 0.206897 |
| 151-180 | 210 | 67 | 45.27 | 0.319048 |
| 181-210 | 107 | 47 | 31.85 | 0.439252 |
| > 210 | 217 | 62 | 169.77 | 0.285714 |

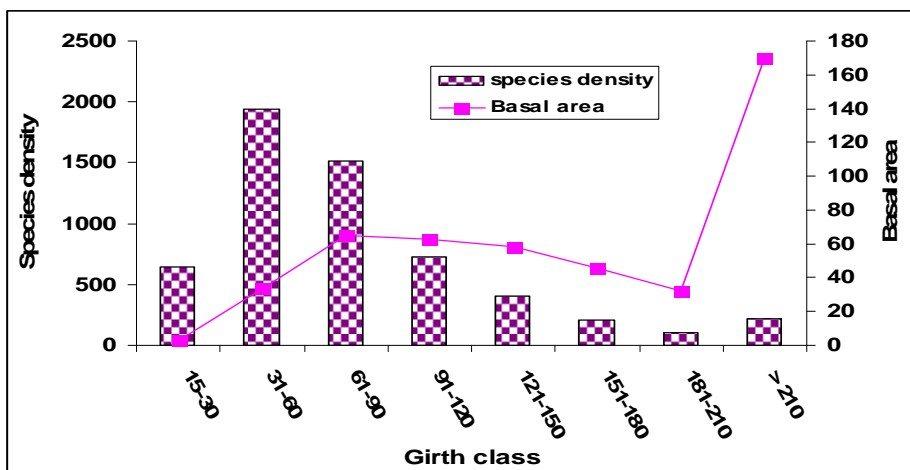


Figure 2.3 Stand density and basal area in different girth class

Familial composition

The number of woody plant families in the sampled area of the study site is 49 (Table 2.5), among them, Mimosaceae is the well-represented family with 13 species dominating the forest canopy, followed by Rubiaceae (12 species) and Euphorbiaceae (10 species). At the generic level, the family Rubiaceae is the dominant one with 9 genera followed by Euphorbiaceae (n=7) and Fabaceae (n=6). Based on density, the family Combretaceae represents the highest number with 742 individuals followed by Mimosaceae (n=513) and Rubiaceae (n=473). The maximum basal area in the present study area was recorded for the family Moraceae (71.53) followed by Combretaceae (53.65) and Myrtaceae (51.98). Of these, Combretaceae is the densest family (12.87 %) in the forest stand, followed by Mimosaceae (8.90 %) and Fabaceae (6.31%). The families Alangiaceae, Araliaceae, Balanitaceae, Bombacaceae, Burseraceae, Caprifoliaceae, Clusiaceae, Cochlospermaceae, Cycadaceae, Elaeocarpaceae, Erythroxylaceae, Lecythidaceae, Malphigiaceae, Myrsinaceae, Pittosporaceae, Salicaceae, Santalaceae, Simaroubaceae, Tiliaceae and Ulmaceae are represented by single species.

Table 2.5 The contribution of plant families to species richness, Genera richness, Family Relative Density, Family Relative Diversity, basal area, Family Relative dominance and family importance value (FIV) in the various forest types of Bannerghatta National Park

| Family | Species richness | Genera richness | No. of Individuals | FR Den | FR Diver | Basal area | FR Dom | FIV |
|---------------|------------------|-----------------|--------------------|--------|----------|------------|--------|-------|
| Alangiaceae | 1 | 1 | 14 | 0.24 | 0.65 | 3.26 | 0.69 | 1.59 |
| Anacardiaceae | 6 | 4 | 294 | 5.10 | 3.92 | 23.54 | 5.01 | 14.03 |
| Annonaceae | 2 | 2 | 91 | 1.58 | 1.31 | 4.39 | 0.93 | 3.82 |
| Apocynaceae | 4 | 3 | 207 | 3.59 | 2.61 | 14.24 | 3.03 | 9.24 |
| Araliaceae | 1 | 1 | 1 | 0.02 | 0.65 | 0.54 | 0.11 | 0.79 |
| Balanitaceae | 1 | 1 | 31 | 0.54 | 0.65 | 0.63 | 0.13 | 1.33 |
| Bignoniaceae | 5 | 3 | 63 | 1.09 | 3.27 | 3.46 | 0.74 | 5.10 |
| Bombacaceae | 1 | 1 | 6 | 0.10 | 0.65 | 0.67 | 0.14 | 0.90 |

| Family | Species richness | Genera richness | No. of Individuals | FR Den | FR Diver | Basal area | FR Dom | FIV |
|------------------|-------------------------|------------------------|---------------------------|---------------|-----------------|-------------------|---------------|------------|
| Boraginaceae | 3 | 2 | 38 | 0.66 | 1.96 | 2.44 | 0.52 | 3.14 |
| Burseraceae | 1 | 2 | 70 | 1.21 | 0.65 | 5.59 | 1.19 | 3.06 |
| Caesalpiniaceae | 4 | 3 | 149 | 2.58 | 2.61 | 16.72 | 3.56 | 8.76 |
| Capparidaceae | 2 | 1 | 20 | 0.35 | 1.31 | 1.84 | 0.39 | 2.05 |
| Caprifoliaceae | 1 | 1 | 1 | 0.02 | 0.65 | 0.22 | 0.05 | 0.72 |
| Celastraceae | 4 | 3 | 80 | 1.39 | 2.61 | 4.81 | 1.02 | 5.03 |
| Clusiaceae | 1 | 1 | 10 | 0.17 | 0.65 | 0.1 | 0.02 | 0.85 |
| Cochlospermaceae | 1 | 1 | 3 | 0.05 | 0.65 | 0.46 | 0.10 | 0.80 |
| Combretaceae | 5 | 2 | 742 | 12.87 | 3.27 | 53.65 | 11.42 | 27.56 |
| Cycadaceae | 1 | 1 | 13 | 0.23 | 0.65 | 0.26 | 0.06 | 0.93 |
| Dipterocarpaceae | 2 | 1 | 285 | 4.94 | 1.31 | 21.35 | 4.55 | 10.80 |
| Ebenaceae | 4 | 2 | 302 | 5.24 | 2.61 | 6.25 | 1.33 | 9.18 |
| Elaeocarpaceae | 1 | 1 | 14 | 0.24 | 0.65 | 0.29 | 0.06 | 0.96 |
| Erythroxylaceae | 1 | 1 | 86 | 1.49 | 0.65 | 7.18 | 1.53 | 3.67 |
| Euphorbiaceae | 10 | 7 | 173 | 3.00 | 6.54 | 11.04 | 2.35 | 11.89 |
| Fabaceae | 7 | 6 | 364 | 6.31 | 4.58 | 31.05 | 6.61 | 17.50 |
| Flacourtiaceae | 2 | 2 | 91 | 1.58 | 1.31 | 2.38 | 0.51 | 3.39 |
| Lecythidaceae | 1 | 1 | 31 | 0.54 | 0.65 | 4.19 | 0.89 | 2.08 |
| Loganiaceae | 2 | 1 | 109 | 1.89 | 1.31 | 8.45 | 1.80 | 5.00 |
| Malphiaceae | 1 | 1 | 6 | 0.10 | 0.65 | 0.07 | 0.01 | 0.77 |
| Melastomataceae | 2 | 1 | 55 | 0.95 | 1.31 | 3.59 | 0.76 | 3.03 |
| Meliaceae | 3 | 3 | 87 | 1.51 | 1.96 | 3.3 | 0.70 | 4.17 |
| Mimosaceae | 13 | 4 | 513 | 8.90 | 8.50 | 31 | 6.60 | 23.99 |
| Moraceae | 6 | 2 | 89 | 1.54 | 3.92 | 71.53 | 15.23 | 20.69 |
| Myrsinaceae | 1 | 1 | 22 | 0.38 | 0.65 | 0.1 | 0.02 | 1.06 |
| Myrtaceae | 6 | 2 | 273 | 4.73 | 3.92 | 51.98 | 11.07 | 19.72 |
| Ochnaceae | 3 | 1 | 197 | 3.42 | 1.96 | 1.83 | 0.39 | 5.77 |
| Oleaceae | 2 | 2 | 72 | 1.25 | 1.31 | 3.58 | 0.76 | 3.32 |
| Pittosporaceae | 1 | 1 | 5 | 0.09 | 0.65 | 0.25 | 0.05 | 0.79 |
| Rhamnaceae | 4 | 3 | 33 | 0.57 | 2.61 | 0.95 | 0.20 | 3.39 |

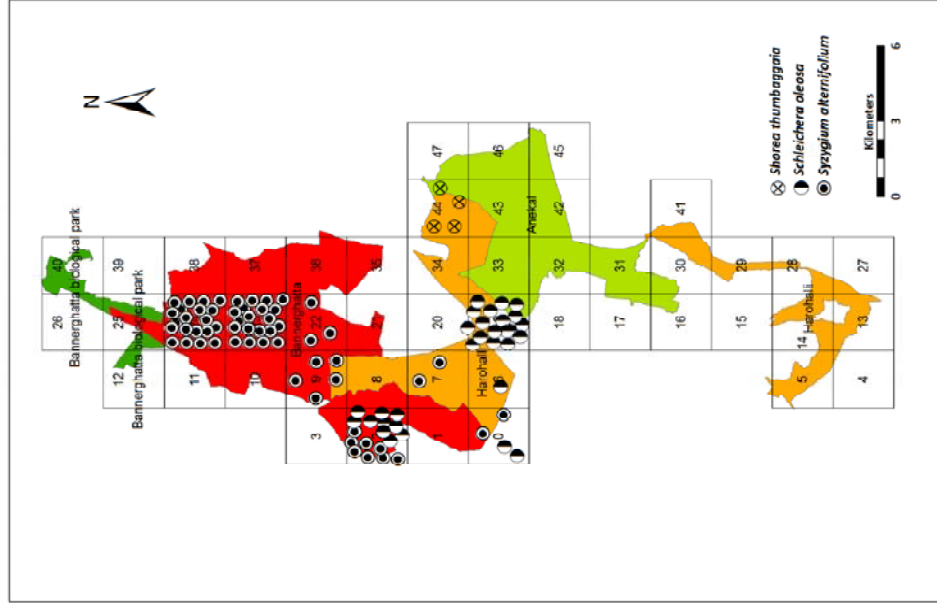
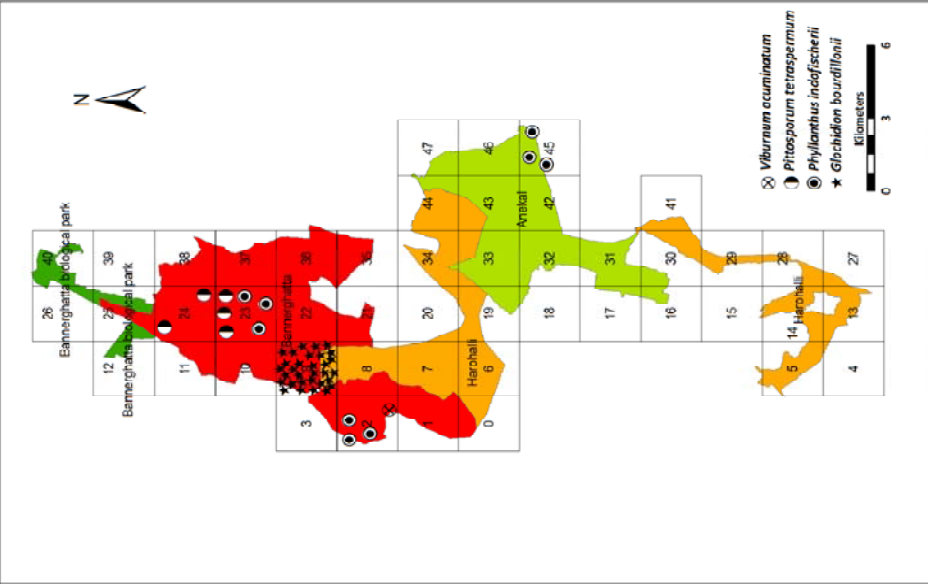
| Family | Species richness | Genera richness | No. of Individuals | FR Den | FR Diver | Basal area | FR Dom | FIV |
|---------------|-------------------------|------------------------|---------------------------|---------------|-----------------|-------------------|---------------|------------|
| Rubiaceae | 12 | 9 | 473 | 8.20 | 7.84 | 27.56 | 5.87 | 21.91 |
| Rutaceae | 6 | 5 | 264 | 4.58 | 3.92 | 13.61 | 2.90 | 11.40 |
| Salicaceae | 1 | 1 | 5 | 0.09 | 0.65 | 0.3 | 0.06 | 0.80 |
| Santalaceae | 1 | 1 | 83 | 1.44 | 0.65 | 0.59 | 0.13 | 2.22 |
| Sapindaceae | 4 | 4 | 49 | 0.85 | 2.61 | 4.65 | 0.99 | 4.45 |
| Sapotaceae | 3 | 3 | 49 | 0.85 | 1.96 | 3.76 | 0.80 | 3.61 |
| Simaroubaceae | 1 | 1 | 10 | 0.17 | 0.65 | 1.22 | 0.26 | 1.09 |
| Sterculiaceae | 3 | 3 | 51 | 0.88 | 1.96 | 6.23 | 1.33 | 4.17 |
| Tiliaceae | 1 | 1 | 19 | 0.33 | 0.65 | 0.56 | 0.12 | 1.10 |
| Ulmaceae | 1 | 1 | 8 | 0.14 | 0.65 | 0.67 | 0.14 | 0.93 |
| Verbenaceae | 4 | 4 | 115 | 1.99 | 2.61 | 13.38 | 2.85 | 7.46 |
| Total | 153 | 109 | 5766 | | | 469.71 | | |

Discussion

Biodiversity of an area is related to a variety of factors such as topography, climate, soil and biotic disturbance. Tree species inventories at defined study sites and in minimum diameter classes give a reliable instrument to indicate the diversity level of a study site (Wattenberg and Breckle, 1995). One of the characteristic features of Tropical forests is high species richness (Ayyappan and Parthasarathy, 1999).

Although there are some studies on structure and dynamics of vegetation in the semi-evergreen and moist deciduous forests in the various parts of Eastern Ghats e.g. Shervarayan hills (Kadavul and Parthasarathy, 1999a), Kalarayan hills (Kadavul and Parthasarathy, 1999b), Kolli hills (Chittibabu and Parthasarathy, 2000a, b), there is no such previous study on vegetation structure in the dry deciduous forests of Eastern Ghats.

The species richness of 153 tree species in 10.25 ha of sampled area of tropical dry deciduous forest in Bannerghatta National Park, shows its high species diversity status. The species richness of the park is very high when compared to semi-evergreen forests of Eastern Ghats, i.e.,



Mapping of some important woody plants

Shervarayan hills which has 70 tree species (excluding lianas) in 4 ha (Kadavul and Parthasarathy, 1999a), Kalarayan hills with 73 species in 4 ha (Kadavul and Parthasarathy, 1999b) and Kolli hills with 78 species (Chittibabu and Parthasarathy, 2000).

The stand density of the present study is 570.67 stems ha⁻². Shervarayan and Kalrayan hills of Eastern Ghats, respectively, stocked a range of 640 to 986 trees ha⁻¹ (Kadavul and Parthasarathy, 1999a), 367 to 667 trees ha⁻¹ (Kadavul and Parthasarathy, 1999b) and 266 to 632 trees ha⁻¹ (Chittibabu and Parthasarathy, 2000). The Stand density of the present study site is lesser than the other sites of Semi-evergreen forests of Eastern Ghats.

The mean stand basal area of the present study site is 44.83 (m² ha⁻²), whereas the mean basal area was 34.9 m² ha⁻¹ in Shervarayan hills and 33.7 m² ha⁻¹ in Kalrayan hills (Kadavul and Parthasarathy, 1999b), 43.6 m² ha⁻² in Kolli hills (Chittibabu and Parthasarathy, 2000). Thus, the mean basal area of the Bannerghatta National Park is on par with the other forests of Eastern Ghats.

Since the study site is a dry deciduous forest, the familial composition is entirely varied when compared to the semi- evergreen forests of Eastern Ghats. At the family level, Mimosaceae is the well-represented family with 13 species dominating the forest canopy, followed by Rubiaceae (12 species) and Euphorbiaceae (10 species) in the present study area. Moraceae (10 species), Lauraceae (9), and Euphorbiaceae (7) were the most speciose families in the tropical evergreen forest of Kolli hills (Chittibabu and Parthasarathy, 2000), while in the adjacent Shervarayan hills Euphorbiaceae (8 species) and Rubiaceae (5 species) were most speciose (Kadavul and Parthasarathy, 1999a).

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Appendix 2.1

Checklist of all the woody plant species in the Bannerghatta National Park

| Sl. No. | Name of the species | Family | Habitat |
|---------|-----------------------------------|-----------------|-----------|
| 1. | <i>Acacia auriculiformis</i> | Mimosaceae | Tree |
| 2. | <i>Acacia caesia</i> | Mimosaceae | Straggler |
| 3. | <i>Acacia chundra</i> | Mimosaceae | Tree |
| 4. | <i>Acacia farnesiana</i> | Mimosaceae | Tree |
| 5. | <i>Acacia ferruginea</i> | Mimosaceae | Tree |
| 6. | <i>Acacia leucophloea</i> | Mimosaceae | Tree |
| 7. | <i>Acacia nilotica</i> | Mimosaceae | Tree |
| 8. | <i>Acacia polyacantha</i> | Mimosaceae | Tree |
| 9. | <i>Acacia</i> sp. | Mimosaceae | Tree |
| 10. | <i>Acacia torta</i> | Mimosaceae | Straggler |
| 11. | <i>Aegle marmelos</i> | Rutaceae | Tree |
| 12. | <i>Ailanthus excelsa</i> | Simaroubaceae | Tree |
| 13. | <i>Alangium salviifolium</i> ** | Alangiaceae | Tree |
| 14. | <i>Albizia amara</i> | Caesalpiniaceae | Tree |
| 15. | <i>Albizia lebbeck</i> | Caesalpiniaceae | Tree |
| 16. | <i>Albizia odoratissima</i> | Caesalpiniaceae | Tree |
| 17. | <i>Allophyllus serratus</i> | Sapindaceae | Shrub |
| 18. | <i>Anacardium occidentale</i> | Anacardiaceae | Tree |
| 19. | <i>Annona reticulata</i> | Annonaceae | Tree |
| 20. | <i>Annona squamosa</i> | Annonaceae | Shrub |
| 21. | <i>Anogeissus latifolia</i> | Combretaceae | Tree |
| 22. | <i>Ardisia solanacea</i> | Myrsinaceae | Shrub |
| 23. | <i>Atalantia monophylla</i> | Rutaceae | Tree |
| 24. | <i>Atalantia racemosa</i> | Rutaceae | Tree |
| 25. | <i>Azadirachta indica</i> ** | Meliaceae | Tree |
| 26. | <i>Balanites aegyptiaca</i> | Balanitaceae | Tree |
| 27. | <i>Bassia latifolia</i> | Sapotaceae | Tree |
| 28. | <i>Bauhinia purpurea</i> | Caesalpiniaceae | Tree |
| 29. | <i>Bauhinia racemosa</i> | Caesalpiniaceae | Tree |
| 30. | <i>Benkara malabarica</i> | Rutaceae | Shrub |
| 31. | <i>Bombax malabaricum</i> | Bombacaceae | Tree |
| 32. | <i>Boswellia ovalifoliolata</i> * | Burseraceae | Tree |

| Sl. No. | Name of the species | Family | Habitat |
|----------------|---------------------------------|------------------|----------------|
| 33. | <i>Boswellia serrata</i> | Burseraceae | Tree |
| 34. | <i>Breynia vitis-idaea</i> | Euphorbiaceae | Shrub |
| 35. | <i>Bridelia crenulata</i> ** | Euphorbiaceae | Tree |
| 36. | <i>Bridelia retusa</i> | Euphorbiaceae | Tree |
| 37. | <i>Buchanania axillaris</i> | Anacardiaceae | Tree |
| 38. | <i>Buchanania lanzan</i> | Anacardiaceae | Tree |
| 39. | <i>Butea monosperma</i> | Fabaceae | Tree |
| 40. | <i>Butea parviflora</i> | Fabaceae | Liana |
| 41. | <i>Callicarpa tomentosa</i> ** | Verbenaceae | Shrub |
| 42. | <i>Cansjeera rheedii</i> | Opeliaceae | Liana |
| 43. | <i>Canthium dicoccum</i> ** | Rubiaceae | Tree |
| 44. | <i>Capparis grandis</i> | Capparidaceae | Tree |
| 45. | <i>Capparis sepiaria</i> | Capparidaceae | Straggler |
| 46. | <i>Capparis zeylanica</i> | Capparidaceae | Straggler |
| 47. | <i>Careya arborea</i> | Lecythidaceae | Tree |
| 48. | <i>Carissa carandas</i> ** | Apocynaceae | Straggler |
| 49. | <i>Carissa spinarum</i> ** | Apocynaceae | Straggler |
| 50. | <i>Carmona retusa</i> | Boraginaceae | Shrub |
| 51. | <i>Casearia tomentosa</i> | Flacourtiaceae | Tree |
| 52. | <i>Cassia fistula</i> | Caesalpiniaceae | Tree |
| 53. | <i>Cassia siamea</i> | Caesalpiniaceae | Tree |
| 54. | <i>Cassine glauca</i> ** | Celastraceae | Tree |
| 55. | <i>Cassine paniculata</i> ** | Celastraceae | Tree |
| 56. | <i>Celastrus paniculatus</i> | Celastraceae | Liana |
| 57. | <i>Chloroxylon swietenia</i> | Rutaceae | Tree |
| 58. | <i>Chrysophyllum roxburghii</i> | Sapotaceae | Tree |
| 59. | <i>Chukrasia tabularis</i> | Meliaceae | Tree |
| 60. | <i>Cipadessa baccifera</i> | Meliaceae | Shrub |
| 61. | <i>Clausena dentata</i> | Rutaceae | Shrub |
| 62. | <i>Cleistanthus collinus</i> | Euphorbiaceae | Tree |
| 63. | <i>Cochlospermum religiosum</i> | Cochlospermaceae | Tree |
| 64. | <i>Commiphora berryi</i> | Burseraceae | Shrub |
| 65. | <i>Commiphora caudata</i> | Burseraceae | Tree |
| 66. | <i>Cordia monoica</i> ** | Boraginaceae | Tree |
| 67. | <i>Cordia obliqua</i> ** | Boraginaceae | Tree |
| 68. | <i>Cordia</i> sp. | Boraginaceae | Tree |
| 69. | <i>Cordia wallichii</i> ** | Boraginaceae | Tree |
| 70. | <i>Crateva roxburghii</i> | Capparidaceae | Tree |
| 71. | <i>Cycas circinalis</i> * | Cycadaceae | Tree |
| 72. | <i>Dalbergia latifolia</i> | Fabaceae | Tree |

| Sl. No. | Name of the species | Family | Habitat |
|----------------|--|-----------------|----------------|
| 73. | <i>Dalbergia paniculata</i> | Fabaceae | Tree |
| 74. | <i>Dalbergia sissoo</i> | Fabaceae | Tree |
| 75. | <i>Decalepis hamiltonii*</i> | Asclepiadaceae | Liana |
| 76. | <i>Derris scandens</i> | Fabaceae | Liana |
| 77. | <i>Dichrostachys cinerea</i> | Mimosaceae | Shrub |
| 78. | <i>Diospyros chloroxylon</i> | Ebenaceae | Tree |
| 79. | <i>Diospyros melanoxylon</i> | Ebenaceae | Tree |
| 80. | <i>Diospyros montana**</i> | Ebenaceae | Tree |
| 81. | <i>Dolichandrone arcuata</i> | Bignoniaceae | Tree |
| 82. | <i>Dolichandrone atrovirens</i> | Bignoniaceae | Tree |
| 83. | <i>Drypetes roxburghii*</i> | Euphorbiaceae | Tree |
| 84. | <i>Drypetes sepiaria</i> | Euphorbiaceae | Tree |
| 85. | <i>Ehretia laevis**</i> | Boraginaceae | Tree |
| 86. | <i>Ehretia ovalifolia**</i> | Boraginaceae | Tree |
| 87. | <i>Ehretia pubescens**</i> | Boraginaceae | Tree |
| 88. | <i>Elaeocarpus serratus</i> | Elaeocarpaceae | Tree |
| 89. | <i>Eriolaena hookeriana*</i> | Sterculiaceae | Tree |
| 90. | <i>Erythrina indica</i> | Fabaceae | Tree |
| 91. | <i>Erythrina stricta</i> | Fabaceae | Tree |
| 92. | <i>Erythroxylum monogynum</i> | Erythroxylaceae | Shrub |
| 93. | <i>Eucalyptus globulus</i> | Myrtaceae | Tree |
| 94. | <i>Eucalyptus tereticornis</i> | Myrtaceae | Tree |
| 95. | <i>Euphorbia antiquorum</i> | Euphorbiaceae | Tree |
| 96. | <i>Euphorbia tortilis</i> | Euphorbiaceae | Tree |
| 97. | <i>Feronia elephantum</i> | Rutaceae | Tree |
| 98. | <i>Ficus amplissima**</i> | Moraceae | Tree |
| 99. | <i>Ficus benghalensis**</i> | Moraceae | Tree |
| 100. | <i>Ficus drupacea**</i> | Moraceae | Tree |
| 101. | <i>Ficus hispida</i> | Moraceae | Tree |
| 102. | <i>Ficus microcarpa**</i> | Moraceae | Tree |
| 103. | <i>Ficus mollis**</i> | Moraceae | Tree |
| 104. | <i>Ficus racemosa**</i> | Moraceae | Tree |
| 105. | <i>Ficus religiosa**</i> | Moraceae | Tree |
| 106. | <i>Ficus tinctoria</i> ssp. <i>parasitica**</i> | Moraceae | Tree |
| 107. | <i>Ficus tsjakela**</i> | Moraceae | Tree |
| 108. | <i>Ficus virens**</i> | Moraceae | Tree |
| 109. | <i>Filicium decipiens**</i> | Sapindaceae | Tree |
| 110. | <i>Firmiana colorata</i> | Sterculiaceae | Tree |
| 111. | <i>Flacourtia indica**</i> | Flacourtiaceae | Tree |

| Sl. No. | Name of the species | Family | Habitat |
|----------------|-----------------------------------|-----------------|----------------|
| 112. | <i>Fluggea leucopyrus</i> | Euphorbiaceae | Shrub |
| 113. | <i>Fluggea virosa</i> | Euphorbiaceae | Shrub |
| 114. | <i>Gardenia gummifera</i> | Rubiaceae | Shrub |
| 115. | <i>Garuga pinnata</i> | Burseraceae | Tree |
| 116. | <i>Givotia moluccana</i> | Euphorbiaceae | Tree |
| 117. | <i>Gliricidia sepium</i> | Fabaceae | Tree |
| 118. | <i>Glochidion bourdillonii*</i> | Euphorbiaceae | Tree |
| 119. | <i>Glycosmis cochinchinensis</i> | Rutaceae | Shrub |
| 120. | <i>Gmelina arborea</i> | Verbenaceae | Tree |
| 121. | <i>Gmelina asiatica</i> | Verbenaceae | Tree |
| 122. | <i>Grewia abutilifolia</i> | Tiliaceae | Tree |
| 123. | <i>Grewia tiliifolia**</i> | Tiliaceae | Tree |
| 124. | <i>Gyrocarpus americanus</i> | Hernandiaceae | Tree |
| 125. | <i>Hardwickia binata*</i> | Caesalpiniaceae | Tree |
| 126. | <i>Helicteres isora</i> | Sterculiaceae | Shrub |
| 127. | <i>Hiptage benghalensis</i> | Malphiaceae | Liana |
| 128. | <i>Holarrhena antidysenterica</i> | Apocynaceae | Shrub |
| 129. | <i>Holoptelea integrifolia</i> | Ulmaceae | Tree |
| 130. | <i>Hugonia mystax</i> | Linaceae | Straggler |
| 131. | <i>Ixora arborea**</i> | Rubiaceae | Tree |
| 132. | <i>Kydia calycina</i> | Malvaceae | Tree |
| 133. | <i>Lannea coromandelica</i> | Anacardiaceae | Tree |
| 134. | <i>Lantana camara**</i> | Verbenaceae | Shrub |
| 135. | <i>Lepisanthes tetraphylla</i> | Sapindaceae | Tree |
| 136. | <i>Linociera malabarica*</i> | Oleaceae | Tree |
| 137. | <i>Loseneeriella obtusifolia</i> | Hippocratiaceae | Liana |
| 138. | <i>Maba buxifolia*</i> | Ebenaceae | Tree |
| 139. | <i>Maclura spinosa</i> | Moraceae | Straggler |
| 140. | <i>Madhuca longifolia</i> | Sapotaceae | Tree |
| 141. | <i>Mallotus philippensis</i> | Euphorbiaceae | Tree |
| 142. | <i>Mangifera indica</i> | Anacardiaceae | Tree |
| 143. | <i>Maytanus emarginata</i> | Celastraceae | Shrub |
| 144. | <i>Melia azaderach</i> | Meliaceae | Tree |
| 145. | <i>Melia dubia</i> | Meliaceae | Tree |
| 146. | <i>Memecylon edule</i> | Melastomataceae | Shrub |
| 147. | <i>Memecylon umbellatum</i> | Melastomataceae | Shrub |
| 148. | <i>Millingtonia hortensis</i> | Bignoniaceae | Tree |
| 149. | <i>Mimusops elengii**</i> | Sapotaceae | Tree |
| 150. | <i>Mitragyna parvifolia</i> | Rubiaceae | Tree |
| 151. | <i>Morinda tinctoria</i> | Rubiaceae | Tree |

| Sl. No. | Name of the species | Family | Habitat |
|----------------|------------------------------------|------------------|----------------|
| 152. | <i>Murraya paniculata</i> | Rutaceae | Shrub |
| 153. | <i>Naringi crenulata</i> ** | Rutaceae | Tree |
| 154. | <i>Nothopeia beddomei</i> * | Anacardiaceae | Tree |
| 155. | <i>Ochna gambleii</i> * | Ochnaceae | Tree |
| 156. | <i>Ochna lanceolata</i> | Ochnaceae | Tree |
| 157. | <i>Ochna obtusata</i> * | Ochnaceae | Tree |
| 158. | <i>Olea dioica</i> | Oleaceae | Tree |
| 159. | <i>Ozyris wightiana</i> | Santalaceae | Shrub |
| 160. | <i>Pavetta indica</i> | Rubiaceae | Shrub |
| 161. | <i>Pavetta montana</i> | Rubiaceae | Shrub |
| 162. | <i>Pavetta tomentosa</i> | Rubiaceae | Shrub |
| 163. | <i>Phyllanthus emblica</i> | Euphorbiaceae | Tree |
| 164. | <i>Phyllanthus indofischerii</i> * | Euphorbiaceae | Tree |
| 165. | <i>Phyllanthus polyphyllus</i> | Euphorbiaceae | Shrub |
| 166. | <i>Pittosporum floribundum</i> ** | Pittosporaceae | Tree |
| 167. | <i>Plecosperrum spinosum</i> | Moraceae | Straggler |
| 168. | <i>Pleiospermium alatum</i> | Rutaceae | Tree |
| 169. | <i>Polyalthia cerasoides</i> ** | Annonaceae | Tree |
| 170. | <i>Pongamia pinnata</i> | Fabaceae | Tree |
| 171. | <i>Premna tomentosa</i> ** | Verbenaceae | Tree |
| 172. | <i>Prosopis juliflora</i> | Mimosaceae | Tree |
| 173. | <i>Pterocarpus marsupium</i> | Fabaceae | Tree |
| 174. | <i>Randia brandisii</i> | Rubiaceae | Shrub |
| 175. | <i>Randia dumetorum</i> | Rubiaceae | Shrub |
| 176. | <i>Randia spinosa</i> | Rubiaceae | Shrub |
| 177. | <i>Saccopetalum tomentosum</i> | Annonaceae | Tree |
| 178. | <i>Salix tetrasperma</i> | Salicaceae | Tree |
| 179. | <i>Santalum album</i> | Santalaceae | Tree |
| 180. | <i>Sapindus emarginatus</i> | Sapindaceae | Tree |
| 181. | <i>Schefflera stellata</i> ** | Aaliaceae | Scandent |
| 182. | <i>Schleichera oleosa</i> ** | Sapindaceae | Tree |
| 183. | <i>Semecarpus anacardium</i> | Anacardiaceae | Tree |
| 184. | <i>Shorea roxburghii</i> * | Dipterocarpaceae | Tree |
| 185. | <i>Shorea tumbaggaia</i> * | Dipterocarpaceae | Tree |
| 186. | <i>Sterculia urens</i> | Sterculiaceae | Tree |
| 187. | <i>Stereospermum colais</i> | Bignoniaceae | Tree |
| 188. | <i>Stereospermum personatum</i> | Bignoniaceae | Tree |
| 189. | <i>Streblus asper</i> ** | Moraceae | Tree |
| 190. | <i>Strychnos nux-vomica</i> | Loganiaceae | Tree |
| 191. | <i>Strychnos potatorum</i> ** | Loganiaceae | Tree |

| Sl. No. | Name of the species | Family | Habitat |
|--|---------------------------------|----------------|-----------|
| 192. | <i>Syzygium alternifolium</i> * | Myrtaceae | Tree |
| 193. | <i>Syzygium cumini</i> ** | Myrtaceae | Tree |
| 194. | <i>Syzygium jambos</i> ** | Myrtaceae | Tree |
| 195. | <i>Syzygium operculatum</i> * | Myrtaceae | Tree |
| 196. | <i>Tamarindus indica</i> | Caesalpinaceae | Tree |
| 197. | <i>Tarenna asiatica</i> | Rubiaceae | Shrub |
| 198. | <i>Tecoma stans</i> | Bignoniaceae | Shrub |
| 199. | <i>Tectona grandis</i> | Verbenaceae | Shrub |
| 200. | <i>Terminalia arjuna</i> | Combretaceae | Tree |
| 201. | <i>Terminalia bellirica</i> | Combretaceae | Tree |
| 202. | <i>Terminalia chebula</i> | Combretaceae | Tree |
| 203. | <i>Terminalia crenulata</i> * | Combretaceae | Tree |
| 204. | <i>Terminalia tomentosa</i> | Combretaceae | Tree |
| 205. | <i>Thespesia populnea</i> | Malvaceae | Tree |
| 206. | <i>Toddalia asiatica</i> | Rutaceae | Straggler |
| 207. | <i>Trema orientalis</i> ** | Ulmaceae | Tree |
| 208. | <i>Ventilago goughii</i> * | Rhamnaceae | Straggler |
| 209. | <i>Ventilago maderaspatana</i> | Rhamnaceae | Straggler |
| 210. | <i>Vitex altissima</i> ** | Verbenaceae | Tree |
| 211. | <i>Vitex negundo</i> | Verbenaceae | Tree |
| 212. | <i>Wendlandia lawii</i> * | Rubiaceae | Shrub |
| 213. | <i>Wendlandia thyrsoides</i> | Rubiaceae | Shrub |
| 214. | <i>Wrightia arborea</i> | Apocynaceae | Tree |
| 215. | <i>Wrightia tinctoria</i> | Apocynaceae | Tree |
| 216. | <i>Ziziphus mauritiana</i> ** | Rhamnaceae | Tree |
| 217. | <i>Ziziphus oenoplia</i> ** | Rhamnaceae | Straggler |
| 218. | <i>Ziziphus trinervia</i> ** | Rhamnaceae | Tree |
| 219. | <i>Ziziphus xylopyrus</i> | Rhamnaceae | Tree |
| * Endemic plants; ** Fleshy fruit yielding plants. | | | |



a. *Cycas circinalis*-An endangered species., **b.** *Carea arborea*- An important medicinal plant in the study area., **c.** *Ardisia solanacea*-A rare species in the study area



a. *Glochidion bourdillonii*-Is a rare and endemic species., **b.** *Firmiana colorata*-One of the rare species in the study area., **c.** *Syzygium alternifolium*-Is a rare and endemic species.

Occurrence and abundance of birds in BNP

Introduction

Birds are regarded as one of the natural indicators of an ecosystem and their role as natural seed dispersers is very important. Most of the wood plant species are dispersed by birds (Corlett, 1998). Hence it is very important to understand the ecology and monitor the avian species in any given area. In India, the distribution and occurrence of bird species is well established on large spatial scales. Naturalists and amateur bird watchers have been reporting rare sightings in different regions on regular scale, which is helping in understanding the distribution limits of birds. However, density estimates and population monitoring of birds are not available for most of the parks or regions. In the present study we estimate the density of birds for Bannerghatta National Park.

Methods

The details of the park and overlaying of the grids is provided in Chapter 1. We followed fixed radius point sampling to estimate bird density. In each grid, at every 200 m, a point was established. Each sampling point was replicated thrice for the bird count. Bird counts were carried out in the early morning hours and during evening hours. At each point, the observer stood for few seconds, and then the birds which were within 15 m radius were recorded with species identity and number of individuals. The observation period was 10 min at each point. The data from all the points from temporal replication was added and treated as one sample. Since the present exercise was of fixed width, the density estimates were calculated for each grid or each species by adding the counts. Bird density is projected as the number of birds per hectare. Nomenclature of Grimmet and Inskipp (1998) was followed for birds.

Results

A total of 178 species of birds belonging to 54 families were recorded during the assessment, of which 145 species were recorded during the point count (Appendix 3.1). Among the 178 species reported 148 were residents while the remaining 30 were local migrants (Fig. 3.1). The

density was estimated for 145 species and the estimates varied between 0.05 and 23.15 birds/ha for different bird species. Amongst the various species, open forest preferring species such as red-vented bulbul *Pycnonotus cafer* (23.15 birds/ha), yellow-billed babbler *Turdoides affinis* (13.92 birds/ha) and red-whiskered bulbul *Pycnonotus jocosus* (12.97 birds/ha) were in the high density, while red spur-fowl *Galloperdix spadicea*, white-eyed buzzard *Butastur teesa*, recorded the lowest density (0.05 birds/ha) for resident birds. Among the local migrants verditer flycatcher *Muscicapa thalassina* had density of 0.05 birds/ha and Blyth's reed-warbler *Acrocephalus dumetorum* (0.11 birds/ha), recorded the lowest density, while green bee-eater (*Merops orientalis*) had the highest density (10.51 birds/ha).

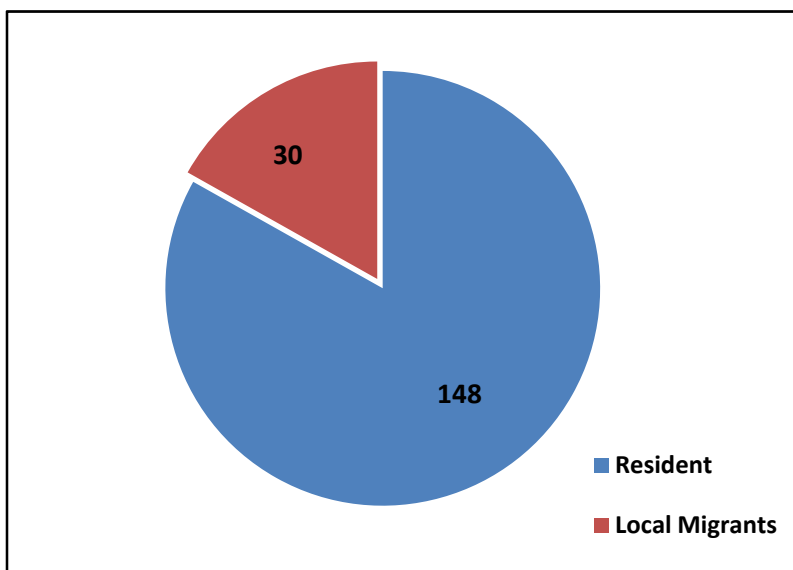


Figure 3.1 Number of resident and local migrant birds recorded in Bannerghatta National Park

The micro habitat occupancy of the bird species varied and was classified broadly into five types (Fig. 3.2). The species were grouped where they were recorded the most, for instances if a species was recorded in trees and also in bushes, the species would be categorized based on where they were seen the most. Among the 178 species 84 were arboreal species constituting 47.19 %, , while wetland accounted for 33 species (18.53%), bush dwellers accounted for 34 species (19.01%), 16 species were ground

dwellers constituting 8.98% and 11 species preferred the rocky areas (including riverine) constituting 6.17%.

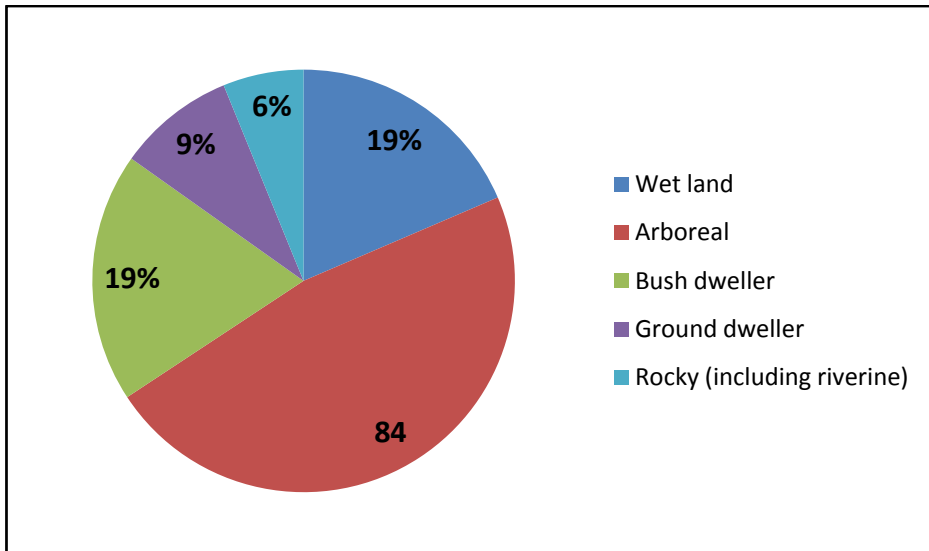


Figure 3.2 Habitat preferences by bird species

The birds were grouped based on their feeding guilds. Broadly, birds were grouped under eight categories depending on their diet (Fig. 3.3). Overall 113 (49%) species were insectivorous, 29 (13%) frugivorous, 23 (10%) granivorous, 09 (4%) nectarivore, 21 (9%) carnivorous birds (birds of prey), 19 (8%) piscivorous (including other aquatic insects and vertebrates) and 8 (4%) species each for omnivores and birds feeding on vegetative matter.

Mixed flocks: Foraging in mixed flocks is common in many species of birds; however the precise reason for this behavior depends on various factors in a given condition. The adaptive hypothesis for the evolution of flocking in birds have usually focused on predation avoidance or foraging enhancement (Guy Beauchamp, 2004). During our survey we regularly recorded feeding parties with six to eight species feeding on fig trees and nectar of flame of the forest trees; and on occasions they were seen just flocking together on trees or in shady areas, however on one occasion we recorded 15 species flocking on flame of the forest tree. The commoners in the feeding parties were the red-whiskered bulbul, red-vented bulbul, yellow-billed babbler, purple-rumped sunbird, purple sunbird, flower

peckers, barbets, rosy starling, jungle myna, small minivet, blue-winged leafbird, lesser whitethroat and verditer flycatcher.

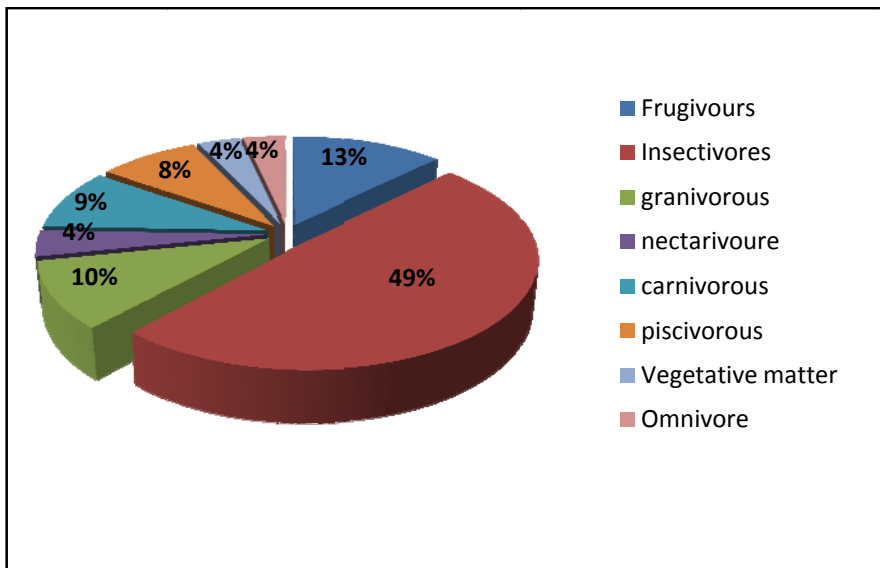


Figure 3.3 Number of bird species under feeding guilds

To explore which factors in the park determine the bird richness and bird density, we estimated the bird richness and density according to the grids. Covariates measured in each grid are provided in Table 3.1. Bird richness ($X^2 = 73.318, p > .000$) and bird density ($X^2 = 420.809, p > .000$) varied significantly between the grids. We ran a Pearson correlation test to see covariates which are influencing the richness and density on spatial scale in Bannerghatta National Park. The covariates were tree density, basal area and average NDVI values as the major forest parameters, and stumps/ lopping rate and dung density of livestock were considered as the disturbance factors. Pearson correlation shows that none of the listed covariates were significantly related to bird richness or bird density on spatial scale, moreover though the relation was not significant but tree density and NDVI were negatively correlated to bird richness and bird density (Table 3.2).

Comparison between the different surveys:

The management plan of the park has a checklist of birds which was provided by Zoological Survey of India (ZSI) that reports 222 species of birds for the park (Management Plan). While Karthikeyan and

Table 3.1 Bird richness and density in different grids and values of covariates

| Grid No. | Bird richness | Bird density | Tree Density | Basal area | Stumps/ lopping | Livestock dung density | Mean NDVI |
|-----------------|----------------------|---------------------|---------------------|-------------------|------------------------|-------------------------------|------------------|
| 0 | 56 | 352.11 | 557.71 | 49.46 | 0 | 46.29 | 0.036481099 |
| 1 | 47 | 213.66 | 656.00 | 66.91 | 104.16 | 201.38 | 0.096553695 |
| 10 | 23 | 172.53 | 611.20 | 26.91 | 0 | 0 | 0.179754871 |
| 11 | 41 | 419.01 | 467.20 | 48.29 | 31.25 | 83.33 | 0.125861932 |
| 13 | 33 | 198.59 | 617.14 | 32.18 | 383.33 | 50.00 | 0.24768177 |
| 19 | 36 | 235.35 | 704.00 | 54.37 | 130.95 | 59.52 | 0.18074518 |
| 2 | 47 | 294.36 | 566.66 | 69.12 | 183.33 | 150.00 | 0.130313731 |
| 22 | 49 | 263.38 | 574.40 | 52.46 | 0 | 8.33 | 0.185032387 |
| 23 | 53 | 219.43 | 585.60 | 53.22 | 39.47 | 35.08 | 0.21186912 |
| 24 | 44 | 218.30 | 672.00 | 46.50 | 34.72 | 6.94 | 0.188507472 |
| 31 | 51 | 235.07 | 580.00 | 56.96 | 64.10 | 57.69 | 0.17654732 |
| 33 | 72 | 226.05 | 510.00 | 41.44 | 230.15 | 99.20 | 0.101057711 |
| 34 | 27 | 148.87 | 430.00 | 44.24 | 59.52 | 47.61 | 0.161276033 |
| 36 | 45 | 325.63 | 442.66 | 39.84 | 208.33 | 218.75 | 0.139135101 |
| 37 | 33 | 154.92 | 624.00 | 28.53 | 55.55 | 22.22 | 0.165628462 |
| 38 | 30 | 221.26 | 582.40 | 19.01 | 83.33 | 130.95 | 0.122310609 |
| 43 | 53 | 235.07 | 488.00 | 47.96 | 93.75 | 41.66 | 0.192242309 |
| 44 | 52 | 266.33 | 508.00 | 32.79 | 60.60 | 106.06 | 0.217107866 |
| 45 | 27 | 222.53 | 595.20 | 28.19 | 266.66 | 166.66 | 0.233431885 |
| 6 | 55 | 326.76 | 550.85 | 52.78 | 308.33 | 741.66 | 0.190707965 |
| 7 | 58 | 245.35 | 644.57 | 38.79 | 48.61 | 173.61 | 0.239022743 |
| 8 | 51 | 267.60 | 672.00 | 45.37 | 388.88 | 145.83 | 0.149799168 |
| 9 | 34 | 122.95 | 486.40 | 55.73 | 0 | 68.18 | 0.175647938 |

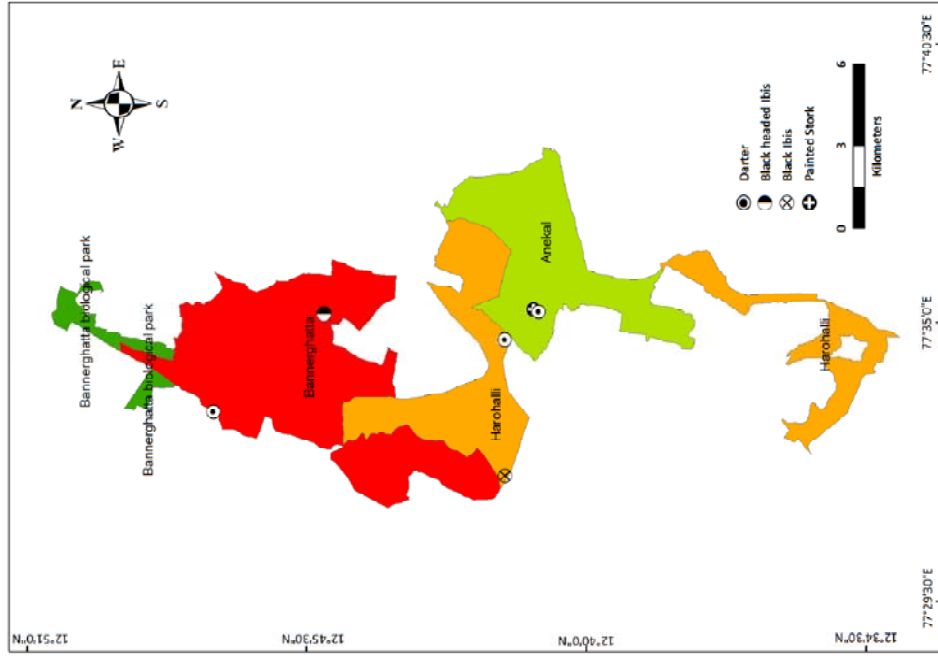
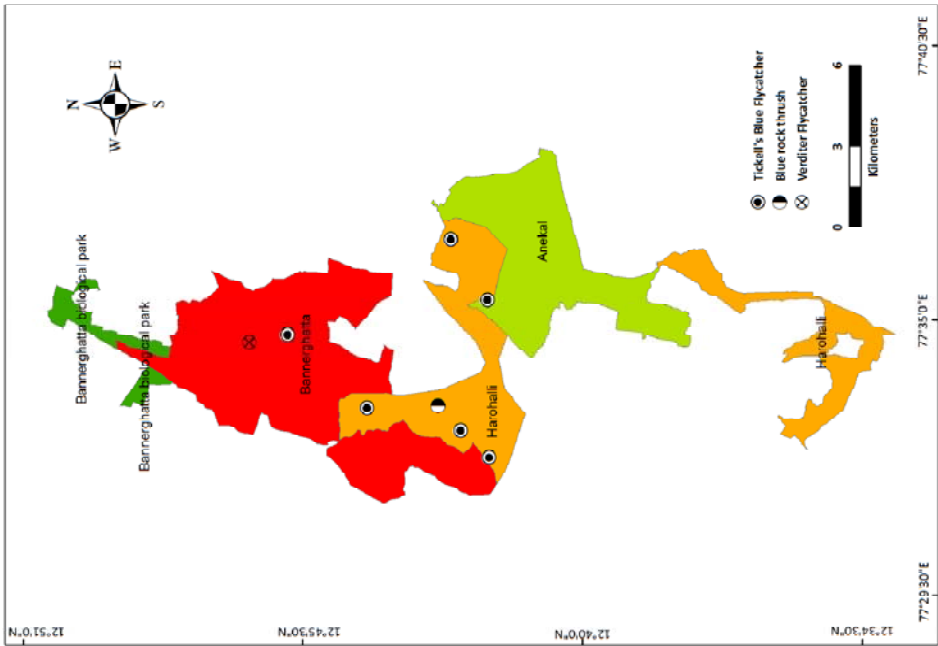
Table 3.2 Test value (Person correlation- r^2) for each covariate (none of them were significant)

| | Tree density | Basal area | Stumps/ lopping | Livestock dung density | Mean NDVI |
|---------------|---------------------|-------------------|------------------------|-------------------------------|------------------|
| Bird richness | -.063 | .406 | .097 | .247 | -.227 |
| Bird Density | -.197 | .229 | .130 | .362 | -.350 |

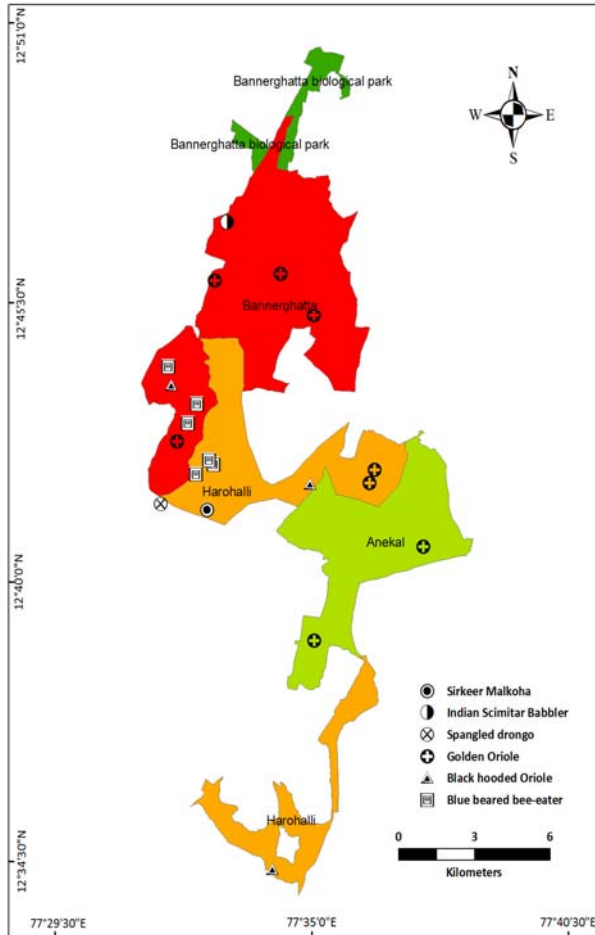
Sunilkumar (2005) reported 203 species of birds from a year long survey in 2005, we were able to record 178 species during our short survey of four months. Though there are small patches of moist deciduous forests along the riverine and seasonal water streams, the park does not have good wet forests. However, many species reported by ZSI are habitat specialists and many of them are known to occur mostly in forests of Western Ghats e.g. mountain imperial pigeon (*Ducula badia*), Malabar whistling thrush (*Myiophonus horsfieldii*), grey-breasted laughing thrush (*Garrulax jerdoni*), crimson-backed sunbird (*Nectarinia minima*), grey-headed canary flycatcher (*Culicicapa ceylonensis*), bar-winged flycatcher-shrike (*Hemipus picatus*), dark-fronted babbler (*Rhopocichla atriceps*), brown-cheeked fulvetta (*Alcippe poiocephala*), grey-headed bulbul (*Pycnonotus priocephalus*), yellow-browed bulbul (*Lole indica*) and lesser coucal (*Centropus bengalensis*), their presence in this habitat is very doubtful and needs further evidence. Another species, the green-billed malkoha (*Phaenicophaeus viridirostris*) known to have distribution from central to North eastern states has been reported from the park. This shows that there may be an error in listing the bird species of Bannerghatta by Zoological Survey of India or species might have disappeared from the park. Further, vulture species like the white-rumped Vulture (*Gyps bengalensis*), long-billed vulture (*Gyps indicus*) and red-headed vulture (*Sarcogyps calvus*) have been reported by ZSI and Karthikeyan and Sunilkumar (2005); however during our survey, we were not able to sight any of them. Our interviews with forest department personnel revealed that these species have not been sighted for at least the past five to six years.

Discussion

Bannerghatta national park is a potential habitat for avifauna. Zoological Survey of India has reported 222 species of birds, while Karthikeyan and Sunilkumar (2005) reported 203 species of birds from a year long survey in 2005. We were able to record 178 species during our short study period of four months. Estimating the density of some nocturnal birds like owls and night jays, and some of the ground dwelling birds was difficult. Such species require exclusive technique to estimate them. Thus, the present estimate is very general and covers only the species that we were able to sight during the day walks. The national park has a good diversity of trees



Mapping of some important bird species



Mapping of some important bird species

which provide ample food sources in the form of fruits. Other than the fruits they also play host to many insects at different strata which the birds feed on. We expected that lesser disturbance level and high density of trees would influence more number of bird species and also density. Surprisingly, the relationship was insignificant. This is probably because the entire park is very narrow in shape, and also human disturbance was observed in the entire park which makes the uniformity in the habitat at both suitable habitat available and also disturbance level. Thus the relationship between any of the covariates with bird richness and bird density was not significant.

Bulbuls (i.e. red-vented bulbul and red-whiskered bulbul) are the most dominant species in the park, and they are habitat generalists. Further, their high density may be attributed to the presence of large extent of lantana cover all around the national park, which these species use as foraging and nesting grounds. However, the increase in Lantana density benefits only few species, leading to greater homogeneity with general decline in diversity (Aravind et al. 2010). As we have recorded most of the local migrant species in lower densities.

The park is recognized as one of the important bird area (Birdlife International, 2011). Darter (*Anhinga melanogaster*), black-headed ibis (*Threskiornis melanocephalous*) and black ibis (*Pseuidbis papillosa*) which are considered as near threatened species were recorded from the tanks found in the park. Endangered long billed vulture (*Gyps indicus*) and vulnerable yellow throated bulbul (*Pycnonotus xantholaemus*) which were reported here earlier have not been sighted during our survey, especially the former has not been sighted for the past six years.

However, continuous mining around the periphery of the forest and other illegal activities hamper bird movements and reduce the roosting site of many raptors which prefer rocky outcrop. Critical interventions with regard to management and conservation of the park can further attract many rare birds and make the habitat suitable for many resident birds for longer survival. The park is situated very close to one of the fastest emerging cosmopolitan cities in the world, thus monitoring of birds will throw light on the impact of expansion of cities and also effectiveness of management.

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Appendix 3.1

Comparative Checklist of birds of Bannerghatta National Park

| Species | 2011 | 2006 | ZSI | Status | Density |
|--|------|------|-----|--------|---------|
| Family: Podicipitidae | | | | | |
| 1. Little Grebe (<i>Tachybaptus ruficollis</i>) | P | P | P | C/R/B | 0.559 |
| Family: Pelecanidae | | | | | |
| 2. Spot-Billed Pelican (<i>Pelecanus philippensis</i>) | NR | NR | P | | |
| Family: Phalacrocoracidae | | | | | |
| 3. Little Cormorant (<i>Phalacrocorax niger</i>) | P | P | P | C/R/B | 0.335 |
| 4. Indian Cormorant (<i>Phalacrocorax fuscicollis</i>) | P | NR | P | R | |
| 5. Great Cormorant (<i>Phalacrocorax carbo</i>) | P | NR | P | C/R/B | 0.111 |
| Family: Anhingidae | | | | | |
| 6. Darter (<i>Anhingamelanogaster</i>) | P | NR | P | r/R | 0.167 |
| Family: Ardeidae | | | | | |
| 7. Grey Heron (<i>Ardea cinerea</i>) | P | P | P | C/R | 0.335 |
| 8. Purple Heron (<i>Ardea purpurea</i>) | P | P | P | C/R | 0.223 |
| 9. Little Heron (<i>Butorides striatus</i>) | NR | P | NR | | |
| 10. Indian Pond Heron (<i>Ardeola grayii</i>) | P | P | P | C/R | 1.286 |
| 11. Cattle Egret (<i>Bubulcus ibis</i>) | P | P | P | C/R | 0.391 |
| 12. Great Egret (<i>Casmerodius albus</i>) | P | NR | P | r/R | 0.111 |
| 13. Intermediate Egret (<i>Mesophoyx intermedia</i>) | P | NR | P | r/R | 0.165 |
| 14. Little Egret (<i>Egretta garzetta</i>) | P | P | P | C/R | 0.503 |
| 15. Black Crowned Night Heron (<i>Nycticorax nycticorax</i>) | C | P | P | r/R | 0.055 |
| Family: Ciconiidae | | | | | |
| 16. Painted Stork (<i>Mycteria leucocephala</i>) | P | P | P | C/LM | 0.111 |
| 17. Openbill Stork (<i>Anastomus oscitans</i>) | P | P | NR | r/LM | |
| 18. Woolly-necked Stork (<i>Ciconia episcopus</i>) | P | P | P | r/LM | 0.223 |
| Family: Threskiornithidae | | | | | |
| 19. Blackheaded Ibis (<i>Threskiornis melanocephalous</i>) | P | NR | P | C/LM | 0.838 |
| 20. Black Ibis (<i>Pseudibis papillosa</i>) | P | NR | NR | r/LM | 0.111 |

| Species | 2011 | 2006 | ZSI | Status | Density |
|--|------|------|-----|--------|---------|
| 21. Eurasian Spoonbill (<i>Plataea leucorodia</i>) | NR | NR | P | | |
| Family: Anatidae | | | | | |
| 21. Lesser Whistling-Duck (<i>Dendrocygna javanica</i>) | P | P | P | r/R | |
| 22. Spot-billed Duck (<i>Anas poecilorhyncha</i>) | P | P | P | C/R/B | |
| 23. Northern Pintail (<i>Anas acuta</i>) | NR | NR | P | | |
| 24. Common Teal (<i>Anas crecca</i>) | NR | NR | P | | |
| Family: Accipitridae | | | | | |
| 25. Black Shouldered Kite (<i>Elanus caeruleus</i>) | P | P | P | C/R | 0.165 |
| 26. Black Kite (<i>Milvus migrans</i>) | P | P | P | C/R/B | 2.068 |
| 27. Brahminy Kite (<i>Haliastur indus</i>) | P | P | P | C/R/B | 0.279 |
| 28. Shikra (<i>Accipiter badius</i>) | P | P | P | C/R/B | 0.615 |
| 29. Twany Eagle (<i>Aquila rapax</i>) | P | P | P | r/LM | |
| 30. Eurasian Marsh Harrier (<i>Circus aeruginosus</i>) | P | NR | NR | r/LM | 0.055 |
| 31. Crested Serpent Eagle (<i>Spilornis cheela</i>) | P | P | P | C/R | 0.503 |
| 32. Oriental Honey Buzzard (<i>Pernis ptilorhynchus</i>) | P | P | P | C/R | |
| 33. Short-toed snake eagle (<i>Circaetus gallicus</i>) | P | P | P | C/R | 0.111 |
| 34. Booted Eagle (<i>Hieraaetus pennatus</i>) | P | P | NR | r/LM | |
| 35. Bonellis Eagle (<i>Hieraaetus fasciatus</i>) | P | P | NR | C/R | 0.615 |
| 36. Changeable Hawk Eagle (<i>Spizaetus cirrhatus</i>) | P | P | NR | C/R | 0.111 |
| 37. Black Eagle (<i>Ictinaetus malayensis</i>) | NR | P | P | | |
| 38. White-eyed buzzard (<i>Butastur teesa</i>) | P | P | P | C/R | 0.055 |
| 39. Greater Spotted Eagle (<i>Aquila clanga</i>) | NR | NR | P | | |
| 40. Montagu's Harrier (<i>Circus pygargus</i>) | NR | P | NR | | |
| 41. White-Rumped Vulture (<i>Gyps bengalensis</i>) | NR | P | P | | |
| 42. Long-billed Vulture (<i>Gyps indicus</i>) | NR | NR | P | | |
| 43. Egyptian Vulture (<i>Neophron percnopterus</i>) | P | P | P | | |
| 44. Red-headed Vulture (<i>Sarcogyps calvus</i>) | NR | P | P | | |
| Family: Falconidae | | | | | |
| 45. Common Kestrel (<i>Falco tinnunculus</i>) | P | NR | P | C/LM | 0.559 |
| 46. Peregrine Falcon (<i>Falco peregrinus</i>) | NR | P | NR | | |
| 47. Eurasian Hobby (<i>Falco subbuteo</i>) | NR | P | NR | | |
| Family: Phasianidae | | | | | |
| 48. Grey Francolin (<i>Francolinus pondicerianus</i>) | P | P | P | C/R/B | 2.236 |
| 49. Common Quail (<i>Coturnix coturnix</i>) | P | NR | P | C/R/B | 0.273 |

| Species | 2011 | 2006 | ZSI | Status | Density |
|--|------|------|-----|--------|---------|
| 50. Rain Quail (<i>Coturnix coromandelica</i>) | NR | P | NR | | |
| 51. Blue-Breasted Quail (<i>Coturnix chinensis</i>) | NR | P | NR | | |
| 52. Jungle Bush Quail (<i>Perdica asiatica</i>) | NR | P | P | | |
| 53. Painted Bush Quail (<i>Perdica erythrorhyncha</i>) | NR | P | P | | |
| 54. Grey jungle fowl (<i>Gallus sonneratii</i>) | P | P | P | C/R/B | 2.739 |
| 55. Red Spurfowl (<i>Galloperdix spadicea</i>) | P | P | P | C/R/B | 0.055 |
| 56. Painted Spurfowl (<i>Galloperdix lunulata</i>) | NR | P | NR | | |
| 57. Indian peafowl (<i>Pavo cristatus</i>) | P | P | P | C/R/B | 0.950 |
| Family: Turnicidae | | | | | |
| 58. Barred Button Quail (<i>Turnix suscitator</i>) | P | P | NR | C/R/B | 0.447 |
| 59. Yellow Legged Button Quail (<i>Turnix tanki</i>) | P | NR | NR | C/R/B | 0.167 |
| Family: Gruidae | | NR | | | |
| 60. Demoiselle Crane (<i>Grus virgo</i>) | NR | NR | P | | |
| Family: Rallidae | | | | | |
| 61. White-breasted Waterhen (<i>Amaurornis phoenicurus</i>) | P | P | P | C/R/B | 0.559 |
| 62. Slaty-Breasted Rail (<i>Gallirallus striatus</i>) | NR | P | NR | | |
| 63. Common Coot (<i>Fulica atra</i>) | P | NR | NR | C/R/B | |
| 64. Purple Swampphen (<i>Porphyrio porphyrio</i>) | P | NR | NR | C/R/B | |
| 65. Common Moorhen (<i>Gallinula chloropus</i>) | NR | NR | P | | |
| Family: Jacanidae | | | | | |
| 66. Pheasant-tailed Jacana (<i>Hydrophasianus chirurgus</i>) | P | P | P | C/R | |
| 67. Bronze-winged Jacana (<i>Metopidius indicus</i>) | P | NR | NR | C/R | |
| Family: Charadriidae | | | | | |
| 68. Red-Wattled Lapwing (<i>Vanellus indicus</i>) | P | P | P | C/R/B | 1.342 |
| 69. Yellow-wattled Lapwing (<i>Vanellus malabaricus</i>) | P | P | P | C/R/B | 0.111 |
| 70. Little Ringed plover (<i>Charadrius dubius</i>) | NR | P | P | | |
| Family: Scolopacidae | | | | | |
| 71. Common Sandpiper (<i>Actitis hypoleucos</i>) | P | NR | P | C/R | 0.335 |
| 72. Wood sandpiper (<i>Tringa glareola</i>) | NR | NR | P | | |
| 73. Green Sandpiper (<i>Tringa ochropus</i>) | NR | P | P | | |
| Family: Recurvirostridae | | | | | |
| 74. Black-winged Stilt (<i>Himantopus himantopus</i>) | NR | NR | P | | |
| 75. Pintail Snipe (<i>Gallinago stenura</i>) | NR | NR | P | | |

| Species | 2011 | 2006 | ZSI | Status | Density |
|---|------|------|-----|--------|---------|
| 76. Eurasian Woodcock (<i>Scolopax rusticola</i>) | NR | NR | P | | |
| Family: Burhinidae | | | | | |
| 77. Eurasian Thick-Knee (<i>Burhinus oedicnemus</i>) | NR | P | P | | |
| Family: Laridae | | | | | |
| 78. River Tern (<i>Sterna aurantia</i>) | P | P | NR | R | 0.657 |
| Family: Pteroclididae | | | | | |
| 79. Painted sandgrouse (<i>Pterocles indicus</i>) | NR | P | NR | | |
| Family: Columbidae | | | | | |
| 80. Yellow-footed Green pigeon (<i>Treron phoenicoptera</i>) | P | P | P | r/R | 0.615 |
| 81. Nilgiri Wood Pigeon (<i>Columba elphinstoni</i>) | NR | P | P | | |
| 82. Mountain Imperial Pigeon (<i>Ducula badia</i>) | NR | NR | P | | |
| 83. Pompadour Green Pigeon (<i>Treron pompadora</i>) | NR | NR | P | | |
| 84. Rock Pigeon (<i>Columba livia</i>) | P | | P | C/R/B | |
| 85. Oriental Turtle Dove (<i>Streptopelia orientalis</i>) | NR | P | NR | | |
| 86. Eurasian Collared Dove (<i>Streptopelia decaocto</i>) | P | P | P | C/R/B | 3.075 |
| 87. Spotted Dove (<i>Streptopelia chinensis</i>) | P | P | P | C/R/B | 10.624 |
| 88. Laughing Dove (<i>Streptopelia senegalensis</i>) | P | P | P | C/R/B | 4.585 |
| Family: Psittacidae | | | | | |
| 89. Plump headed parakeet (<i>Psittacula cyanocephala</i>) | P | P | P | C/R | 2.684 |
| 90. Rose-ringed Parakeet (<i>Psittacula krameri</i>) | P | P | P | C/R/B | 3.970 |
| 91. Malabar Parakeet (<i>Pittacula columboides</i>) | NR | NR | P | | |
| 92. Vernal Hanging Parrot (<i>Loriculus vernalis</i>) | NR | NR | P | | |
| Family: Cuculidae | | | | | |
| 93. Pied Cuckoo (<i>Clamtor jacobinus</i>) | P | P | P | r/LM | |
| 94. Common hawk cuckoo (<i>Hierococyx varius</i>) | P | P | P | C/R/B | 0.447 |
| 95. Indian Cuckoo (<i>Cuculus micropterus</i>) | P | NR | P | C/R/B | |
| 96. Grey-Bellied Cuckoo (<i>Cacomantis passerinus</i>) | NR | P | NR | | |
| 97. Asian Koel (<i>Eudynamys scolopacea</i>) | P | P | P | C/R/B | 0.671 |
| 98. Greater Coucal (<i>Centropus sinensis</i>) | P | P | P | C/R/B | 1.565 |
| 99. Lesser Coucal (<i>Centropus bengalensis</i>) | NR | NR | P | | |
| 100. Blue-faced Malkoha (<i>Phaenicophaeus viridirostris</i>) | P | P | P | r/R | 0.335 |
| 101. Green-Billed Malkoha (<i>Phaenicophaeus viridirostris</i>) | NR | NR | P | | |

| Species | 2011 | 2006 | ZSI | Status | Density |
|---|------|------|-----|--------|---------|
| 102. Sirkeer malkoha (<i>Phaenicophaeus leschenaultia</i>) | P | P | P | r/R | 0.055 |
| Family: Strigidae | | | | | |
| 103. Barn Owl (<i>Tyto alba</i>) | P | P | P | C/R | |
| 104. Collared Scops Owl (<i>Otus bakkamoena</i>) | P | P | NR | R | |
| 105. Oriental Scops Owl (<i>Otus sunia</i>) | NR | P | NR | | |
| 106. Spotted Owlet (<i>Athene brama</i>) | P | P | P | C/R/B | 0.223 |
| 107. Jungle Owlet (<i>Glaucidium radiatum</i>) | NR | P | P | | |
| 108. Eurasian Eagle Owl (<i>Bubo bubo</i>) | P | P | P | r/R | 0.055 |
| 109. Brown fish owl (<i>Bubo zeylonensis</i>) | P | P | P | r/R | |
| 110. Mottled Wood Owl (<i>Strix ocellata</i>) | NR | P | P | | |
| Family: Caprimulgidae | | | | | |
| 111. Indian Nightjar (<i>Caprimulgus asiaticus</i>) | P | P | P | C/R | 0.223 |
| 112. Grey Nightjar (<i>Caprimulgus indicus</i>) | NR | P | P | | |
| 113. Savanna Nightjar (<i>Caprimulgus affinis</i>) | NR | NR | P | | |
| 114. Jerdon's Nightjar (<i>Caprimulgus atripennis</i>) | NR | NR | P | | |
| 115. Large-Tailed Nightjar (<i>Caprimulgus macrurus</i>) | NR | P | P | | |
| Family: Apodidae | | | | | |
| 116. House Swift (<i>Apus affinis</i>) | P | P | P | C/R | 1.453 |
| 117. Asian Palm Swift (<i>Cypsiurus balasiensis</i>) | P | P | NR | C/R | |
| 118. Alpine Swift (<i>Tachymarpis melba</i>) | NR | P | P | | |
| 119. Indian Swiftlet (<i>Collocalia unicolor</i>) | NR | NR | P | | |
| 120. Crested Tree Swift (<i>Hemiprocne coronata</i>) | NR | P | P | | |
| Family: Alcedinidae | | | | | |
| 121. Common Kingfisher (<i>Alcedo atthis</i>) | P | P | P | C/R/B | 0.167 |
| 122. White-Throated Kingfisher (<i>Halcyon smyrnensis</i>) | P | P | P | C/R/B | 1.062 |
| 123. Pied Kingfisher (<i>Ceryle rudis</i>) | P | P | P | C/R | 0.111 |
| Family: Meropidae | | | | | |
| 124. Blue-bearded Bee-eater (<i>Nyctiornis athertoni</i>) | P | P | P | r/LM | 0.726 |
| 125. Green Bee-eater (<i>Merops orientalis</i>) | P | P | P | C/LM | 10.512 |
| 126. Blue-tailed Bee-eater (<i>Merops philippinus</i>) | P | NR | NR | C/LM | 0.391 |
| 127. Chestnut-Headed Bee-Eater (<i>Merops leschenaulti</i>) | NR | P | NR | | |
| Family: Coraciidae | | | | | |
| 128. Indian Roller (<i>Coracias benghalensis</i>) | P | P | P | C/R | 0.167 |

| Species | 2011 | 2006 | ZSI | Status | Density |
|--|------|------|-----|--------|---------|
| Family: Upupidae | | | | | |
| 129. Common Hoopoe (<i>Upupa epops</i>) | P | P | P | C/R/B | 0.167 |
| Family: Bucerotidae | | | | | |
| 130. Indian Grey Hornbill (<i>Ocyrceros birostris</i>) | P | NR | P | C/R/B | 0.447 |
| Family: Capitonidae | | | | | |
| 131. Brown-headed Barbet (<i>Megalaima zeylanica</i>) | P | P | P | C/R/B | 1.677 |
| 132. White Cheeked Barbet (<i>Megalaima viridis</i>) | P | P | P | C/R/B | 1.342 |
| 134. Coppersmith Barbet (<i>Megalaima haemacephala</i>) | P | P | P | C/R/B | 3.0195 |
| Family: Picidae | | | | | |
| 135. Rufus Woodpecker (<i>Micropternus brachyurus</i>) | P | P | P | r/R/B | |
| 136. Brown-Capped Pigmy Woodpecker (<i>Picoides nanus</i>) | NR | P | P | | |
| 137. Heart-spotted Woodpecker (<i>Hemicircus canente</i>) | P | NR | NR | r/R | |
| 138. Yellow crowned woodpecker (<i>Dendrocopos mahrattensis</i>) | P | P | P | C/R/B | 0.223 |
| 139. Black-Rumped Flameback (<i>Dinopium benghalense</i>) | P | P | NR | C/R/B | 0.391 |
| 140. White-Naped Woodpecker (<i>Chrysocolaptes festivus</i>) | NR | P | NR | | |
| 141. Streak -Throated Woodpecker (<i>Picus xanthopygeus</i>) | NR | P | NR | | |
| 142. Common Flameback (<i>Dinopium javanense</i>) | NR | NR | P | | |
| Family: Pittidae | | | | | |
| 143. Indian Pitta (<i>Pitta brachyuran</i>) | P | P | P | r/LM | |
| Family: Alaudidae | | | | | |
| 144. Singing Bush lark (<i>Mirafracantillans</i>) | P | NR | NR | C/R | 0.279 |
| 145. Indian Bush Lark (<i>Mirafra erythroptera</i>) | P | NR | NR | C/R | |
| 146. Ashy-crowned Sparrow Lark (<i>Eremopetrix grisea</i>) | P | P | P | C/R | 0.111 |
| 147. Rufous-winged lark (<i>Mirafra assamica</i>) | P | P | P | C/R | |
| 148. Rufous-tailed Lark (<i>Ammomanes phoenicurus</i>) | P | P | NR | C/R | 0.223 |
| Family: Hirundinidae | | | | | |
| 149. Wire-tailed Swallow (<i>Hirundo smithii</i>) | P | P | P | C/R | 0.167 |
| 150. Red-rumped Swallow (<i>Hirundo daurica</i>) | P | P | P | C/R/B | 3.410 |
| 151. Barn Swallow (<i>Hirundo rustica</i>) | NR | P | P | | |
| 152. Dusky crag martin (<i>Hirundo concolor</i>) | P | P | NR | C/R | |

| Species | 2011 | 2006 | ZSI | Status | Density |
|--|------|------|-----|--------|---------|
| Family: Laniidae | | | | | |
| 153. Baybacked Shrike (<i>Lanius vittatus</i>) | P | P | P | C/R/B | 1.453 |
| 154. Long-tailed Shrike (<i>Lanius schach</i>) | P | P | P | C/R/B | 0.559 |
| 155. Brown Shrike (<i>Lanius cristatus</i>) | P | P | P | r/LM | |
| Family: Oriolidae | | | | | |
| 156. Eurasian Golden Oriole (<i>Oriolus oriolus</i>) | P | P | P | C/LM | 0.167 |
| 157. Black-hooded Oriole (<i>Oriolus xanthornus</i>) | P | P | P | C/LM | 0.279 |
| 158. Black-Naped Oriole (<i>Oriolus chinensis</i>) | NR | P | NR | | |
| Family: Dicuridae | | | | | |
| 159. Black Drongo (<i>Dicrurus macrocercus</i>) | P | P | P | C/R | 4.026 |
| 160. Ashy Drongo (<i>Dicrurus leucophaeus</i>) | P | P | P | C/R | 0.671 |
| 161. White-bellied Drongo (<i>Dicrurus caeruleus</i>) | P | P | P | C/R | 4.641 |
| 162. Spangled Drongo (<i>Dicrurus hottentottus</i>) | P | P | NR | r/R | 0.055 |
| 163. Bronzed Drongo (<i>Dicrurus aeneus</i>) | NR | NR | P | | |
| 164. Greater Racket tailed Drongo (<i>Dicrurus paradiseus</i>) | NR | NR | P | | |
| Family: Artamidae | | | | | |
| 165. Ashy Woodswallow (<i>Artamus fuscus</i>) | P | P | P | C/R | 0.391 |
| Family: Sturnidae | | | | | |
| 166. Chestnut-Tailed Starling (<i>Sturnus malabaricus</i>) | P | P | P | r/LM | |
| 167. Brahminy Starling (<i>Sturnus pagodarum</i>) | P | P | P | C/R | 2.013 |
| 168. Rosy Starling (<i>Sturnus roseus</i>) | P | NR | P | C/LM | 0.894 |
| 169. Common Myna (<i>Acridotheres tristis</i>) | P | P | P | C/R/B | 4.417 |
| 170. Jungle Myna (<i>Acridotheres fuscus</i>) | P | P | P | C/R/B | 2.180 |
| 171. Hill Myna (<i>Gracula religiosa</i>) | NR | NR | P | | |
| Family: Corvidae | | | | | |
| 172. House Crow (<i>Corvus splendens</i>) | P | P | P | C/R/B | 1.397 |
| 173. Large-Billed Crow (<i>Corvus macrorhynchos</i>) | P | P | P | C/R/B | 4.976 |
| 174. Rufous treepie (<i>Dendrocitta vagabunda</i>) | P | P | P | C/R/B | 2.684 |
| Family: Campephagidae | | | | | |
| 175. Large Wood Shrike (<i>Tephrodornis gularis</i>) | NR | NR | P | | |
| 176. Common Woodshrike (<i>Tephrodornis pondicerianus</i>) | P | P | P | C/R | |
| 177. Large Cuckoo-Shrike (<i>Coracina novaehollandiae</i>) | P | P | P | C/R | 0.111 |

| Species | 2011 | 2006 | ZSI | Status | Density |
|--|------|------|-----|--------|---------|
| 178. Black Headed Cuckooshrike (<i>Coracina melanoptera</i>) | P | P | P | r/LM | 0.223 |
| 179. Small Minivet (<i>Pericrocotus cinnamomeus</i>) | P | P | P | C/R/B | 2.236 |
| 180. White-bellied Minivet (<i>Pericrocotus erythropygus</i>) | NR | NR | P | | |
| 181. Scarlet Minivet (<i>Pericrocotus cinnamomeus</i>) | P | P | P | r/R | 0.111 |
| Family: Irenidae | | | | | |
| 182. Common Iora (<i>Aegithina tiphia</i>) | P | P | P | C/R/B | 1.230 |
| 183. Marshall's Iora (<i>Aegithina nigrolutea</i>) | P | NR | NR | R | 0.223 |
| 184. Blue-winged Leafbird (<i>Chloropsis cochinchinensis</i>) | P | P | P | C/R | 0.391 |
| 185. Gold-fronted leafbird (<i>Chloropsis auriformis</i>) | P | P | P | C/R | 0.447 |
| Family: Pycnonotidae | | | | | |
| 186. Red-whiskered Bulbul (<i>Pycnonotus jocosus</i>) | P | P | P | C/R/B | 12.972 |
| 187. Red-vented Bulbul (<i>Pycnonotus cafer</i>) | P | P | P | C/R/B | 23.149 |
| 188. White-browed Bulbul (<i>Pycnonotus lutelus</i>) | P | P | P | C/R/B | 1.342 |
| 189. Yellow throated Bulbul (<i>Pycnonotus xantholaemus</i>) | NR | NR | P | | |
| 190. Grey-headed Bulbul (<i>Pycnonotus priocephalus</i>) | NR | NR | P | | |
| 191. Yellow-browed Bulbul (<i>Lole indica</i>) | NR | NR | P | | |
| 192. Black Bulbul (<i>Hypsipetes leucocephalus</i>) | NR | NR | P | | |
| Family: Muscicapinae Sub-Family: Timaliinae | | | | | |
| 193. Puff-throated Babbler (<i>Pellorneum ruficeps</i>) | P | P | P | r/R | |
| 194. Indian Scimitar Babbler (<i>Pomatorhinus horsfieldii</i>) | P | P | P | r/R | 0.447 |
| 195. Jungle Babbler (<i>Turdoides striatus</i>) | P | P | P | C/R/B | 5.479 |
| 196. Yellow-eyed babbler (<i>Chrysomma sinense</i>) | P | P | P | C/R/B | 0.671 |
| 197. Twany- bellied babbler (<i>Dumetia hyperythra</i>) | P | P | P | C/R | 2.795 |
| 198. Common babbler (<i>Turdoides caudatus</i>) | P | P | P | r/R | 1.342 |
| 199. Large Grey Babbler (<i>Turdoides malcolmi</i>) | P | P | P | C/R | 1.621 |
| 200. Yellow-Billed Babbler (<i>Turdoides affinis</i>) | P | P | P | C/R/B | 13.923 |
| 201. Dark-Fronted Babbler (<i>Rhopocichla atriceps</i>) | NR | NR | P | | |
| 202. Brown-Cheeked Fulvetta (<i>Alcippe poiocephala</i>) | NR | NR | P | | |
| Family: Muscicapinae | | | | | |
| 203. Asian Brown flycatcher (<i>Muscicapa dauurica</i>) | P | P | P | r/LM | 0.055 |
| 204. Brown-breasted Flycatcher (<i>Muscicapa muttui</i>) | NR | NR | P | | |

| Species | 2011 | 2006 | ZSI | Status | Density |
|--|------|------|-----|--------|---------|
| 205. Red-Throated Flycatcher (<i>Ficedula parva</i>) | NR | P | P | | |
| 206. Tickell's blue Flycatcher (<i>Cyornis tickelliae</i>) | P | P | P | r/R | 0.391 |
| 207. Grey-Headed Canary Flycatcher (<i>Culicicapa ceylonensis</i>) | NR | NR | P | | |
| 208. Verditer Flycatcher (<i>Muscicapa thalassina</i>) | P | P | P | r/LM | 0.055 |
| 209. Nilgiri Flycatcher (<i>Eumyias albicaudata</i>) | NR | P | P | | |
| 210. Black-napped Monarch (<i>Hypothymis azurea</i>) | NR | P | P | | |
| 211. Bar- Winged Flycatcher-Shrike (<i>Hemipus picatus</i>) | NR | NR | P | | |
| 212. White Browed Fantail-Flycatcher (<i>Rhipidura aureola</i>) | P | P | P | C/R/B | 1.062 |
| 213. White-Throated Fantail-Flycatcher (<i>Rhipidura albicollis</i>) | P | P | P | C/R/B | 0.503 |
| Family: Monarchinae | | | | | |
| 214. Asian Paradise-Flycatcher (<i>Terpsiphone paradisi</i>) | P | P | P | C/LM/B | 0.615 |
| Family: Sylviinae | | | | | |
| 215. Plain Prinia (<i>Prinia inornata</i>) | P | P | P | C/R/B | 0.782 |
| 216. Ashy Prinia (<i>Prinia socialis</i>) | P | P | P | C/R/B | 4.417 |
| 217. Zitting Cisticola (<i>Cisticola juncidis</i>) | P | P | P | C/R/B | 0.279 |
| 218. Grey-breasted Prinia (<i>Prinia hodgsonii</i>) | P | P | P | r/R | |
| 219. Jungle Prinia (<i>Prinia sylvatica</i>) | P | P | P | C/R/B | |
| 220. Common Tailorbird (<i>Orthotomus sutorius</i>) | P | P | P | C/R/B | 4.529 |
| 220. Blyth's Reed-Warbler (<i>Acrocephalus dumetorum</i>) | P | P | P | r/LM | 0.111 |
| 221. Clamorous Reed Warbler (<i>Acrocephalus stentoreus</i>) | NR | P | P | | |
| 223. Booted Warbler (<i>Hippolis caligata</i>) | P | P | NR | r/LM | 1.957 |
| 224. Lesser whitethroat (<i>Sylvia curruca</i>) | P | P | NR | r/LM | 0.671 |
| 225. Greenish Warbler (<i>Phylloscopus trochiloides</i>) | P | P | P | r/LM | 1.118 |
| 226. Orphean Warbler (<i>Sylvia hortensis</i>) | NR | P | P | | |
| 227. Western crowned Warbler (<i>Phylloscopus occipitalis</i>) | NR | NR | P | | |
| Family: Turdinae | | | | | |
| 228. Blue Throat (<i>Luscinia svecica</i>) | NR | P | NR | | |
| 229. Indian Blue Robin (<i>Luscinia brunnea</i>) | NR | P | NR | | |
| 230. Oriental Magpie-Robin (<i>Copsychus saularis</i>) | P | P | P | C/R/B | 4.417 |
| 231. White-Rumped Shama (<i>Copsychus malabaricus</i>) | NR | P | NR | | |

| Species | 2011 | 2006 | ZSI | Status | Density |
|--|------|------|-----|--------|---------|
| 232. Black Redstart (<i>Phoenicurus phoenicurus</i>) | NR | P | NR | | |
| 234. Pied Bushchat (<i>Saxicoloides caprata</i>) | P | P | P | C/R/B | 1.397 |
| 235. Common stonechat (<i>Saxicola torquata</i>) | P | NR | P | C/R/B | 0.559 |
| 236. Indian Robin (<i>Saxicoloides fulicata</i>) | P | P | P | C/R/B | 5.256 |
| 237. Blue-Capped Rock Thrush (<i>Monticola cinclorhynchus</i>) | NR | P | P | | |
| 238. Blue Rock Thrush (<i>Monticola solitarius</i>) | P | P | P | r/LM | 0.111 |
| 239. Orange-Headed Thrush (<i>Zoothera citrina cyantotus</i>) | P | P | P | r/R | |
| 240. Grey-Breasted Laughing Thrush (<i>Garrulax jerdoni</i>) | NR | NR | P | | |
| 241. Malbar Whistling Thrush (<i>Myiophonus horsfieldii</i>) | NR | NR | P | | |
| 242. Eurasian Blackbird (<i>Turdus merula</i>) | NR | P | P | | |
| Family: Paridae | | | | | |
| 243. Great Tit (<i>Parus major</i>) | P | P | P | C/R | 1.230 |
| 244. White-Naped Tit (<i>Parus nuchalis</i>) | NR | NR | P | | |
| 245. Black-Lored Tit (<i>Parus xanthogenys</i>) | NR | P | NR | | |
| Family: Sittidae | | | | | |
| 246. Chestnut-Bellied Nuthatch (<i>Sitta castanea</i>) | P | NR | P | C/R | 0.223 |
| 247. Velvet-fronted Nuthatch (<i>Sitta frontalis</i>) | NR | NR | P | | |
| Family: Motacillidae | | | | | |
| 248. Richard's Pipit (<i>Anthus richardi</i>) | NR | NR | P | | |
| 249. Olive-Backed Pipit (<i>Anthus hodgsoni</i>) | NR | P | P | | |
| 250. Paddy Field Pipit (<i>Anthus rufulus</i>) | P | NR | P | C/R | |
| 251. Yellow Wagtail (<i>Motacilla flava</i>) | P | NR | P | r/LM | 0.111 |
| 252. Grey Wagtail (<i>Motacilla cinerea</i>) | P | P | P | C/LM | 0.111 |
| 253. White-Browed Wagtail (<i>Motacilla maderaspatensis</i>) | P | P | P | C/R | 0.559 |
| 254. Forest Wagtail (<i>Dendronanthus indicus</i>) | NR | NR | P | | |
| 255. White Wagtail (<i>Motacilla alba</i>) | NR | NR | P | | |
| Family: Dicaeidae | | | | | |
| 256. Thickbilled Flowerpecker (<i>Dicaeum agile</i>) | P | P | P | C/R/B | 3.690 |
| 257. Pale-Billed Flowerpecker (<i>Dicaeum erythrohynchos</i>) | P | P | P | C/R/B | 2.348 |
| Family: Nectariniidae | | | | | |
| 258. Loten's sunbird (<i>Nectarinia lotenia</i>) | P | P | P | C/R/B | 1.174 |

| Species | 2011 | 2006 | ZSI | Status | Density |
|--|------------|------------|------------|--------|---------|
| 259. Purple-rumped Sunbird (<i>Nectarinia zeylonica</i>) | P | P | P | C/R/B | 12.301 |
| 260. Purple Sunbird (<i>Nectarinia asiatica</i>) | P | P | P | C/R/B | 8.723 |
| 261. Crimson-Backed Sunbird (<i>Nectarinia minima</i>) | NR | NR | P | | |
| Family: Zosteropidae | | | | | |
| 262. Oriental White-eye (<i>Zosterops palpebrosa</i>) | P | P | P | C/R/B | 0.559 |
| Family: Ploceinae | | | | | |
| 263. House Sparrow (<i>Paser domesticus</i>) | P | P | P | | |
| 264. Chestnut-Shouldered Petronia (<i>Petronia xanthocollis</i>) | NR | P | NR | | |
| 265. Baya Weaver (<i>Ploceus philippinus</i>) | P | P | P | C/R/B | |
| 266. Streaked weaver (<i>Ploceus manyar</i>) | NR | P | NR | | |
| Family: Estrildidae | | | | | |
| 267. Red Avadavat (<i>Amandava amandava</i>) | P | P | P | C/R/B | 0.559 |
| 268. Indian Silverbill (<i>Lonchura malabarica</i>) | P | P | P | C/R/B | 0.223 |
| 269. White-Rumped Munia (<i>Lonchura striata</i>) | P | P | P | C/R/B | |
| 270. Scaly-Breasted Munia (<i>Lonchura punctulata</i>) | P | P | P | C/R/B | 1.006 |
| 271. Blackheaded Munia (<i>Lonchura malacca</i>) | P | P | NR | C/R/B | 1.174 |
| Family: Fringillidae | | | | | |
| 272. Common Rosefinch (<i>Carpodacus erythrinus</i>) | P | P | P | C/R/B | 0.950 |
| Total | 178 | 202 | 222 | | |

C: Common, r: Rare, R: Resident, LM: Local Migrant; P: Recorded, NR:Not Recorded



a. Grey Francolin., b. Blue-bearded Bee-eater., c. Jungle Babbler., d. Red-whiskered Bulbul., e. Red-vented Bulbul., f. Pied Bushchat., g. Yellow-billed Babbler., h. Yellow-crowned Woodpecker., i. Sirkeer Malkoha., j. Chestnut-tailed Starling., k. Spangled Drongo., l. Common Hawk Cuckoo.



a. Brown Fish Owl., b. Shikra., c. Short-toed Snake Eagle., d. Oriental Honey-buzzard.

Occurrence and abundance of large mammals in BNP

Introduction

Among all the taxonomic group of organisms, mammals are the most susceptible to anthropogenic activities like hunting. Being large in size, they yield more meat, which attracts people. Besides this, loss of habitat has led to a reduction in the range of occupancy of most of the species. In developing countries like India, the rate of shrinkage of forest is more drastic due to overshooting human population. Though the protected area (PA) network in India is very well established, the basic mission of creation of PA network has been suffering due to various sociopolitical reasons. Conversely, in India, management of protected area is not based on scientific reasons. Many of the protected areas may not even have baseline data on the important taxonomic groups. Further, monitoring of these populations does not take place, which makes it more difficult to evaluate the conservation effort and functionality of each protected area. Bannerghatta National Park being close to the city, faces various pressures. Due to expansion of the city, part of the park has been surrounded by developmental activities and construction of buildings, presence of many quarries and sand mining making the situation more vulnerable at the buffer regions of the park. The narrow park has got little chance for easy movement of animals, hence the rate of movement of animals outside the boundary has increased and led to human-animal conflict, especially in the case of elephants. Further, high human density along the fringes of the park and their dependence on forest for firewood and grazing for their livestock has made the park more fragile. Nevertheless, many species of mammals are known to occur in the park. In the present chapter we report our findings on occurrence and abundance of large mammals in the park.

Methods

Common methods followed are discussed in the first chapter. In each grid, 6 m X 20 m plots were laid on the transect line at intervals of 200 m. Droppings of the animal were counted in these plots with species identity.

Since the mammal abundance in the park is poor, we have used the abundance of droppings of each species as proxy for the abundance of species in each grid. The abundance of droppings was represented as droppings per hectare.

Some of the species which are strictly nocturnal, could not be assessed for their abundance during the day transect walks, hence we conducted night surveys to find the occurrence and abundance of such species. We selected the existing motorable roads in the sanctuary and each road was travelled three consecutive nights between 19.00 to 24.00 hrs. During this exercise the jeep was driven at a speed of 10 km/hr, and an observer sitting atop the jeep used a flash light connected to the jeep to sight nocturnal animals. Once the animal was spotted by an eye shine, animals were differentiated based on the colour of the reflection from eyes, distance between the eyes and size; if the animal was far from the observer then a binocular was used to identify the species. The distance covered was documented using the vehicle odometer or known distance of each route. The abundance of nocturnal animals was presented as encounter rate (animals/km).

Results

Occurrence: Considering the nominal distribution of a species, we expected 33 species of mammals from the park, however we were able to get evidence for the occurrence of 20 species (Table 4.1). Among diurnal primates Hanuman langur *Semnopithecus priam* is absent and only bonnet macaque *Macaca radiata* was found in the Bannerghatta range. The nocturnal primate slender loris *Loris lydekkerianus* was also recorded from the Bannerghatta range. Two other arboreal mammals, Malabar giant squirrel *Ratufa indica* and large brown flying squirrels *Petaurista petaurista* were absent from the park. Though we did not see a single species of large carnivore, secondary evidences shows the presence of leopard *Panthera pardus*, sloth bear *Melursus ursinus* and jackal *Canis aureus*, and also the occasional visit of dholes *Cuon alpinus* was reported. We were unable to get proper evidence for the occurrence of tiger *Panthera tigris* and wolf *Canis lupus* in the park. Among small carnivores, common mongoose *Herpestes edwardsi*, small Indian civet *Viverricula indica* and Asian palm civet *Paradoxurus hermophroditus* were recorded from many parts of the park. The fox *Vulpes bengalensis* was reported to occur only in marginal areas of the park. Chital *Axis axis*,

Table 4.1 Occurrence of large mammals in different forest range of Bannerghatta National Park

| Species | IUCN status | Forest Ranges | | |
|---|-------------|---------------|-----------|--------|
| | | Bannerghatta | Harohalli | Anekal |
| Hanuman langur (<i>Semnopithecus priam</i>) | LC | AB | AB | AB |
| Bonnet macaque (<i>Macaca radiata</i>) | LC | P(1) | ? | ? |
| Slender loris (<i>Loris lydekkerianus</i>) | LC | P(1) | ? | ? |
| Tiger (<i>Panthera tigris</i>) | EN | ? | ? | ? |
| Leopard (<i>P. pardus</i>) | NT | P(2) | P(2) | P(2) |
| Jungle cat (<i>Felis chaus</i>) | LC | P(2) | P(2) | P(2) |
| Leopard cat (<i>Prionailurus bengalensis</i>) | LC | ? | ? | ? |
| Rusty spotted cat (<i>Prionailurus rubiginosus</i>) | VU | ? | ? | ? |
| Indian gray wolf (<i>Canis lupus pallipes</i>) | LC | AB | AB | AB |
| Dholes (<i>Cuon alpinus</i>) | EN | P(2) | P(2) | P(2) |
| Golden jackal (<i>Canis aureus</i>) | LC | P(3) | P(3) | P(3) |
| Bengal fox (<i>Vulpes bengalensis</i>) | LC | P(3) | P(3) | P(3) |
| Small Indian civet (<i>Viverricula indica</i>) | LC | P(1) | P(2) | P(1) |
| Asian palm civet (<i>Paradoxurus hermophroditus</i>) | LC | P(1) | P(2) | P(1) |
| Stripe-necked mongoose (<i>Herpestes vitticollis</i>) | LC | ? | ? | ? |
| Common mongoose (<i>H. edwardsi</i>) | LC | P(1) | P | P |
| Ruddy mongoose (<i>H. smithii</i>) | LC | ? | ? | ? |
| Malabar giant squirrel (<i>Ratufa indica</i>) | NT | AB | AB | AB |
| Common Giant flying squirrel (<i>Petaurista petaurista</i>) | LC | AB | AB | AB |
| Southern Red Muntjac (<i>Muntiacus muntjac</i>) | LC | P(1) | P(2) | P(2) |
| White spotted Chevrotain (<i>Tragulus meminna</i>) | LC | ? | ? | ? |
| Indian wild pig (<i>Sus scrofa</i>) | LC | P(2) | P(2) | P(2) |
| Chital (<i>Axis axis</i>) | LC | P(1) | P(1) | P(1) |
| Sambar (<i>Cervus unicolor</i>) | VU | P(1) | P(1) | P(1) |
| Gaur (<i>Bos gaurus</i>) | VU | P(1) | P(2) | P(2) |
| Elephant (<i>Elephas maximus</i>) | EN | P(1) | P(1) | P(1) |
| Four-horned antelope (<i>Tetracerus quadricornis</i>) | VU | P(2) | P(2) | P(2) |
| Blackbuck (<i>Antelope cervicapra</i>) | NT | AB | AB | AB |
| Indian crested Porcupine (<i>Hystrix indica</i>) | LC | P(2) | P(2) | P(2) |
| Thick-tailed Pangolin (<i>Manis crassicaudata</i>) | NT | ? | ? | ? |
| Sloth bear (<i>Melursus ursinus</i>) | VU | P(2) | P(2) | P(2) |
| Striped hyena (<i>Hyaena hyaena</i>) | NT | ? | ? | ? |
| Black-naped hare (<i>Lepus nigricollis</i>) | LC | P (1) | P(1) | P(1) |

P: Present; ?: No Information; AB: May be absent; EN: Endangered; VU: Vulnerable; NT: Near threatened; LC: Least concern; DD: Data deficient; 1: Sighted; 2: Fecal deposit; 3: Local information;

**Table 4.2 Sightings of animals during the night survey
(Km covered: Bannerghatta = 66 km; Harohalli = 72; Anekal = 75)**

| Species | Bannerghatta | Harohalli | Anekal | Total |
|--------------------|--------------|-----------|---------|-----------|
| Slender loris | 4 (0.06) | 0 | 1(0.01) | 5 (0.02) |
| Asian palm civet | 6 (0.09) | 0 | 0 | 6 (0.028) |
| Small Indian Civet | 2 (0.03) | 0 | 0 | 2 (0.009) |

Table 4.3 Droppings per hectare in different sampling grids

| Grid No. | Elephant | Gaur | Sambar | Chital | Muntjac | S bear | Wild pig | Porcupine |
|-------------|----------|--------|--------|--------|---------|--------|----------|-----------|
| 0 | 55.83 | 9.16 | 0 | 65.00 | 0 | 0 | 0 | 0 |
| 1 | 35.00 | 0 | 0 | 20.83 | 0 | 14.16 | 0 | 0 |
| 10 | 31.66 | 0 | 10.83 | 115.00 | 0 | 0 | 0 | 0 |
| 11 | 125.00 | 0 | 31.66 | 31.66 | 0 | 10 | 51.66 | 0 |
| 13 | 16.66 | 16.66 | 8.33 | 25.00 | 8.33 | 0 | 0 | 8.33 |
| 19 | 35.83 | 0 | 0 | 35.83 | 0 | 0 | 0 | 0 |
| 2 | 33.33 | 0 | 0 | 108.33 | 0 | 33.33 | 0 | 25.00 |
| 22 | 108.33 | 16.66 | 16.66 | 0 | 0 | 0 | 100.00 | 0 |
| 23 | 61.66 | 21.66 | 4.16 | 4.16 | 9.16 | 17.5 | 0 | 4.16 |
| 24 | 55.83 | 27.5 | 110.83 | 0 | 0 | 0 | 27.50 | 0 |
| 31 | 57.50 | 0 | 0 | 31.66 | 0 | 25.83 | 95.83 | 0 |
| 33 | 11.66 | 0 | 15.83 | 63.33 | 0 | 8.33 | 4.16 | 0 |
| 34 | 71.66 | 59.16 | 0 | 11.66 | 0 | 0 | 0 | 0 |
| 36 | 83.33 | 0 | 10 | 0 | 0 | 0 | 0 | 0 |
| 37 | 44.16 | 10.83 | 16.66 | 10.83 | 5.83 | 0 | 10.83 | 16.66 |
| 38 | 155.00 | 0 | 35.83 | 47.50 | 0 | 0 | 11.66 | 0 |
| 43 | 93.33 | 20.83 | 20.83 | 41.66 | 10 | 5.00 | 15.83 | 5.00 |
| 44 | 113.33 | 68.33 | 53.33 | 45.83 | 0 | 8.33 | 15.00 | 0 |
| 45 | 166.66 | 0 | 0 | 133.33 | 16.66 | 0 | 16.66 | 83.33 |
| 6 | 66.66 | 16.66 | 0 | 133.33 | 0 | 0 | 16.66 | 0 |
| 7 | 62.50 | 0 | 0 | 55.83 | 0 | 0 | 14.16 | 0 |
| 8 | 48.33 | 0 | 0 | 69.16 | 6.66 | 0 | 0 | 0 |
| 9 | 75.83 | 0 | 0 | 0 | 0 | 30.00 | 0 | 0 |
| Mean | 69.96 | 11.63 | 14.56 | 45.65 | 2.46 | 6.63 | 16.52 | 2.19 |
| χ^2 | 526.45 | 135.57 | 343.50 | 526.00 | 8.158 | 51.66 | 379.66 | 192.14 |
| Sig. | .00 | .00 | .00 | .00 | NS | .00 | .00 | .00 |

sambar *Cervus unicolor*, gaur *Bos gaurus*, four-horned antelope *Tetracerus quadricornis* and elephants were recorded from all the forest ranges.

Abundance of nocturnal mammals from night survey: A total of 213 km of night survey was carried out in the park. During this we sighted slender loris, Asian palm civet and small Indian civet, apart from chital, sambar, gaur and elephant. Surprisingly we had very low encounters of all the species. We had five sightings of slender loris, six sightings of Asian palm civet and two sightings of small Indian civets, and most of the sightings were from Bannerghatta forest range. The overall encounter rate was 0.02, 0.028 and 0.009 for slender loris, Asian palm civet and small Indian civet respectively (Table 4.2).

The density of droppings for all the species in each grid is provided in Table 4.3. Since the animals live in low abundance in the park, we considered droppings of all the possible species which we were able to identify and count. Mean density of droppings for elephant (69.96) and chital (45.65) was more than that of the other animals. Further, non parametric chi-square test shows that density of droppings of all the species varied significantly between grids (Table 4.3) except for the muntjac *Muntiacus muntjac*.

Though the density of droppings significantly varied between grids, none of the covariates showed any significant relation for elephant, gaur, sambar, wild boar *Sus scrofa* and porcupine *Hystrix indica*. The density of droppings of the sloth bear was significantly related to the basal area. Increase in livestock seems to have positive influence on the increase in use of the area by chitals.

Discussion

Bannerghatta National Park being very close to the city faces many anthropogenic pressures like movement of people, grazing pressure and firewood collection in the entire park. Nevertheless, large number of mammal species persists, this shows the conservation effort that has been taken by the forest department. However, all the mammal species live in very low density in the park.

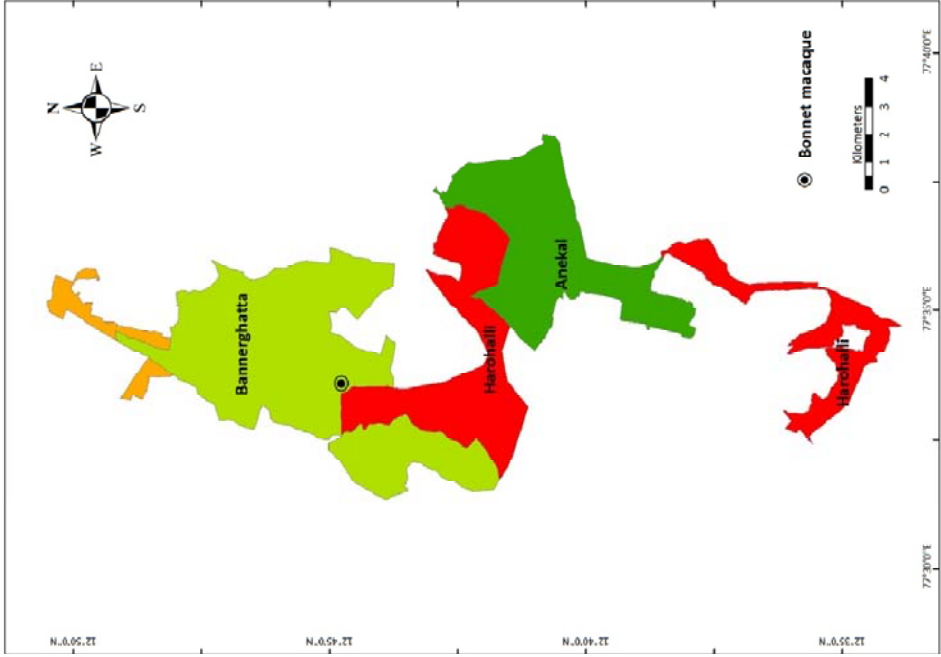
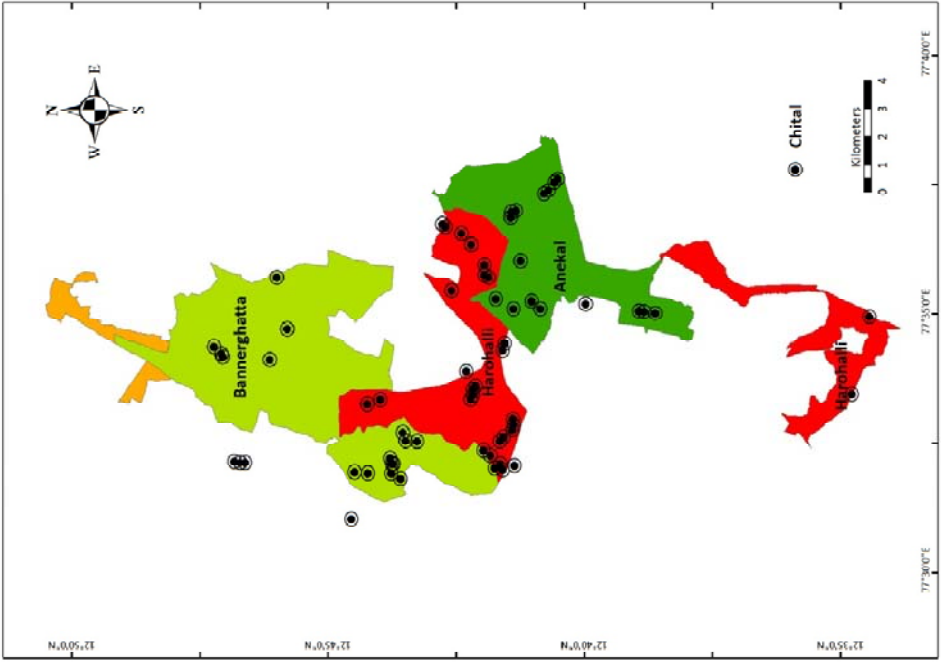
Table 4.4 Parameters that we considered influencing the utilization of habitat by different species of mammals

| Grid No. | Tree Density | Basal Area | Stumps/lopping | Livestock dung density | Mean NDVI |
|----------|--------------|------------|----------------|------------------------|-------------|
| 0 | 557.71 | 49.46 | 0 | 46.29 | 0.036481099 |
| 1 | 656.00 | 66.91 | 104.16 | 201.38 | 0.096553695 |
| 10 | 611.20 | 26.91 | 0 | 0 | 0.179754871 |
| 11 | 467.20 | 48.29 | 31.25 | 83.33 | 0.125861932 |
| 13 | 617.14 | 32.18 | 383.33 | 50.00 | 0.24768177 |
| 19 | 704.00 | 54.37 | 130.95 | 59.52 | 0.18074518 |
| 2 | 566.66 | 69.12 | 183.33 | 150.00 | 0.130313731 |
| 22 | 574.40 | 52.46 | 0 | 8.33 | 0.185032387 |
| 23 | 585.60 | 53.22 | 39.47 | 35.08 | 0.21186912 |
| 24 | 672.00 | 46.50 | 34.72 | 6.94 | 0.188507472 |
| 31 | 580.00 | 56.96 | 64.10 | 57.69 | 0.17654732 |
| 33 | 510.00 | 41.44 | 230.15 | 99.20 | 0.101057711 |
| 34 | 430.00 | 44.24 | 59.52 | 47.61 | 0.161276033 |
| 36 | 442.66 | 39.84 | 208.33 | 218.75 | 0.139135101 |
| 37 | 624.00 | 28.53 | 55.55 | 22.22 | 0.165628462 |
| 38 | 582.40 | 19.01 | 83.33 | 130.95 | 0.122310609 |
| 43 | 488.00 | 47.96 | 93.75 | 41.66 | 0.192242309 |
| 44 | 508.00 | 32.79 | 60.60 | 106.06 | 0.217107866 |
| 45 | 595.20 | 28.19 | 266.66 | 166.66 | 0.233431885 |
| 6 | 550.85 | 52.78 | 308.33 | 741.66 | 0.190707965 |
| 7 | 644.57 | 38.79 | 48.61 | 173.61 | 0.239022743 |
| 8 | 672.00 | 45.37 | 388.88 | 145.83 | 0.149799168 |
| 9 | 486.40 | 55.73 | 0 | 68.18 | 0.175647938 |

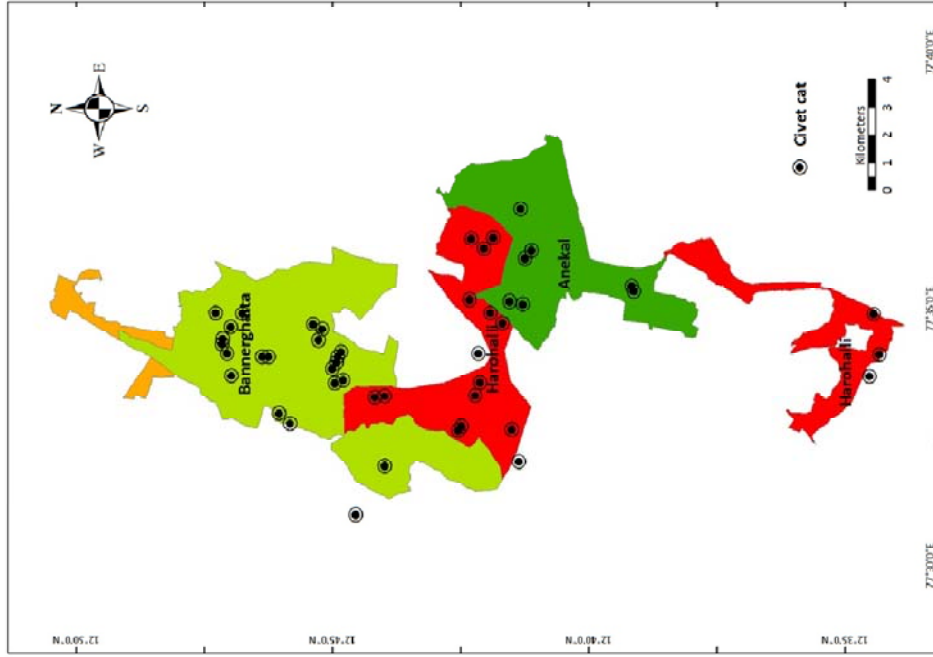
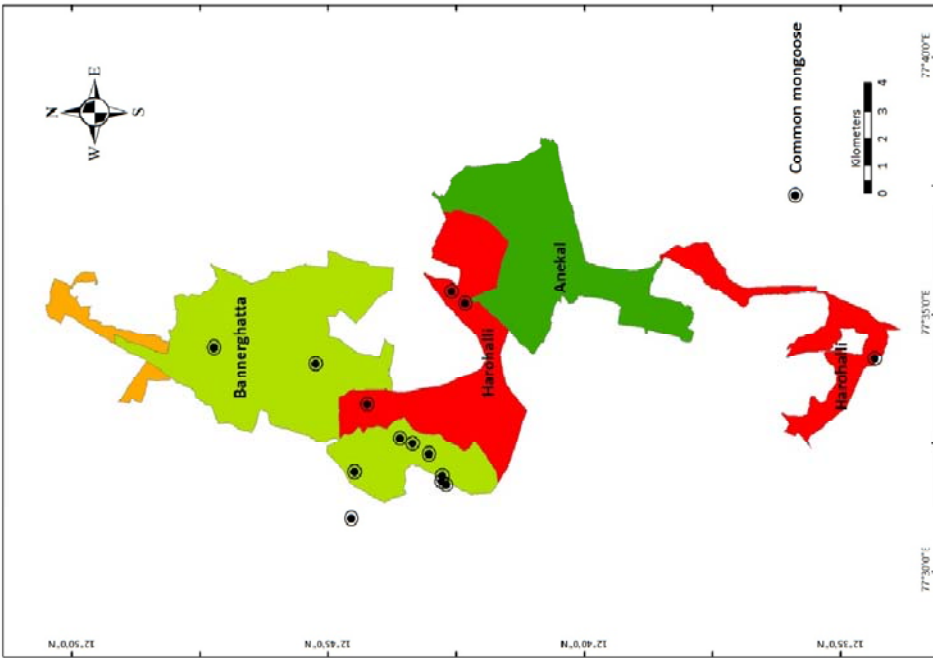
Table 4.5 Test value (Person correlation- r^2) for each covariate

| Species | Tree density | Basal area | Stumps/lopping | Livestock dung density | Mean NDVI |
|-----------|--------------|------------|----------------|------------------------|-----------|
| Elephant | -.330 | -.335 | -.176 | .065 | .148 |
| Gaur | -.326 | -.123 | -.174 | -.081 | .286 |
| Sambar | .068 | -.242 | -.258 | -.230 | .091 |
| Chital | .130 | -.136 | .404 | .504* | .017 |
| Muntjac | .141 | -.282 | .407 | -.099 | .451* |
| S bear | .194 | .620** | -.187 | -.083 | -.119 |
| Wild boar | -.041 | .162 | -.289 | -.117 | .125 |
| Porcupine | .095 | -.220 | .300 | .039 | .280 |

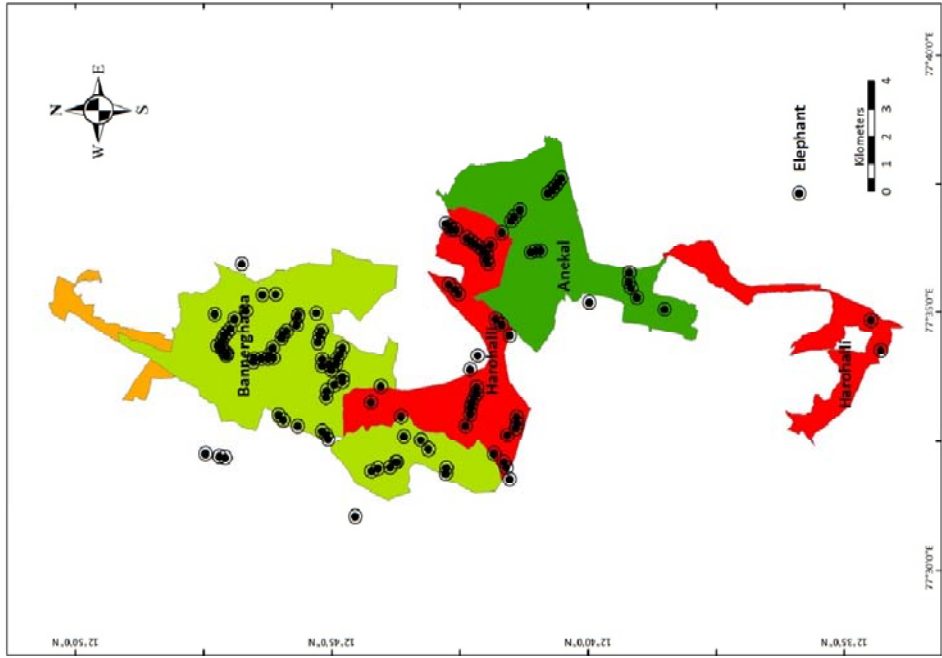
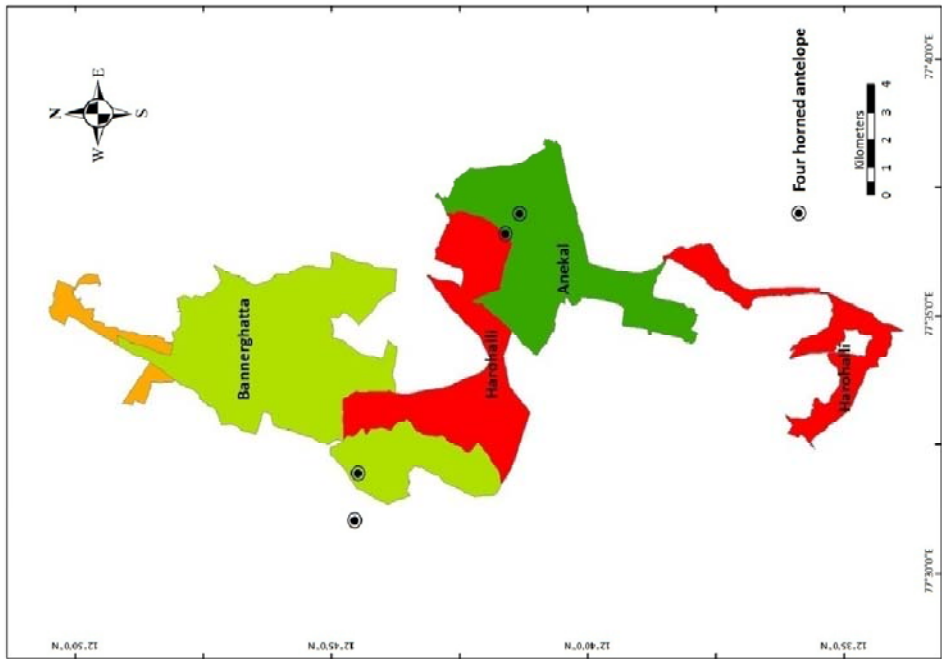
*Significant at .05 ; **Significant at .01



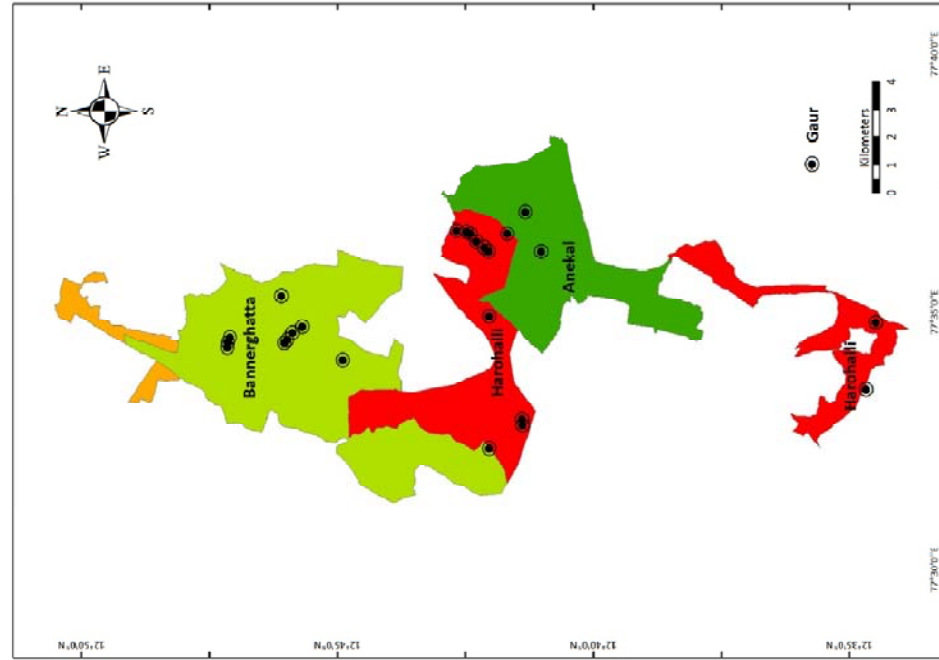
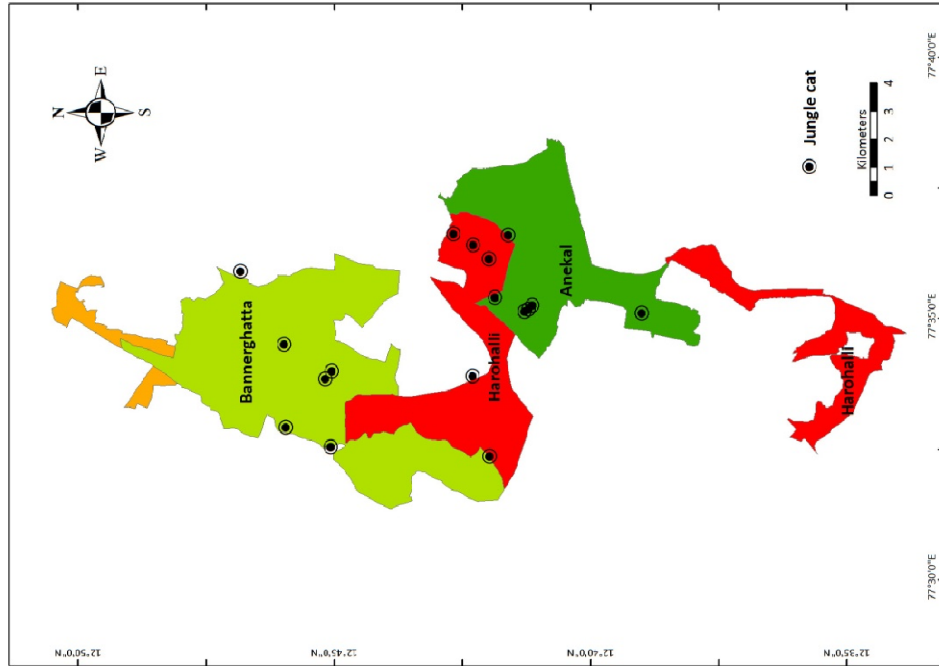
Sightings and evidences of different mammal species in Bannerghatta National Park



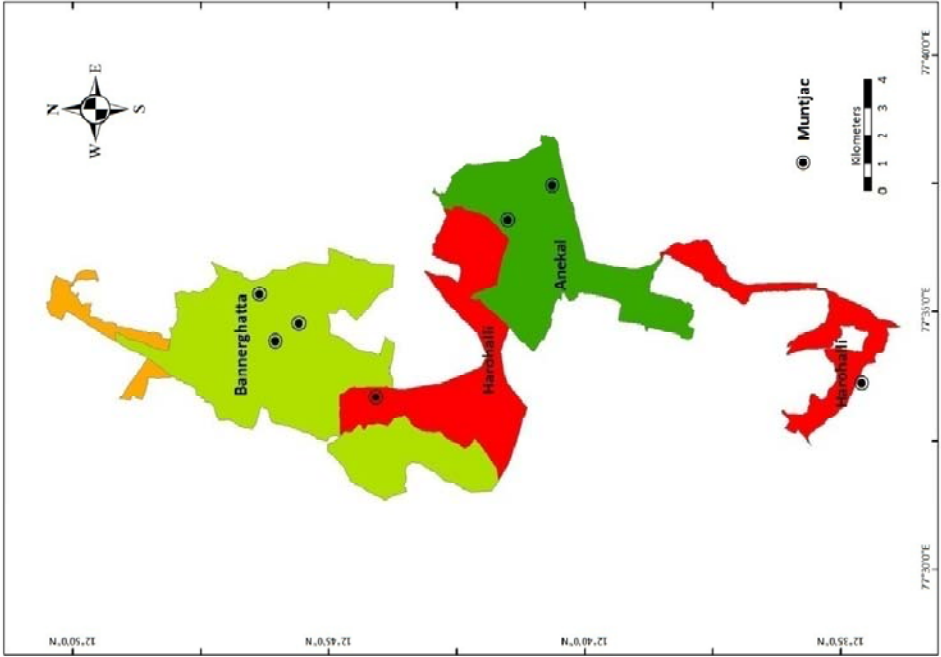
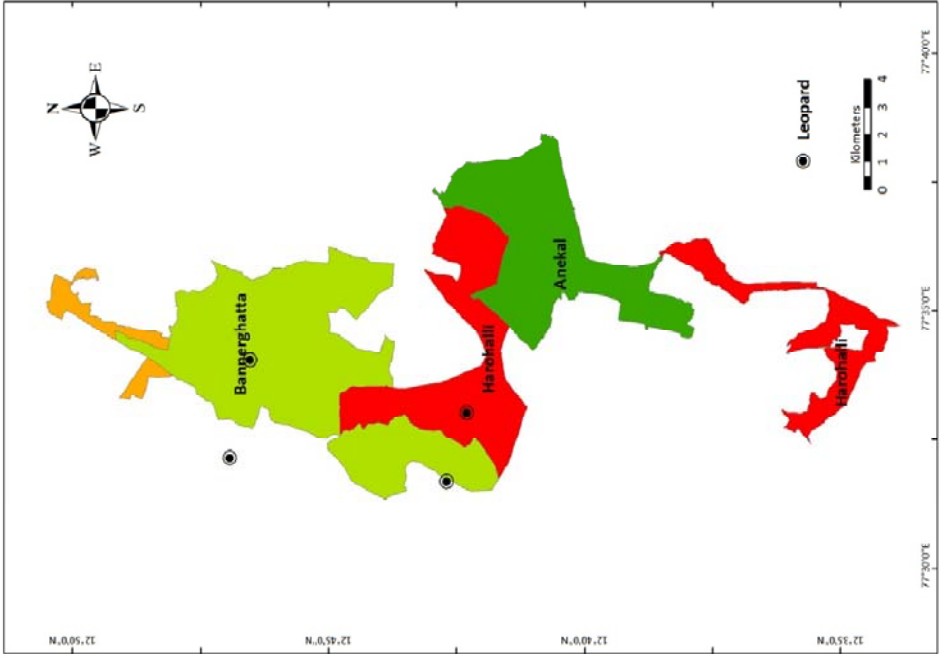
Sightings and evidences of different mammal species in Bannerghatta National Park



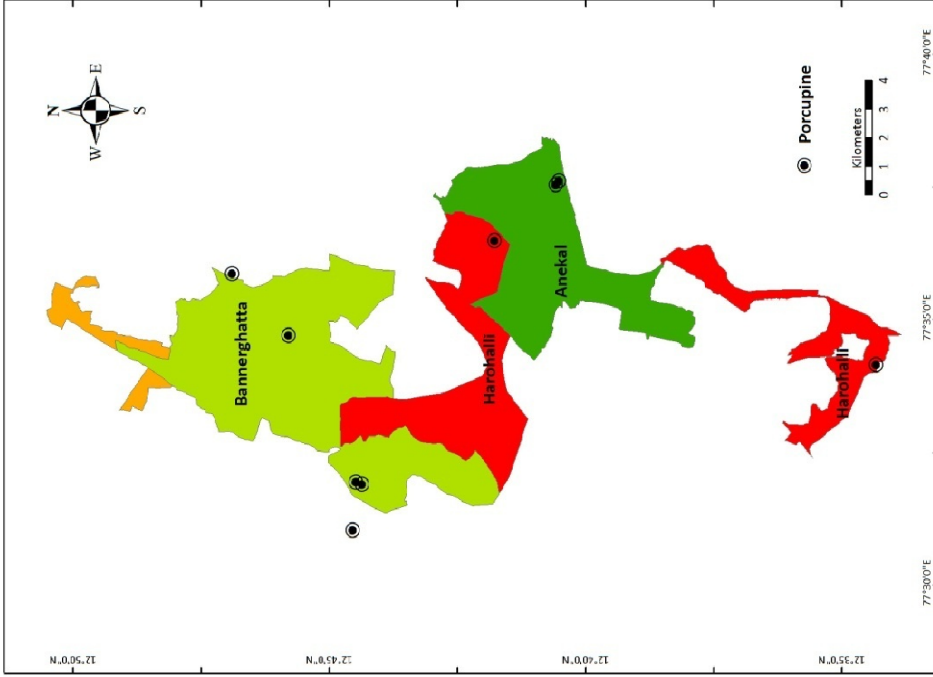
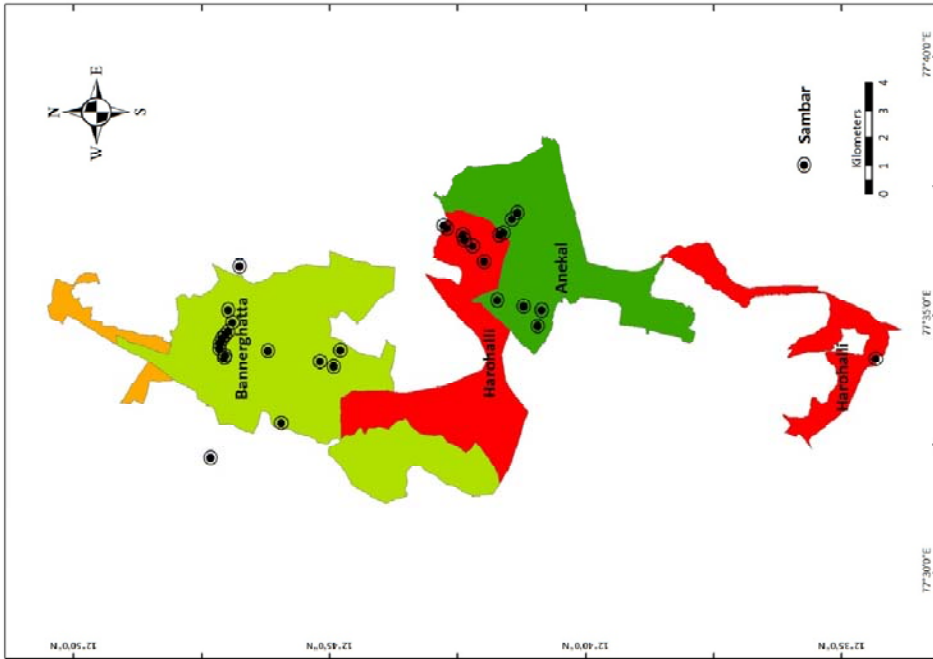
Sightings and evidences of different mammal species in Bannerghatta National Park



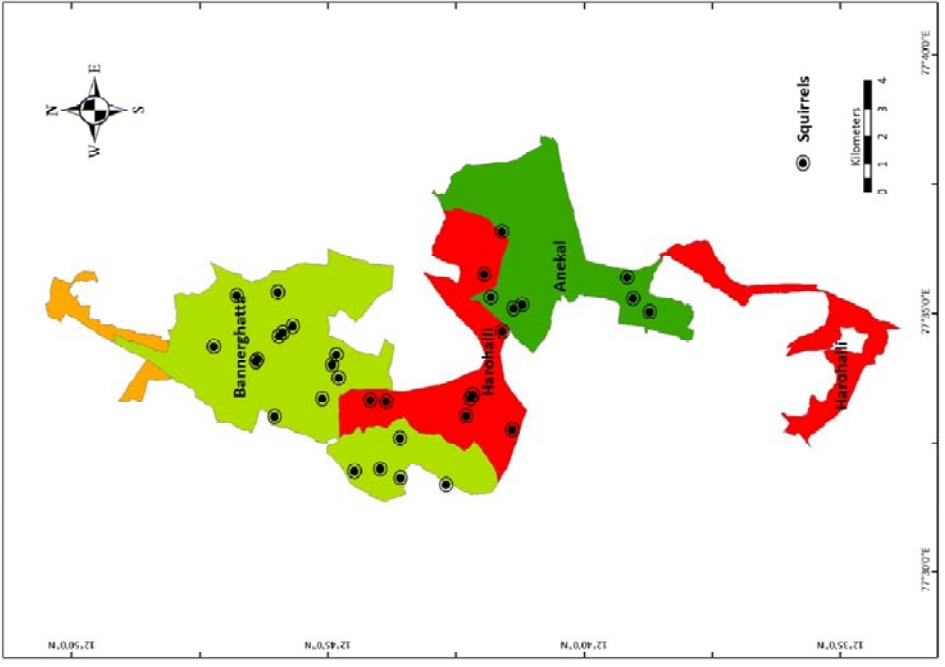
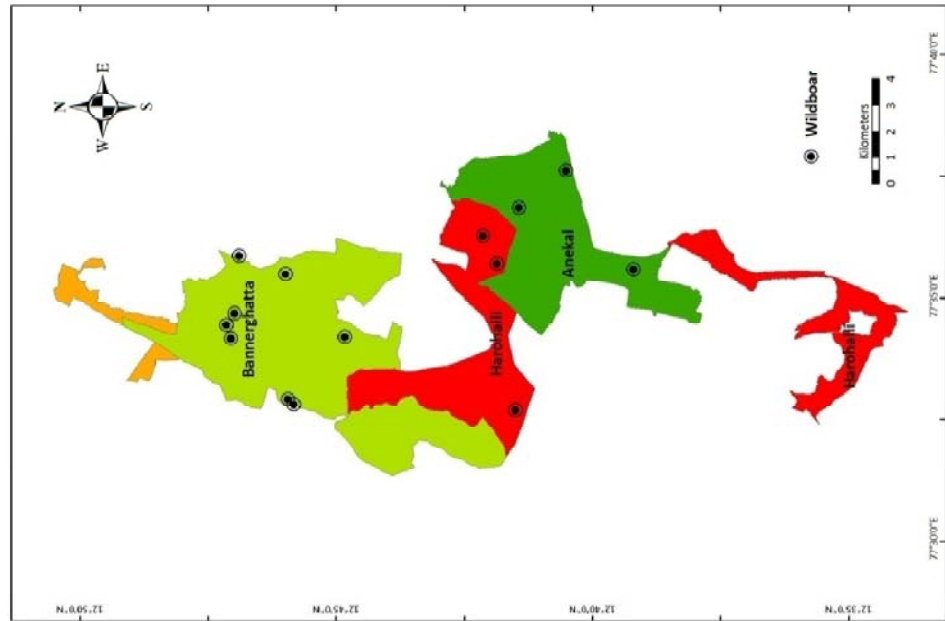
Sightings and evidences of different mammal species in Bannerghatta National Park



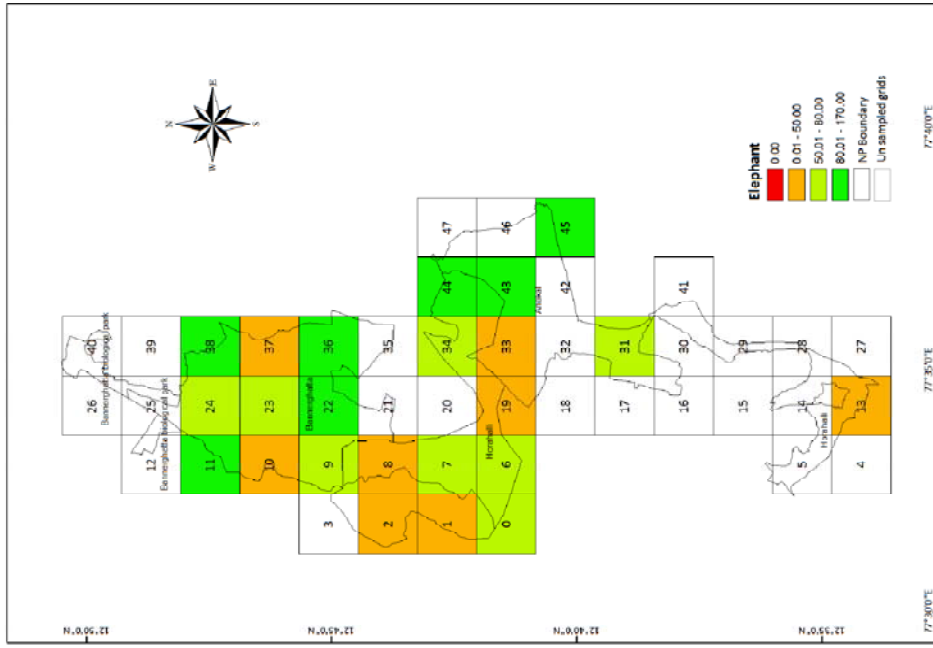
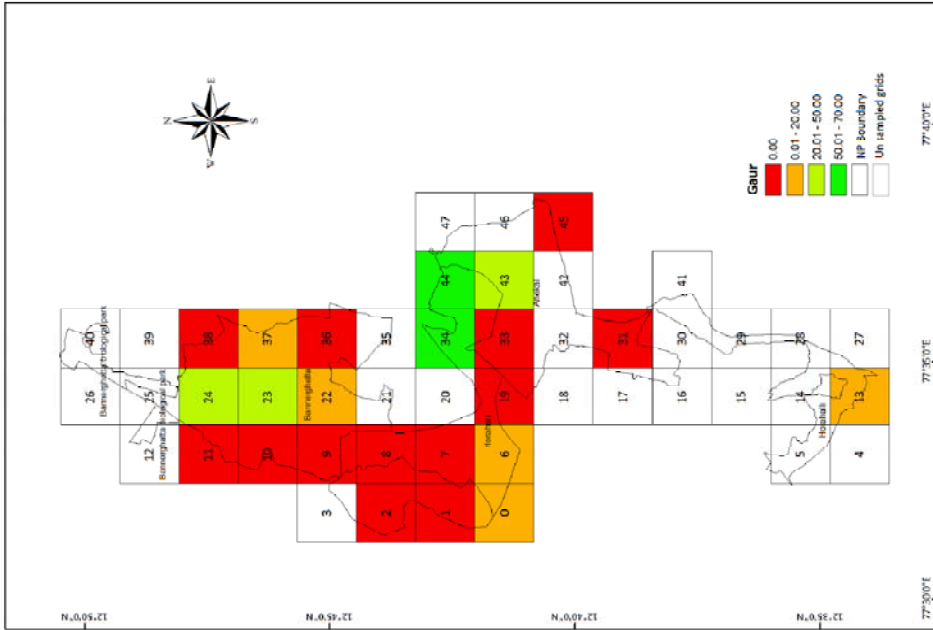
Sightings and evidences of different mammal species in Bannerghatta National Park



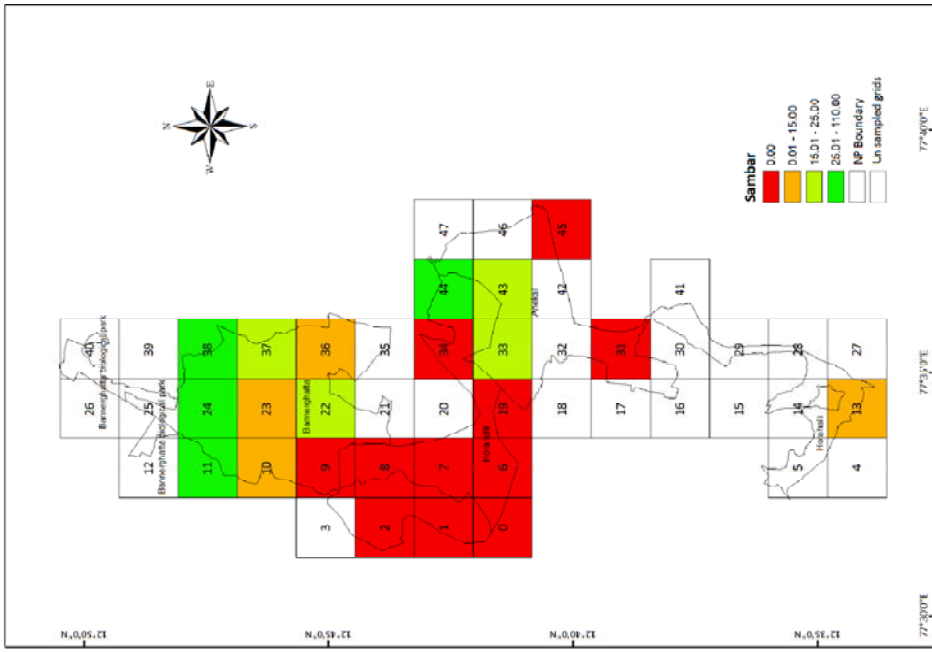
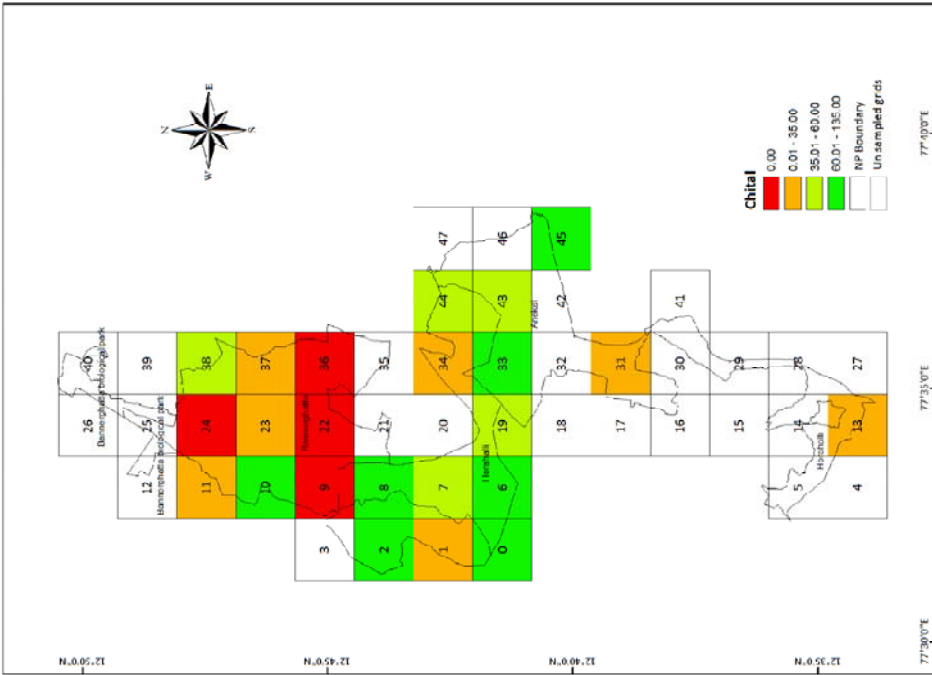
Sightings and evidences of different mammal species in Bannerghatta National Park



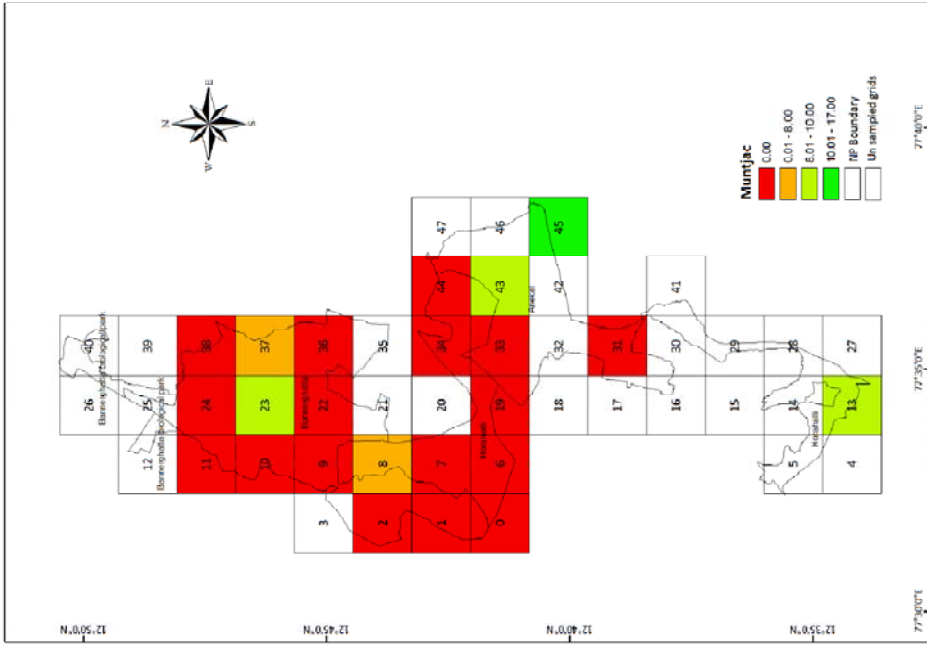
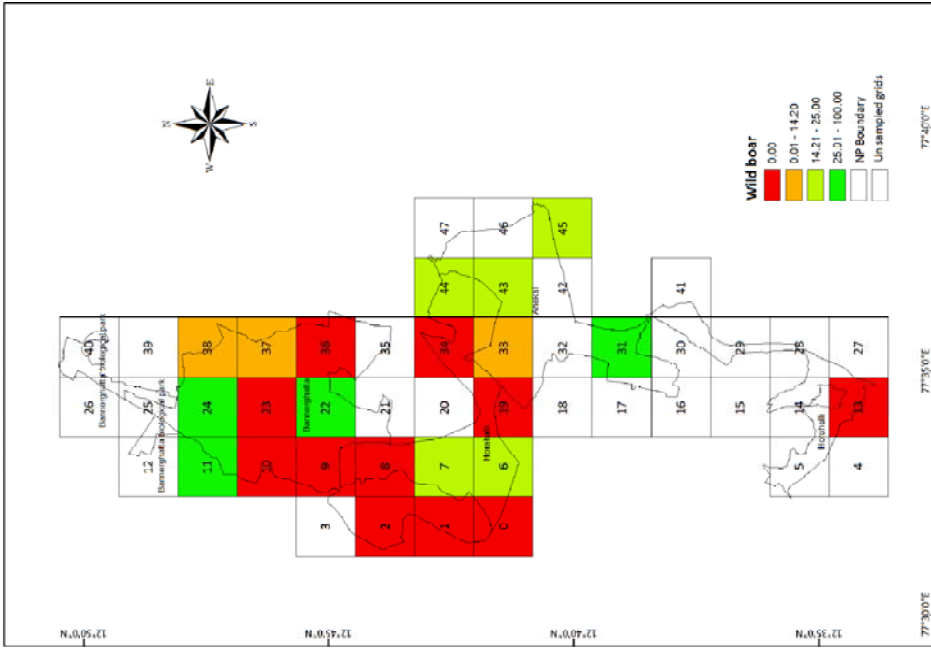
Sightings and evidences of different mammal species in Bannerghatta National Park



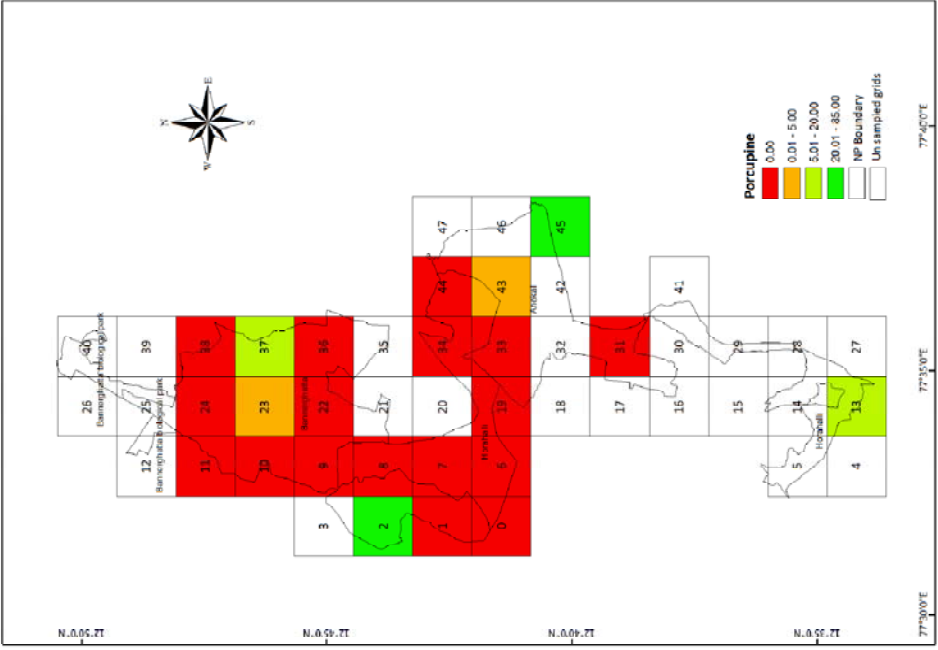
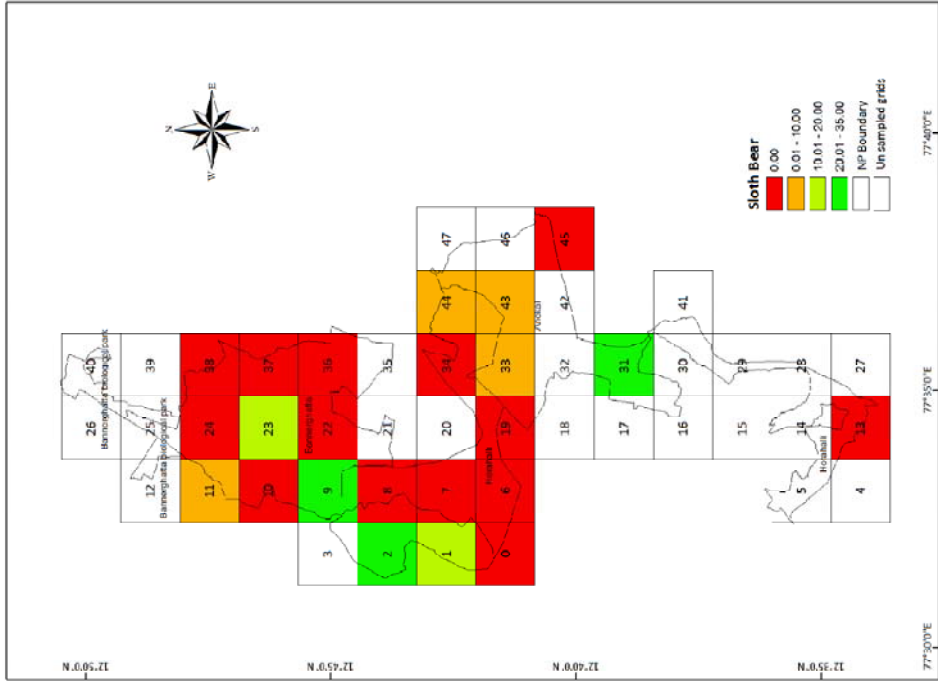
Density of droppings in different grids



Density of droppings in different grids



Density of droppings in different grids



Density of droppings in different grids

We expected species like slender loris to be in large numbers in the park since the species has less value for hunting due to its small body size, but we encountered it in low numbers. Almost all arboreal mammals including Hanuman langur, Malabar giant squirrel and large brown flying squirrel were totally absent from the park, except bonnet macaque, which was found only in one location. Usually these species are relatively habitat generalists thus we expected them in at least riparian forests. Further, during our entire study, all the chital herds sighted had herd size less than seven. This led us to suspect the existence of severe biotic pressure in the past. There are no other reasons for the absence, low abundance or small in herd size of some species. The forests of the park are contiguous with other forests in the south, visits of some species was expected e.g. dholes. The low prey density in the park cannot afford to have resident populations of all the large carnivore species thus the presence of few leopards and occasional visits of dholes in the park are acceptable. Only elephants were found in relatively large numbers, but even they show seasonal movement to the park (Anand et al., 2009).

Human interference was noticed in the entire Park, and narrow stretch of the forest with less altitudinal variation and vegetation type has made the park less heterogeneous for mammal species. Probably, this could be the reason that none of the forest parameters and disturbance factors influenced the habitat utilization by most species. Probably, patches with more grass were used by both livestock and chital, hence chital abundance was positively correlated with the area used by livestock. On the other hand, probably old forest with good trees was preferred by sloth bears.

Apart from firewood collection and other biotic pressures instigated by local people, there are many quarries all around the National park. These activities hamper the options for recolonisation for many species and therefore should be stopped to ensure that habitat is not affected. Wildlife management practices should be based on scientific outputs for effective delivery.

Reference

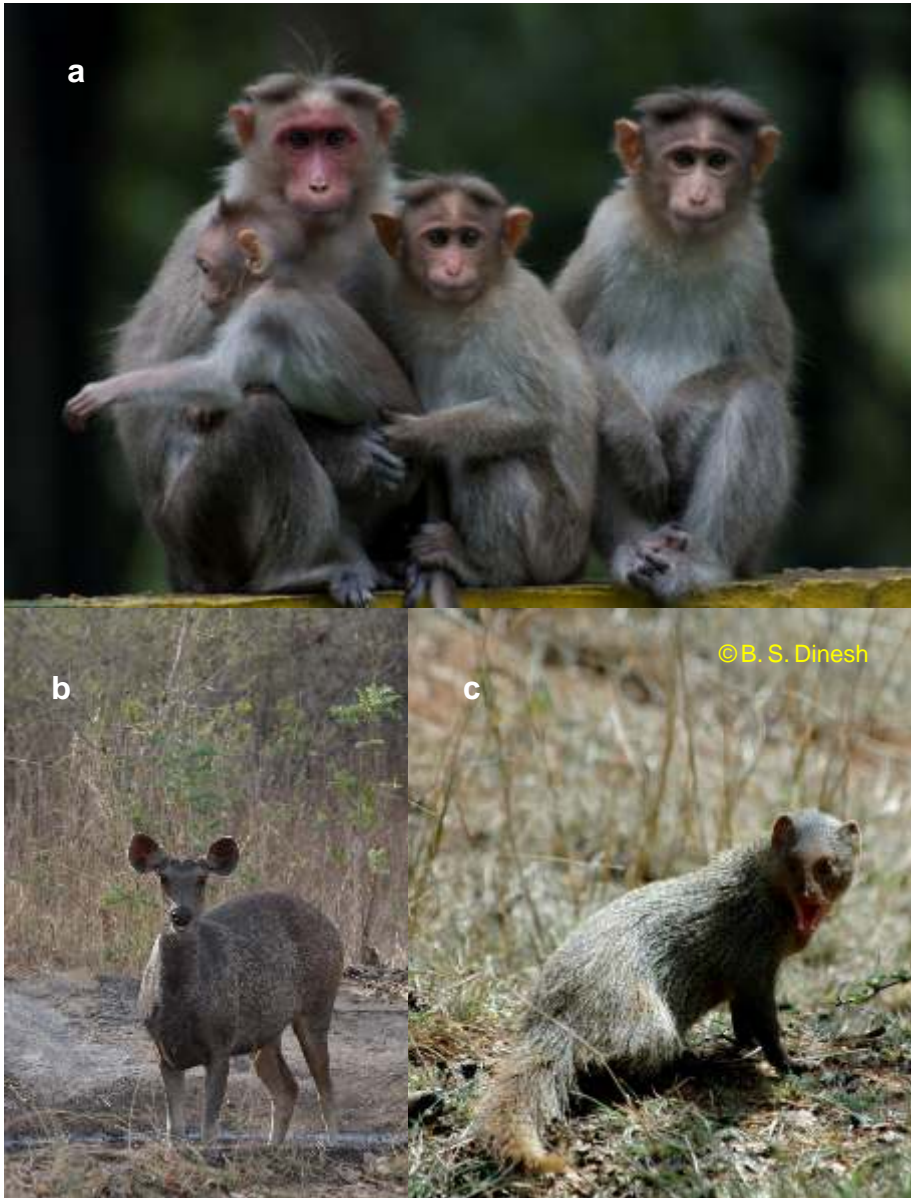
Anand, V.D., Varma, S. and Gopalakrishna, S.P (2009). Conservation of Asian elephant through mitigation of human-elephant conflict in Bannerghatta National Park, Southern India. Technical Report II: 2009. A Rocha India, Bangalore.



a. Elephant herd., b. Guar.



a. Black-naped Hare., b. Leopard.



a. Bonnet Macaque., **b.** Sambar Deer , **c.** Common Mongoose.



Indirect evidences of mammals: a & b: Droppings of four horned antelope.,
c. Droppings of Sloth Bear., d. Leopard scat.

Conclusions and Conservation measures

Bannerghatta National Park being close to one of the fast growing cities 'Bengaluru' faces numerous pressures. Being a linear patch of forest with negligible buffer zone it is exposed to high biotic disturbances. Probably this has led to less heterogeneity in the forests of the park. The major issues in and around the park are listed below.

Due to increased demand of sand and grey stones (Jelly stones) for construction purposes from the ever growing urban areas, the price of sand has gone up in multiple folds. This has led to exploitation of all available resources of sand in and around the Bengaluru city. Many illegal sand quarries in the name of 'filter sand' and grey stones (Jelly stones) extractions have mushroomed around the Bannerghatta National Park. This has increased the movement of people and heavy vehicles around the park, and has also created disturbance to the forest.

The park has low density of herbivore species, and in correspondence to this the large carnivore species are also poor in numbers. If the existing populations of herbivore species have to flourish in the park, appropriate actions needs to be initiated to conserve the available natural food sources and zero tolerance to disturbance is inevitable. The existing severe grazing by livestock can deplete the availability of the fodder for these wild animals and further, can also transfer diseases to wild animals which can lead to local extinction of these species. Thus protecting and managing the park in anticipation of these problems are very crucial.

Few villages (Harohalli and Anekal forest ranges) and a few small private lands (Harohalli forest range) within the park eventually creates more problems and conflicts. Moreover, road access to these villages & houses are through the forested areas/forest roads. These constraints inside the National park will hinder further conservation and management activities.

Department personnel require further training to work effectively in the forest, especially the ground staff who are involved in management of the human-elephant conflict situations. They should be provided with

additional accessories to chase the elephants away from the crop fields and also to protect themselves from life endangering situations.

Though the mammal richness and density is poor in the park, the density and species richness of trees and birds was good in the park, and is on par with the many other parts of Eastern Ghats. Provided with continuous protection the species richness and density of birds and trees can be retained that intern can help in reestablishing the mammals. Occasional visits of dholes and persistence of leopards in the park shows the potential of the region for conservation.

Among all the mammals, elephant is one of the important and dominant species in the Bannerghatta National Park. Anand et al. (2009) and Management Plan of the park clearly shows the existence of high rate of human-elephant conflict in the buffer areas of the park. Proper monitoring of the elephant population, their movement, understating the crop pattern, human-elephant conflict and mitigation steps are very critical. Local people should be taken into cofidance for the mitigation activity. Anand et al. (2009) and Shivanandaiah (2010) recommended various measures to bringdown the human elephant conflict rate that can be adopted in the management practice of the park.

When urbanization is engulfing the land and forest, many, so called common birds also disappear as potential habitat is disappearing, thus retaining the common birds as common is also equally important. BNP holds good population of many such species, population of these should be monitored and protected.

We encourage periodical (at least once in three years) monitoring of trees, birds and mammals using the same protocol which will help understand the impact of steps taken to manage the park.



Anthropogenic activities in the national park: a. Forest guard removing wire snare from the NP., b. Stone quarry adjacent to the NP., c. Forest fire., d. Fire wood extraction.



a. Cattle grazing inside NP., b. Sand quarry (Filter sand) around the NP.

