INTRODUCTION

The forest of India is ancient in nature and composition. Each Indian forest is rich in variety and shelter a wide range of fauna, including worms, insects, amphibians, reptiles, birds and mammals. The fact that they have existed for very long time is proved from the ancient texts all of which have some mention of the forests. The people revered forests in India and a large number of religious ceremonies centered on trees and plants. Even today in parts of India the sacred groves exist and are worshipped.

India possesses a distinct identity, not only because of its geography, history and culture but also because of the great diversity of its natural ecosystems. The panorama of Indian forest ranges from evergreen tropical rain forests in the Andaman and Nicobar Islands, the western ghats, and the north-eastern states, to dry alpine scrub high in the Himalaya to the north. Between the two extremes, the country has semi-evergreen rain forests, deciduous monsoon forests, thorn forests, subtropical pine forests in the lower montane zone and temperate montane forests (Lutz 1956).

As per the latest reports, the actual forest cover of India is 19.27% of the geographic area, corresponding to 63.3 million hectares. Only 38 million hectares of forests in India are well stocked (crown density above
40%). The statistics says that the country has five percent of world’s land area. At the same time the country accommodates 16 percent of the world's human population and 19 percent of cattle population. This over population of both human and cattle definitely has an impact on the forests and forest resources of the country.

The social and cultural history of India is replete with paradoxes. For example there is an evidence that the 'ashram' system was practiced as early as 4000 B.C. The ashrams were sylvan asylums, the abode of thinkers, philosophers, poets and writers, who preached human social values and veneration of trees, forests and their inhabitants. The Agni Purana, written about 4000 years ago, stated that man should protect trees to have material gains and religious blessings. Around 2500 years ago, Gautama Buddha preached that man should plant a tree every five years. Sacred groves were marked around the temples where certain rules and regulations applied. When Chandra Gupta Maurya came to power around 300 BC, he realized the importance of the forests and appointed a high officer to look after the forests. Ashoka stated that wild animals and forests should be preserved and protected. He launched programmes to plant trees on a large scale. These rules continued even during the Gupta period.
The Muslim invaders were all keen hunters and therefore had to have patches of forests where they could go hunting. This ensured that the trees in these areas were not felled, and the forest ecology was not tampered with. The Mughals showed more interest in gardens and their development. Akbar ordered the planting of trees in various parts of his kingdom. Jahangir was well known for laying out beautiful gardens and planting trees.

During the early part of the British rule, trees were felled without any thought. Large numbers of trees such as the sal, teak, and sandalwood were cut for export. The history of modern Indian forestry was a process by which the British gradually appropriated forest resources for revenue generation. Trees could not be felled without prior permission and knowledge of the authority. This step was taken to ensure that they were the sole users of the forest trees.

But after some time, the British began to regulate and conserve. In 1800, a commissioner was appointed to look into the availability of teak in the Malabar forests. In 1806, the Madras government appointed Capt. Watson as the commissioner of forests for organizing the production of teak and other timber suitable for the building of ships. In 1855, Lord Dalhousie framed regulations for conservation of forest in the entire country. Teak plantations were raised in the Malabar hills and acacia and
eucalyptus in the Niligiri Hills. In Bombay, the conservator of forest, Gibson, tried to introduce rules prohibiting shifting cultivation and plantation of teak forests. From 1865 to 1894, forest reserves were established to secure material for imperial needs. From the 18th century, scientific forest management systems were employed to regenerate and harvest the forest to make it sustainable. Between 1926 and 1947 afforestation was carried out on a large scale in the Punjab and Uttar Pradesh. In the early 1930s, people began showing interest in the conservation of wildlife.

During World War I forest resources were severely depleted as large quantities of timber were removed to build ships and railway sleepers and to pay for Britain’s war efforts. Between the two wars, great advancements in scientific management of the forests were made, with many areas undergoing regeneration and sustained harvest plans being drawn up. Sadly, emphasis was still not on protection and regeneration but on gaining maximum revenue from the forests. World War II made even greater demand on the forest than World War I had done.

With the independence of India in 1947, a great upheaval in forestry organization occurred. The princely states were managed variably, giving more concessions to the local populations. The transfer of these states to the government led to deforestation in these areas. But
some forest officials claim that the maharajas cut down a lot of their forests and sold them. This may have been the case in some instances, but a lot of forest had existed and has been lost since the government took over these states (http://www.britanica.com).

The new Forest Policy of 1952 recognized the protective functions of the forest and aimed at maintaining one-third of India’s land area under forest. Certain activities were banned and grazing restricted. Much of the original British policy was kept in place, such as the classification of forest land into two types. The next 50 years saw development and change in people’s thinking regarding the forest. A constructive attitude was brought about through a number of five-year plans. Until 1976, the forest resource was seen as a source of earning money for the state and therefore little was spent in protecting it or looking after it. In 1976, the governance of the forest came under the concurrent list. ‘Development without destruction’ and ‘forests for survival’ was the themes of the next two five-year plans, aiming at increasing wildlife reserves and at linking forest development with the tribal economy. But a large gap between aim and achievement exists still.

The history of forests of India is linked with its political history and its demographic pressure. The country was divided into many princely states and those who ruled these states have made rules
according to their choices. The political changes in states now and then also have lead to new developments in administering of forests as well. The two world wars made enormous demands on forests and necessitated the progress of forestry on scientific lines. Even apart from the adverse effects of wars or political changes with passage of time the primeval forests have had to give place to well managed forest estates or organized plantations. The demographic pressure, which has increased almost in geometrical proportions, has made insidious inroads into forests. The vast land of forests with its varied climatic and geological conditions, its different types and its enormous population with its ever increasing demands have all contributed to make the history of India’s forestry complicated at the same time interesting. More than two centuries of British rule also has significant impact on the history of Indian forestry (Stebbing, 1929).

Stebbing (1929) is of the opinion that the scientific forestry in India is a couple of centuries old. According to him over the bulk of this period, the history of Indian forestry would refer to the forests of the subcontinent of India and Burma. Therefore most of the faunistic or floristic studies carried out before 1920 is enlisted as fauna or flora of India, Burma, Ceylon and Pakistan. In 1837, Munro, Superintendent of forests in Travancore, estimated that around 100,000 teak trees would be
available for extraction in that year. The idea of fixing and forecasting the annual yield on the basis of some form of computation of contents of forests combined with the rate of growth of trees, was indeed new in the country for his time and therefore, Stebbing (1929) was perhaps right in assuming that, “the credit of having been the first to introduce a simple form of forest working plan in India must be ascribed to Mr. Munro”. However, one can say that the real beginning of scientific forestry in India started with the initiative taken by Conolly, Collector of Malabar in 1842, when he formed for the first time in the world, teak plantations (Anonymous, 1993).

**Global scenario of forests**

Forests can be found in all regions of the globe capable of sustaining tree growth, at altitudes up to the tree line, except where natural fire frequency or other disturbance is too high, or where the environment has been altered by human activity. The total surface of the earth is approximately 510 million km$^2$ of which, 71% (361 million km$^2$) is ocean and 29% (149 million km$^2$) is land (Dwivedi, 1993). The extent of forest area on the earth is about 37.2% of the total geographical area.

The latitudes 10° north and south of the equator are mostly covered in tropical rain forest, and the latitudes between 53° and 67° have boreal forest. As a general rule, forests dominated by angiosperms (*broadleaf*
forests) are more species-rich than those dominated by gymnosperms (conifer, montane, or needleleaf forests), although exceptions exist (Wikipedia). Further, as per the above estimate the vegetation differs greatly not only between the three main belts of tropical rain forests but in different portions of each belt itself. Of the total of approximately 2,50,000 species of flowering plants in the world, about 1,17,000 occur in tropics. Half of these are in the New World South of Mexico, 35,000 in tropical Africa (including 8500 in Madagascar), and 40,000 in Asia with 25,000 in Malaysia. Individual regions such as Congo and Borneo have been estimated to contain about 10,000 species of phanerogams (seed plants) each. In Malayan peninsula alone, about 2500 species of trees are known, while the great rain forests or hilaea of the Amazon contains at least that many species of large trees (Anonymous, 1982, Sommer, 1976).

In continental Asia, tropical rain forests clothe the Malayan peninsula from Chumphon (11° N) to north of Isthmus of Kra, then continue up to the west coast in Burma into Pegu Yoma - east of Irrawaddy river, west of Irrawaddy, a detached block follows Arakan Yoma in Burma, north through the Chittagong hill tracts of Bangladesh to Nagaland and Assam in north eastern India. There are out lying pockets on the western ghats of peninsular India and in the humid southwestern Srilanka. Andaman islands also support climax forests of this type.
There are a few relics of rain forests remaining on the east coast of Madagascar and on the islands of Mauritius, Reunion, Rodriguez, and Seychelles. These rain forests of the south Indian Ocean islands were never very extensive. Tropical rain forests in Australia constitute an interesting but very small proportion (1%) of Australian tropical vegetation. Features of this region’s rain forests include their apparent floristic relationships with both south East Asian and Gondwana land floras. The variation in the vegetation in different parts also has its impact on fauna. Thus distinct differences in the faunal composition exist in different parts.

The composition and geographical variation in terrestrial ecosystems is to be looked into, on a global basis to really appreciate the existing distribution pattern of tree species in different zones. Though, climate and substrate, the two groups of environmental factors, together with population interactions determine the nature of ecosystems, the chance factor of their occurrence controlled by geographical barriers cannot be ignored. Plants show a wide distribution over the earth, nevertheless each continental area tends to have its own special flora and fauna (Odum, 1971). The fascinating subject of biogeography thus has special relevance in the evolution of terrestrial communities.
Indian scenario of forests

The total geographical area of the country is 328.8 million hectare (Dwivedi, 1993). Approximately 67.42 million hectare land is classified as forests. As per the statistics of state forest departments, the total area of forests is 75.1 million hectares. Most of the forests of India are distributed in the mountainous regions (Dwivedi 1993). They can be broadly classified into four groups viz., tropical rainy climate group, dry climate group, humid sub-tropical climate group and mountain climate group.

Tropical rainy climatic region experiences persistent high temperatures which normally do not go below 18°C even in the coolest month. There are two climatic types which fall under this group: tropical monsoon rain forests and tropical wet and dry deciduous forests. The monsoon rain forests are spread over in the western ghats and the eastern regions including Assam. The dry climate group region consists of area where the rate of evaporation of water is higher than the rate of moisture received through precipitation. It is subdivided into three climate types: Tropical semi-arid steppe climate, situated to the south of tropic of cancer and east of the western ghats and the cardamon hills; Tropical and sub-tropical desert, spread over the western Rajasthan characterised by scanty rainfall; Tropical and sub-tropical steppe, the region towards the east of the tropical desert running from Punjab and Haryana to Kathiwar
experiences this climate type. The humid subtropical climate group is characterized by low temperature during the cold months (18 and 0°C) and high temperature during summer. They are spread over the foot hills of Himalayas, Punjab-Haryana plains, UP, Bihar and north of West Bengal. The mountain climate region is arid with decrease in temperature with increasing altitude. This area is spread over Himalayan mountain slopes covering Jammu, Kashmir, Himachal Pradesh, Uttaranchal, Sikkim and Arunachal Pradesh (Nadkarni et al 1989).

Although several types of forests exist in the country, the tropical forests found in India are more interesting. They are identified along with Indo-Malaysian tropical forest region and contain almost similar vegetation seen in countries of east of India. These tropical rain forests of India are developed in western ghats, along the western coast of Andamans, and around Khasi hills in Himalayas in the north eastern part of the country and even in plains too. Because of the diversity of both flora and fauna these two regions are identified as 'biodiversity hotspots'. Most of the trees in these forests grow up to a height of about 45 m and they form a very dense canopy. These forests are multistoried and quite often could see two or three distinct levels with a luxuriant ground cover. Climbers and woody lianes, and palms and canes will be conspicuously present (Dwivedi, 1993).
As the forests of the country vary a great deal according to different climatic and edaphic conditions, it is but natural that the application of forestry in different parts of India should also be variable. Corresponding to the forest types, the fauna in these regions are also highly variable. They also require different management strategies for their conservation. Indians are traditionally forest loving people. They retreated to forests for enlightenment, relaxation, or even recreation. Though, the cultural and agricultural pursuits over centuries have made deep incursions into forest lands, the most destructive agents have been the European invaders. Though they are the people who made distinct laws and also responsible for enforcement of protective measures, thoughtlessly destroyed the forests for the needs of the two world wars. The assessment by Forest Survey of India in 1993 indicates an extent of around 75 million hectares (22% of total land area) is only under forest cover of which closed forest may vary between 40 and 57 million hectares.

The Western Ghats

The western ghats are the main mountain ranges of peninsular India, running almost parallel to the Arabian Ocean all along the west coast, and extends over 1600 km long. The whole range of ghats covers an area of 16,000 km². This stretch emerges in the north near Tapti river
(21° N) and ends at the southern tip of the continent near Kanyakumari (8° N). It covers six states, Gujarat, Maharashtra, Goa, Karnataka, Kerala and Tamilnadu. Western ghats is the stable mass of archaean and pre-cambrian formations, where mountain building had ceased in pre-cambrian times. The eastern side of the ghats merges with peninsular plateau, which is partly overlaid by Gondwana and later formations by Deccan lava (Nair, 1991; and Pascal, 1982a). Geologists say that they are not true mountains, but are the faulted edge of the Deccan plateau (Stebbing 1929).

There are different views on the origin of western ghats. According to Craddock (1977) separation of Indo Antarctic continent from Africa began in the late triassic and continued throughout jurassic and the drift proper started during late jurassic, the separation of India and Antarctica took place during cretaceous. Smith et al. (1981) believed that the separation of Madagascar, India and Ceylon block from Africa and Antarctica have taken place between late jurassic and early cretaceous. However, the most generally accepted view on the origin of western ghats is that India broke away from Madagascar only during middle cretaceous, the drift began in late cretaceous. As early as the palaeocene, North India approached the equator while the Mysore region had traversed during eocene. The Indian land mass collided with the Asiatic landmass, thrusting and forcing the Himalayas up. India took its
present position during the miocene. The western part of peninsula was elevated during the tertiary in successive phases. Most of the exposed gneisses of western ghats are 2500 million years old and there are also intrusions with ages of about 2000-2100 and 450-600 million years (Pascal, 1982 a & b and Pascal, 1988).

Geologically the region principally consists of basalt which is the predominant rock found in the hills reaching a depth of 3 km (2 mi). Other rock types found are charnockites, granite gneiss, khondalites, leptynites, metamorphic gneisses with detached occurrences of crystalline limestone, iron ore, dolerites and anorthosites (Vilas and Valenico 1977). Residual laterite and bauxite ores are also found in the southern hills. The western ghats area also houses number of mountain peaks such as Anamudi in Kerala which has an elevation of 2,695 m (8,842 ft), Doddabetta in Tamilnadu with an altitude of 2,637 m (8,652 ft), Mullayanagiri in Karnataka with an altitude of 1,950 m (6,398 ft). The entire mountain range is separated by two belts - Goa gap, between Maharashtra and Karnataka sections and Palghat gap on the Tamil Nadu/Kerala border between Nilgiri and Annamalai Hills.

Presently western ghats dominates the western coast of Indian peninsula and demands a very important status in the country's development activities. These ranges, to a very great extent, influence the
socioeconomic and cultural activities of the local people. At the same time these ghats pose series of problems especially due to ecological vulnerability.

Thus the geologically distinct Indian sub-continent is also richest in terms of biodiversity. Owing to its vast geographical area, varied topography and climate harbors variety of habitats. As it has already mentioned, the Himalayas and the western ghats have been declared as biodiversity hotspots. Although some effort has been made to preserve this diversity, a scientific approach for the conservation has not yet been made, particularly in the region of western ghats.

**Bhadra sanctuary**

For the purpose of management and conservation, western ghats region has been divided in to a few national parks and sanctuaries. Bhadra wildlife sanctuary is one such sanctuary situated in the Chikamagalur District of Karnataka, India. It covers a forest area of about 492.46 km$^2$. It is located between 12° 55’ N and 13° 54’ N latitude and between 75° 50’ E longitude to 76° 22’ E) (Map 1). It forms part of western ghats, with mountains as natural borders on three sides and one side covered by the backwaters of Bhadra reservoir. In an aerial view it appears as a trough like valley which is geographically isolated and
movement of animals from other parts is naturally prevented. Because of these natural boundaries protection and management has become easy for the wildlife managers of the state. In fact, Bhadra wildlife sanctuary is one of the best protected areas in the state with scenic beauty and diverse vegetation harboring a variety of fauna.

**Review of literature**

The following is a brief account on the research that has been carried out so far on the wildlife of Indian subcontinent by different workers. A list of species of different taxonomic groups is found in Fauna of British India (Morley, 1936). A few of the literature documenting the faunistic wealth of the country are found in Prater (1965, 71), Prue and Napier (1977), Russel (1900), Sanderson (1982), Schaller (1967, 69), Spillet (1967), Stebbing (1929). Some information is also available in the form of reports (Anonymous 1984; Karanth 1978, 81, 83; Neginhal 1974; Ramprasad and Malhotra 1984). The review of these papers suggests that research has been mostly confined to some of the selected larger mammals.

Literature on the forest ecology around the globe and in India (Moran, 1980; Pascal, 1982a & b; Puri, 1983; Puri, *et al*, 1983; Ramprasad and Malhotra, 1984; Saldanha, 1984; Shamasundar and
Reddy, 1986; Stebbing, 1929; Untwale and Wafer, 1986) is also available. A number of reports on survey on wildlife by various authors have been published (Basappanavar, 1985; Berwick, 1976; Dinerstein, 1980; Eisenberg, 1980; Eisenberg and Lockhart, 1972; Eisenberg and Sidensticker, 1976; Spillet, 1967). An attempt to show the relationship between population structure, density and biomass of certain selected groups of animals has been made by Basappanavar (1979), Panwar (1979a & b), Richard and Eberhardt (1985), Rodger and Panwar (1988), Rogers (1987), Soepadmo (1987). The food habits of certain animals were studied by Seryheen (1991).

Among the large predators, tiger by virtue of its magnificent appearance has attracted the attention of many wildlife observers and researchers. Both scientific literature and literature depicting the experiences of individuals with tigers is also available. Observations have been made on the tiger distribution (Basappanavar, 1985; Mc Dougal, 1977; Panwar, 1979 a & b, Sanderson, 1982, 83), behavior (Sunquist, 1981; 83; Sunquist and Sunquist, 1989; Tamang, 1982) and prey - predator relationship (Johnsingh, 1983; Johnsgih et al 1990; Karanth, 1987 a & b; Schaller, 1967).

Elephant is another animal which has attracted the attention of wildlife biologists. The ecology, food habit and social behavior of Indian elephant in different distributional ranges have also been reported (Nair

The gaur, the second largest animal in the Peninsular India has been one of the least studied anywhere in its ranges. However, good amount of literature on gaurs is available from other Southeast Asian countries. For example, Srikosamtara and Suteethorn (1995) have reviewed the status of different sub species of gaur in their different ranges. Status and distribution of the species in Thailand was investigated by Dobias (1982 & 1985), Supmee (1986), Paliphod (1989), Climo (1990) and Midas (1993). Blower (1982) and Yin (1993) reported the distribution in Myanmar. Oliver, 1978, Olivier and Woodford (1994) and Duckworth et al. (1994) estimated the population in Cambodia and Lao PDR respectively. Gaur is reportedly exterminated from most part of China (Xiang and Santiapillai, 1993) but for remnant population along the China - Myanmar border (Ma et al., 1994). Conry (1980, 1981 &1989) reported the habitat use of gaur in Malaysia and discussed the impact of developmental activities on the species.
Schaller (1967) was the first to report the status and distribution of gaur in India. According to Krishnan (1972), the undulating hills of western ghats is the true home of gaur in India. In western ghats, it is reported from Karnataka, Kerala and Tamil Nadu where a good population occurs in the hilly-forested tracts. However, most of the information on the species in India has been from casual observations (Cameron, 1929; Brander, 1935; Blackburn, 1935; Morris, 1937; Mustill, 1938; Russel, 1940; Robinson, 1942; Hutton, 1951; Hundley, 1951; Davidar, 1970; Bansal and Joshi, 1980). A few have reported the status of gaur in different parts of India (Basappanvar, 1985; Karanth, 1986; Samant, 1990; Debroy, 1991; Rodger, 1991). Vairavel (1998) studied the species in detail in Parambikulam wildlife sanctuary, Kerala. Schaller (1967) mentioned the inadequacy of information on gaur due to lack of long-term studies.

Although some literature is available on the wildlife of India in general and western ghats in particular, the studies on the wildlife of Bhadra sanctuary are very limited. Being almost geographically isolated the sanctuary is definitely provides interesting information on wildlife. During Brisith rule lot of silvicultural activities had taken place and a few teak plantations had been put up in the sanctuary. In the absence of any literature Raju (2001) took up some studies on the effect of silvicultural and management practices on the gaur population in the sanctuary.
Jathanna *et al.* (2003) have recorded the density of a few herbivores in Bhadra sanctuary and suggested that it is too low when compared to other sanctuaries. Karanth and Kumar (2005) studied the tiger population and tried to estimate the predator-prey relationship in the sanctuary. They have all suggested a detailed scientific study is necessary in the Bhadra sanctuary to have effective management. According to Raju and Hegde (1996) Bhadra sanctuary is a 'fragile ecosystem' with wildlife which demands greater care and protection. A good management is possible only if sufficient scientific information on various aspects of population is available. In this context the present study has been undertaken by the author to study the distribution, density, population structure and dynamics of a few mega mammals in the Bhadra sanctuary.