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ECOLOGY OF SACRED *KAN* FORESTS IN CENTRAL WESTERN GHATS

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ECOLOGY OF SACRED *KAN* FORESTS IN CENTRAL WESTERN GHATS

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Discovery of two Critically Endangered tree species and issues related to relic forests
Ecology of swampy Relic Forests

ECOLOGY OF SACRED KAN FORESTS IN CENTRAL WESTERN GHATS

SUMMARY

The Western Ghats is one among the 34 global hotspots of biodiversity and it lies in the western part of peninsular India in a series of hills stretching over a distance of 1,600 km from north to south and covering an area of about 1,60,000 sq.km. The flora of Western Ghats comprises about 12,000 species from unicellular cyanobacteria to the flowering plants. In this spectrum of the flowering plants of Western Ghats comprises about 27 % of the Indian flora. Of the 4,000 species of flowering plants about 1,500 species are endemic species. Of the 4,000 species of flowering plants about 3,100 species occur in the wet evergreen forests. The growth forms are result of plant segregation due to light requirements, and availability of space. Main objective of this study is to understand the ecology and conservation aspects of sacred kan forests in central Western Ghats. This study was carried out in Kathalekan a *kan* protected by the peasant community in the past and a good part of the sample area to this day retains features of a primeval forest. It is a home land for various Western Ghats endemic species. One of the main and easily identifiable components of biodiversity is endemism. The study shows that *kans* act as micro-watershed in local areas and are always associated with a fresh water ecosystem used to trap and collect the rain water for the local water supply. Major threats to such fragile ecosystems include cultivation within *kans*, encroachment, grazing, lopping apart from unplanned developmental activities. Kathalekan as a relic forest with high degree of plant endemism and myristica swamp liberally sprinkled with southern climax species such as *Dipterocarpus indicus, Palaquium ellipticum, Mesua ferrea, Syzygium spp*, etc with rich under growth of especially the slender palm Pinanga dicksonii and clumps of Ochlandra is a visual demonstration of congenial microclimatic condition and rich soil with high water conservation values. The swamps being the peak expression of the high water content, the Myristica swamps are also sources of perennial streams and have some of the most ancient land biodiversity of the earth dating back to the Gondwanaland. This short term study therefore has become helpful for formulating a conservation and management plan for Kathalekan, which include declaring as biodiversity heritage site, management of water courses, maintenance of savanna, regulation of cattle grazing and stricter vigil to prevent encroachment.

1. INTRODUCTION

1.1 Western Ghats: One of the 34 Biodiversity hot spots of the world, the Western Ghats, together with the west coast form an important ecological region, springing from the Arabian Sea coast to the montane heights of over 2,000 m. The Western Ghats form a practically unbroken relief dominating the western coast of the Indian peninsula for almost 1600 km from the mouth of the river Tapti (21^0 N) to the tip of South India (about 8^0 S), covering an area of approximately 160000 km^2. The Ghats have an elevation range of 300-2700 m and a latitudinal spread from 8^0 N to 20^0 N. Palghat gap in Kerala is a major gap in this mountain range which was a part of the Indian plate of the Gondwanaland. The flow of Deccan lavas resulted in horizontally stratified mountains in the Deccan traps north of the river Krishna (Nayar, 1996). The origin of the of Peninsular India, particularly that of the Western Ghats and its complexity and diversity need to be viewed against the back drop of much-researched phenomenon of plate tectonics (Raven and Axelord 1974). India certainly appears to have remained connected to Madagascar and Africa until at least 100 m.y BP (million years before present) thereafter commencing its northward motion until it collided with Asia by mid-Eocene.

The Western Ghats straddle the states of Kerala, Tamil Nadu, Karnataka, Goa, Maharashtra, and southern Gujarat. Just as the Himalayas Preside over the biogeography of India, the Western Ghats to a large extent presides over the ecology and biogeography of Peninsular India (Subramanyam and Nayar, 1974). Its presence creates major precipitation gradients. This apparent unity in fact masks the great heterogeneity of the environmental conditions resulting from geographical, geological and demographic differences. The physiographic and geological diversity in the Deccan traps of basaltic rock north of the Krishna basin and of Precambrian crystallic rocks formed of granites, gneiss south of the Krishna basin are conspicuous. The soil consists of black soil, laterites and red loam and coastal alluvium. The annual rainfall varies from 2350 in the north to 7450 mm in the south which makes the Western Ghats the water shed of the Peninsula. (Nair and Daniel, 1986). Godavari, Krishna and Cauvery are the major east flowing rivers from Western Ghats. The West coast is intersected by over 80 rivers that run their shorter courses before joining the Arabian Sea.

The latitudinal and altitudinal gradients, rainfall patterns brought in by South-West and North-East Monsoons, the rapid decline in rainfall on the leeward side of the mountains, the Deccan Plateau, the presence of mosaic of soil types, variations in soil nutrients and over three millennia of vegetational changes caused by human impacts have resulted in a mosaic of ecological islands, niches and refugia which favour high degrees of endemism and relic species. According to Stebbins and Major (1965), in regions on the borderline between zones of adequate moisture and deficient moisture, even small climatic shifts will change local conditions beyond the limit of tolerance of the resident species, so that they may either migrate or evolve new ranges of tolerance. Over a distance of 20 km, the dry season ranges from 3 to 8 months due to relief, wind flow in the gradient on the leeward side, resulting in the formation of a unique flora in small ecological islands and the borderlines of wet evergreen moist deciduous dry evergreen and dry deciduous forests (Nayar, 1996).

1.2 The flora: The flora of Western Ghats comprises about 12,000 species from unicellular cyanobacteria to the flowering plants. In this spectrum of the flowering plants of Western Ghats comprises about 27 % of the Indian flora. Of the 4,000 species of flowering plants about 1,500 species are endemic species (Nayar, 1989). The presence of alpha diversity in Western Ghats depends on the four niches; habitat phenology, growth form and regeneration tactics. The species packing in the close evergreen forest is based on the growth form of the canopied trees, second storey species, lianas, epiphytes, shade tolerant shrubs, herbs and saprophytic ground flora. Of the 4,000 species of flowering plants about 3,100 species occur in the wet evergreen forests. The growth forms are result of plant segregation due to light requirements, and availability of space.

1.1.2 Endemism-Biodiversity hotspot: One of the main and easily identifiable components of biodiversity is endemism. While biodiversity is the biological capital of the Earth, endemic flora and fauna (which includes genes, species and ecosystems) of a region or nation are the exclusive biological capital of that region or nation (Nayar, 1996). Endemism encompasses taxonomic units of any rank or taxa (includes plants, animals and microorganisms), which occur in a biogeographical area usually isolated by geographical, ecological or temporal barriers. The areas of endemism may be large or small. The degree of endemism increases with increase in size of a homogenous biogeographical area having the same floristic history and ecological conditions. The distribution of endemics usually follows biogeographical provinces, patterns of unique ecological features, topographical and climatic interfaces. Endemic taxa restricted to a particular Peninsula, mountain range, an island or a mountain peak may be well remnants of an ancient flora which in the course of geological and climatic changes found refugium in isolated or restricted geographical region. Endemics once lost, it is an irretrievable loss for the region or nation (-ibid-)

The floral distribution in Western Ghats is not uniform; it varies between region to region. These distributional variations are clearly visible along the latitudinal gradient from southern tip to the northern part of the Western Ghats. More endemic species are occurring in the lower latitudes and decline drastically in higher latitude. The main contributory parameters for the changes in the vegetation in Western Ghats are the climatic gradients and the local topographic variations (Ramesh and Pascal, 1997). The reliefs of the Ghats act as a barrier to the eastward movement of the cloud masses brought by the summer monsoon winds. These masses bring prodigious amounts of rainfall over the reliefs of the Ghats causing diminished rainfall towards the east. This decrease results in the isolation of moist formations which are confined to the humid regions with a high rainfall (west east gradient). Lengthening of the dry season from low latitude to higher i.e., the duration of the dry season gradually increases from one month in the southern part of the Ghats to over eight months north of Mumbai. This gradient is determining richness of the biodiversity of a region and also endemism. (Ramesh and Pascal, 1997; Pascal, 1988).

1.4 Importance of *Kans*: As we go from southern part of the Western Ghats to northern region declining trend is observable in plant species richness. The existing evergreen forests are practically all localised in a narrow strip extending from the foot of the Ghats almost to summit (in south Kerala) and to about 10-20 km beyond the edge of the plateau (from Palghat, northwards). Towards the northern parts as well there are isolated patches of primary evergreen forest more or less similar to southern forests in floristic and faunal richness. On the Karnataka plateau some forests are about 20-40 km away from the present eastern limit of the evergreen continuum, and constitute evergreen or more often semi evergreen islets surrounded by moist deciduous formations. These islets may be considered as the relics of the past extent of the evergreen forests (Pascal, 1988). Even though many parts of the Western Ghats are subjected to severe anthropogenic pressures these types of relic formations keep their identity up to this period. These relic forests are known as *kans* in central Western Ghats of Uttara Kannada and Shimoga. The backdrop of the ecological history makes it clear that since time immemorial people preserved these forest patches as abodes of local deities. These *kans* are places where ancient vegetation is intertwined with the socio-cultural and religious practices. The *kans* are similar to Devarakadus of Coorg and Kavus in Kerala.

The genesis of sacred groves in the Western Ghats may go back to hunting gathering societies which attributed sacred values to patches of forest within their territories as they did to several other topographic or landscape features like mountain peaks, rocks, caves, springs and rivers. But practice of setting aside patches of forests as sacred groves would have strengthened with the spread of agriculture, when slashing and burning of forest on a massive scale caused decline in biodiversity and diminished water shed. The groves, in addition to their role as the abodes of gods, would have protected a range of landscape elements with their characteristic biodiversity (Chandran *et al*, 1998).

Kans ranging in area from part of a hectare to few hundred hectares and protected from time immemorial, may be considered as the best samples of climax forest of the region. Even when the protection has become less stringent these days any removal of live wood continuous to be taboo. Today these groves therefore serve critical function like sheltering rare plants, protection of the water resources, and being the only remnant of tree vegetation along the country are also the main sources of leaf litter Most of the Kan forest are endowed with faunal richness. They often serve as the last refuge for arboreal birds and mammals, especially monkeys (Chandran and Gadgil, 1993). The landscape heterogeneity and biodiversity are positively correlated within this ecosystem. These groves formed part of a landscape of well connected natural elements and functioned as refugia for many species of plants and animals. The medical plants from groves are known to cure many ailments according to traditional medicinal system (Devar 2008). *Kan* forest act as a seed banks for many important species and it would have ideally helped in forest regeneration and restoration around it through supply of seeding material.

The evergreen kan in traditional land use system acted as fire proof barriers protecting surrounding landscape elements from catching fire. Sacred groves operate as microwater sheds in local areas (Pushpangadan, et al, 1998). The grove increases the watershed value of the area by enhancing the recharging process of ground water by increased filtration. The non timber products obtained from the *kan* forests aided subsistence of local people. The produce included edible fruits, spices, honey, toddy, etc. The *kans* during the pre British time were well known centers for pepper (Chandran and Gadgil, 1993).

The British occupation of the Western Ghats, from early 19th century, set the tone for forestry operations to date (Chandran, 1997). Government reservation of *kans* following the Indian Forest Act of 1878, Uttara Kannada as state forests, followed by introduction of contract system for collection of non wood produce, which replaced the community management (Wingate, 1888). Reservation of the forest would have led to the villagers losing their hold over the *kan.*

Exploitation of the evergreen forests during 1940-1980 has affected the forest resources. During Second World war trees such as *Calophyllum tomentosum, Artocarpus hirsutus and Tectona grandis* were removed from the forests for ship building. *Dipterocarpus indicus*, an evergreen tree exclusively present in some *kan* forest was supplied to the railways and plywood companies (Shanmukhappa, 1977). Selective logging continued in these forests till it was banned in 1987. Despite anthropogenic influence of varied kinds continuously operating on the *kan* forests, many *kans* still harbour an enriched assemblage of flora and fauna compared to the adjoining forest patches.

1.5 Significance of Kathalekan: Kathalekan the focal area of this report was once, in all probability such a *kan* protected by the peasant community in the past. What prompted this study is the fact that a good part of the sample area to this day retains features of a primeval forest. It is a homeland for various Western Ghats endemic species. In its species composition it shows similarity with Western Ghats southwards having *Dipterocarpus indicus* dominated forest than with north having *Persea –Diospyros* community. In addition to *Dipterocarpus indicus* are also found *Palaquium ellipticum, Mesua ferrea, Myristica fatua, Gymnacranthera canarica, Pinanga dicksonii* which are rather absent or rare in forest of northern latitude. The Myristica swamps of the Kathalekan are more similar to those of Travancore than anything such in the north. It is also almost the northern most range for distribution of the Lion Tailed Macaque.

It is unfortunate that such forest has not captured adequate attention of conservationists and forest management although some sporadic studies have been carried out here, especially in the Myristica swamp region. Selection felling and enormous incidental damages would not have taken place if there was more comprehensive ecological studies conducted earlier. At least today such opportunity has been used to conduct a co-ordinated and systematic ecological study of Kathalekan. This study with interesting findings hopefully may lead to more fruitful outcome in future, especially in the form of a more scientific management plan.

1.6 Objectives of the Study

Main objective of this study is to understand the ecology and conservation aspects of sacred kan forests in central Western Ghats. This involve:

- reconstruct forest history so as to understand the past of Kathalekan forest;
- decipher vegetational composition and structure (restricted to flowering plants) by using ecological survey methods;
- analysis of field data for diversity, evergreenness and endemism;
- exploring the regeneration related details of tree species of the region; and
- investigate anthropogenic threats operating in the study area and to formulate conservation plans.

2. LITERATURE REVIEW

Schimper's (1903) work on tropical forest has been considered as one of the pillars of modern ecology. The *Tropical Rain Forest* by Richards (1952) is an acknowledged classic that generated considerable amount of interest. It is based on the studies carried out in Guyana, Borneo and Nigeria. Corner's, '*The Life of Plants'* (1964) considers tropical rain forest as the matrix of terrestrial vegetation type. The first important work on India's vegetation is by Champion (1936) and revised by Champion and Seth (1968).

Early botanical studies in Uttara Kannada district, towards the south of which is situated Kathalekan, the focus of this study, were purely floristic. The systematic and detailed inventories of flowering plants of the erstwhile Bombay Presidency prepared by Cooke (1901-08) and Talbot (1909) are still some of the best reference materials for the flora of this district. Since the time of Cooke and Talbot, more than 1700 species of flowering plants have been reported from the district. (Daniels, 1989). Arora (1961) for the first time explored the Uttara Kannada forests as a part of his studies on the floristic ecology of Western Ghats. Pioneering work by Chandran (1993, 1997) on kans of Western Ghats constitute the basis for this work.

The studies on sacred groves in India gained impetus with the pioneering works of Gadgil and Vartak (1975, 1976) in the Western Ghats, especially from Maharashtra state. Gadgil and Berkes (1991) attributed the traditional practice by most human societies of rendering complete protection to certain biological communities by setting aside of refugia (sacred groves, for instance) to a variety of regulatory measures which have been an integral part of utilization of biological resources. Such regulatory measures also included quantitative quotas as to how much material is harvested restriction of harvests to certain season or life history stages, restriction on harvesting techniques employed etc.

Sacred groves belong to the traditional practice of protecting, patches of vegetation, mostly of the primeval kind, on religious grounds subtended by cultural practices. They have been identified all over the world and in all shades of cultures. In India, the groves have been reported from the forest ranges in the hills, arid regions like the deserts and along agricultural plains as well (Ramakrishnan et al. 1998). Whereas larger groves are considered mini-biosphere reserves, the smaller ones are also of biological value as they harbour some old and magnificent specimens of trees and climbers (Gadgil and Vartak 1975).

The genesis of sacred groves in the Western Ghats may go back to hunting gathering societies which attributed sacred values to patches of forests within their territories as they did to several other topographic or landscape features like mountain peaks, rocks, caves, springs and rivers. But the practice of setting aside patches of forests as sacred groves would have strengthened with the spread of agriculture, involving widespread slashing and burning of forests. The groves, in addition to their role as the abodes of gods, would have also protected a range of landscape elements with their characteristic biodiversity. (Chandran *et, al* 1998).

Study of a *kan* forest is the focus of this work. In fact *kans* were known as special patches of forests from all over the central Western Ghats, especially of Shimoga and Uttara Kannada districts. The *kans* were known to the local inhabitants as forests preserved primarily on religious grounds. But most British records never acknowledged the role of local communities in preservation of the *kans.* Chandran and Gadgil (1993), and Chandran (1997), explained various socio-religious, historical, economic, and ecological aspects of the *kan* forests. They were important pieces of pre-colonial forest conservation in the Western Ghats. Myriad relics of such groves exist even today all over the Western Ghats. These sacred forests in pre colonial landscape, served many functions like conservation of biodiversity and watershed, moderation of climate and enhancement of landscape heterogeneity which promoted varied wildlife. The people had also much reliance on subsistence hunting. The village sacred groves ranged in size from few ha to few hundred ha each.

The practice of keeping aside sacred forests by the early farmers would have provided the necessary seeds for the re-establishment of the evergreen forests that have been during the slash and burn cultivation process, rampant until the late 19th century in the Western Ghats. Although the evergreen forests tend to re-establish on its lost grounds, in the absence of fire and other anthropogenic factors, it is likely that some of the elements of climax evergreen forest did not stage their come back, may be due to some apparently irreversible soil changes brought about burning (Chandran, 1993).

Concomitant with a climatic change towards more aridity, during the fourth millennium BP, widespread vegetational changes were expected to have taken place in the Indian sub-continent. To support such climatic change related changes in vegetation Caratini *et.al* (1991) brought in palynological data from a marine core closer to Karwar in Uttara Kannada. The pollen data showed substantial increase in pollen of savanna plants against those of forest plants. The find was used to buttress the argument that the fourth millennium BP climatic change had not spared even the humid forest belt of lower altitude portions of Western Ghats. However, a look into composition of *kan* forests of Uttara Kannada, particularly the Kathalekan and Karikan showed that these are today major refugia for hygrophilous species like *Dipterocarpus*. The pollen of which was present in the Karwar marine core far north in the offshore of Uttara Kannada. The very presence of *Dipterocarpus, Vateria indica, Myristica* spp. etc. all very sensitive species, specially in the *kans* are taken as evidence by Chandran (1997) for agricultural clearances and not climatic change as the cause for vegetational mid fourth millennium BP changes.

Rajendraprasad (1995) compared the floristic diversity of climax evergreen forests and sacred groves of Kerala and reported that the Shannon-Weiner's diversity index value varied from 2.6 to 3.6 for climax forests and it was 2.8 to 3.6 for the sacred forest. Within the sacred forest, the diversity value varied and was positively related to the disturbances. In the disturbed groves of Uttara Kannada, Shannon-Wiener's index value varied from 3.2 to 3.6. The floristic difference between highland and coastal groves was maximum and the highland and midland showed maximum similarity (Devar,2008).

Balasubrahmanya and Induchoodan (1996) estimated 761 important sacred groves in Kerala with floristic wealth of over 722 species belonging to 474 genera and 217 families. This study revealed that the biodiversity potential of sacred forest was found to be very high when compared to well protected evergreen formations of South India. They estimated the area of groves in Kerala to be 90 sq.km.

Nayar (1996) considers 'Devavanams' or 'Kavu' meaning sacred groves as some of the last refugia for our endemic flora and fauna. Plants and animals are worshipped along with gods and goddess in sacred groves. Mohanan and Nair (1981) had collected a new species of *Kunstleria* which is essentially a Malayan genus from one of the sacred groves of Kerala, and described the new species as *Kunstleria keralensis*. *Syzygium travancoricum* Gamble, was collected by Bourdillon in 1894 from Kerala and it was not located for about seven decades. Nair and Mohanan (1981) had relocated the species in the sacred groves of Kodumon and Aickad in Kollam district of Kerala in 1981 and Pandurangan had located 15 to 20 trees in Guddrikka (Nayar, 1996).

Boriah (2001) conducted a comparative study with respect to species composition of regenerating species among the reserved forests and sacred groves and revealed that the species richness was highest for the reserve forest (160) followed by disturbed sacred groves (156) and conserved sacred groves (146), the last showing a slight decrease in the species number. This study indicates that some disturbances can increase diversity.

The studies of Bourgeon (1989) and Pascal *et al* (1988), on the edaphic features of the Western Ghats forests show that in some cases, edaphic compensation, especially better moisture holding capacity of soils enables the maintenance of evergreen formations even when the rainfall is somewhat lower. The '*kan*' forests of the Karnataka plateau, of particularly Sorab-Sagar region in Shimoga were taken up for illustration.

Sacred groves act as microwater shed in local areas. The sacred groves are always associated with a fresh water ecosystem used to trap and collect the rain water for the local water supply. If they are destroyed or disrupted the water cycle would be interrupted. The heavy canopy and undergrowth along with the litter of the sacred groves is helpful in reducing the impact of rain drops on the soil. This humus rich soil facilitates rapid infiltration of rain water during rainy season as a result of improved hydrological properties of the soil (Pushpangadan *et al.,* 1998)

Kathalekan of Siddapur taluk was obviously a kan or a sacred forest of the pre-Brahmin people. Despite the logging damage it suffered ever since the Second World War, primarily due to the extraction of valuable timbers of species like *Dipterocarpus indicus*, *Calophyllum tomentosum* and some other industrial timbers it still harbors great amount of endemism in the ground layer (Gadgil and Chandran, 1989).

The study by Pomeroy et al (2003) on the four plots in Uttara Kannada such as Kathlekan, Devimane, Malemane, Kodakani in Uttara Kannada showed that the forest of Kathlekan has relatively lower density of trees, around 330 trees/ha. In contrast to the other forests, Kathlekan has a higher percentage of large trees (>50 cm dbh). Road construction followed by selective logging occurred through these plots, though Kathlekan was exposed to these activities earlier than other nearby places). The census in the 1993 and 1997 indicates that the mortality rate of trees in Kathalekan had reached 8% and the mean estimated recruitment rate also increased dramatically to around 4% approximately balancing the mortality. The timber extraction from Kathalekan had caused a decline in forest cover; the low point was during 1977 to 1984, the peak of industrial felling, when tree density was only 70 % of the original density. Prohibition on timber extraction from 1987 obviously promoted forest recovery. By 1993 there has been some pronounced recovery in Kathalekan forests.

Dasappa and Swaminath (2000) described a new critically endangered species viz., *Semecarpus kathlekanensis* from the *kan* forest of Kathlekan .The reproductive biological study of the same plant by Vasudeva *et al*. (2001) reported that the species has primitive breeding system a combination of dioecious and monoecious species.

Devar (2008) in his study on species composition and diversity with respect to various size classes of *kan* forests in the Sirsi Forest Division of Uttara Kannada showed that among various size classes the small fragments had comparatively higher species composition and diversity than that of large *kans* and medium sized *kans*. The species composition of small *kan* forests showed that though the species distribution is accumulating with increased size of the *kans,* it does have strong relationship with the increasing species richness. Similar trend was followed with respect to species diversity which indicates that species diversity increases with the size of the *kan*. The distribution of species also shows a positive relationship with the size of the kan forests suggesting more equitable distribution in the entire area of *kan* forests.

Among the different species recorded in the *kan* forests of Sirsi Forest Division, were *Actinodaphne hookeri, Artocarpus hirsutus, Cinnamomum macrocarpum, Diospyros cadolleana, Flacourtia montana, Holigarna beddomei, Hopea ponga, Knema attenuata, Macaranga peltata, Mimosops elengi, Olea dioca, Syzigium cumini, S. gardneri, Terminalia paniculata* and *Vitex altissima*. These were more commonly seen across rainfall ranges indicating their broad distribution. (Devar, 2008)

Kathalekan is also home to rare type of swamp forests. Swamp forests were reported from the foothills of the Himalayas (Dakshini, 1960; Somadeva and Srivastava, 1978, Ghildiyal and Srivatava, 1989; Gupta, et.al., 2006) and Kalakkad-Mundathurai (Ganesan, 2002). Krishnamurthy (1960) first reported the *Myristica* Swamp from the Travancore region of South Western Ghats which was classified under a newly introduced category, 'Myristica Swamp Forests' under the sub group 4C by Champion and Seth (1968). These Swamps are well developed in the valleys of Shendurney, Kulathupuzha and Anchal forest ranges in the Southern Western Ghats of Travancore. In Uttara Kannada district of Karnataka studies revealed 51 swamp patches. The swamps were highlighted for their evolutionary and ecological characters. (Chandran, 1993; Chandran et al 1999; Chandran and Mesta, 2001) A swamp associated with a sacred grove in the Satari taluk of Goa was reported by Santhakumaran *et al* (1995).

Nair, *et al*. (2007) made an excellent effort towards documenting the biodiversity of the *Myristica* swamps of southern Kerala. They estimated the total area of *Myristica* Swamp in Kerala to be about 1.5 km^2 (which hardly make up the 0.004 % of the total land area of the state). The biodiversity inventory revealed that the swamps contained 12 red-listed plants and 28 plants endemic to Western Ghats. It also highlighted the enormous faunal wealth of the *Myristica* swamps, including various species of nematodes, annelids, molluscs, insects, arachnids, fishes, amphibians, reptiles, birds and mammals.

The non-biotic ecological conditions essential for the *Myristica* swamp have been projected by Varghese, (1992) and Chandran *et al.* (1999). The swamps need special ecological conditions like flat bottomed or gently slopping valley in between heavily forested hills of evergreen forests, deep soil in the adjoining hills with rock below which will allow water to be stored above the rock layer, slow seepage of water from the side hills in to the valley throughout the year, heavy annual rainfall averaging 3000 mm and temperature ranging from 20-30 ^{0} C. Hence these Swamps are highly restricted in distribution.

Myristica Swamp may be considered as an endangered habitat. Rare Western Ghat endemics like *Myristica fatua* var. *magnifica*, *Gymnacranthera canarica*, *Semicarpus kathalekanensis* and a fragile palm *Pinanga dicksonii* were notable of the plants associated with the swamps. Although swamps are sources of perennial streams they have faced large scale destruction in the recent past causing in all probability diminishing watershed value of the Western Ghats (Chandran and Mesta, 2001).

According to Whitmore, (1984), in tropical evergreen forests, the level of disturbance as expressed as gap size is very important. A small gap may be filled by one or more ‘fugitive’ species which can result in an increase in species diversity. On the other hand a large gap may be filled by a dense stand of a single pioneer species or a handful of them.

The forests of Uttara Kannada have had a long history of disturbance and transformation by man. As they stand today, woody plant species numbers tend to fall with the declining rainfall gradient in a northeastern direction. The evergreen forests have the highest species richness. Daniels (1989) observed that one hectare of evergreen forest in some of the least disturbed parts of the district contain between 40 and 60 species of trees (≥30 cm GBH)

Pascal, 1988 characterised the species like *Terminalia*, *Lagerstroemia, Artocarpus*, *Olea dioica* and *Macaranga peltata* as invaders of disturbed evergreen forests. He suggested that these species cannot increase the diversity significantly. They are all characteristic of the northern Sahyadris (of Goa-Maharashtra), a region subjected to greater dry period. Hence their increased number in more south could be indicative of disturbance.

Endemism of the Western Ghats is very high among the evergreen trees than deciduous ones. The significant positive correlations exist between evergreenness and endemism. The cutting and burning of the forest patches for shifting cultivation, widely practiced once, in Uttara Kannada and other parts of the Western Ghats would have naturally lowered the endemism of the forest patches where they operated since the regrowth on abandoned cultivation sites would initially have promoted the growth of deciduous trees (Chandran, 1993). The alterations brought about in the primary forest of the Western Ghats by the early agricultural societies would have lowered the endemism substantially. However on the abandoned 'kumri' the foresters often noticed the return of the evergreen forests (Gadgil and Chandran, 1989).

According to World Conservation Monitoring Center (1992), preservation of the tropical forest is vital for conserving biodiversity. Although they cover only 6-7% of the earth surfaces these forests probably contain more than 50% and possibly as much as 90% of all species of plants and animals. Lugo and Brown (1992) indicate the importance of the forest in the carbon dioxide assimilation process. The study reveals, tropical forest including vast areas of degraded forests, also function as sinks of atmospheric carbon.

The *kan* forests were not given due importance in state-centred conservation circles. That many *kans* are relics of the original climax forests has been more an overlooked fact. Recently, in some such relic forests of Uttara Kannada were found the presence of critically endangered trees *Madhuca bourdillonii* (Gamble) Lam. and *Syzygium travancoricum* Gamble. These trees were at one time thought to be extinct from southern Western Ghats from were they were reported for the first time. Later, however, they were rediscovered in the south. Their presence about 700 km north of their original home in latitude between 14º and 15º N may be considered as an evidence of the persistence of the relic forests with their rare biota (Chandran *et al*., 2008). The *kans* are obviously such relic forests, and much need to be done in future for study and conservation of *kans*. That is why Kathalekan, a notable *kan* of central Western Ghats has been chosen as the theme for this work.

3. MATERIALS AND METHODS

3.1 Study area

The Uttara Kannada of Karnataka State, where the study area Kathalekan has been chosen (Fig.3.1), forms the northern end of the central Western Ghats and is ecologically and biogeographically important as the northern most limit of the distribution of major evergreen forest formations and many evergreen endemic tree species (Devar, 2008). The total forest cover of the district is 7,807 sq.km out of total geographic area of 10,291 sq.km. (Bhattacharya and Gadgil, 1993); the district has the highest forest cover in Karnataka. Recent vegetation analysis in Uttara Kannada district by Ramachandra and Savitha (2007) shows that 4325 sq.km under evergreen, 843 sq.km under deciduous, 580 sq.km. under scrub savanna and grasslands and 599 sq.km under barren or waste land categories, highlighting the large scale changes in land cover (http://wgbis.ces.iisc.ernet.in/energy/water/paper/ETR24/index.htm).

'Kathalekan' is the name of a hamlet in the Malemane village of Siddapur taluk towards the south-east of Uttara Kannada. It is situated between 14º 26' N to 14º 27'N and 74º 73' E to 74º 75' E. Kathalekan, which has just three families living in it, probably had more population once upon a time, when the adjoining hills and some parts within it were under shifting cultivation. Today the hamlet is a largely forested area without any means to trace its geographic boundaries. Therefore for this study was chosen a total area of 2.25 km^2 (in a square shape of 1500m x 1500m). The forest is administered by the Siddapur Range of Sirsi Forest Division in the Canara Circle.

3.2 Topography and Climate

In Uttara Kannada district the Western Ghats are low not exceeding 600 to 700 m in most places. Kathalekan has altitude ranging from 500 to 700 m. It is surrounded on all sides by hill ranges and towards its south is steep gorge through which flows the river Sharavathi. The terrain within it is also very uneven with valleys and hills. Some of the valleys are endowed with perennial streams having swamps alongside them. Generally it has a tropical, humid climate. The climate does not show marked variation in both seasonal and diurnal temperature. The hottest months of the year are March, April, and May and the coldest months are December, January and February. Kathalekan receives good rainfall as the annual rainfall measured in the adjoining Mavingundi is 3435 mm. The bulk of the rainfall is from the south-west monsoon between June and October. The mean monthly rainfall during this period is: June: 813 mm; July: 1197 mm; August: 982 mm; September: 206 mm; 115 mm. January and February are practically rainless months whereas remaining months have rainfall less than 100 mm. Pre-monsoon summer showers are received during April-May.

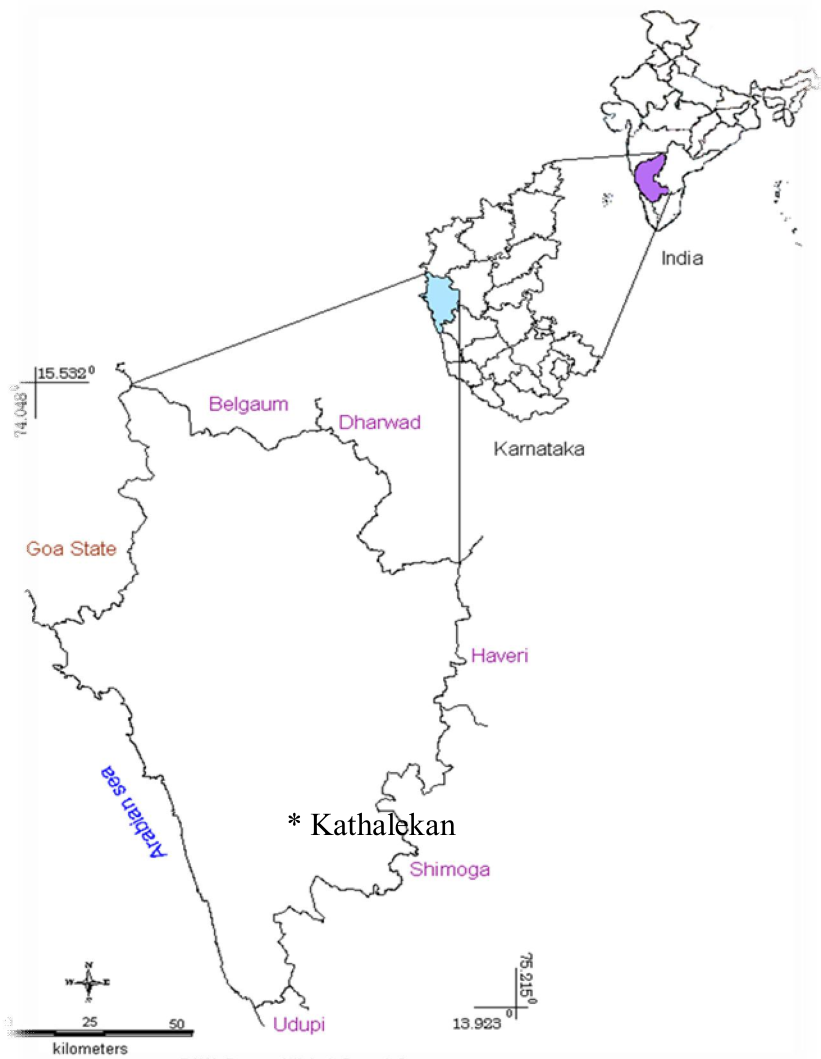

Figure 3.1: **Study area – Kathalekan, Uttara Kannada district, Karnataka State, India**

3.3 Selection of study area and devising sampling methods

Preliminary reconnaissance study of the region was conducted in January 2009 by trekking over the entire study area and familiarizing with the terrain that consists of hills and valleys, streams and swamps, evergreen forests, savanna grasslands and rocky places and very limited agricultural areas. Topographic maps of the Survey of India (1: 50,000 scale) and Google imagery were used during the preliminary field surveys.

It was then decided to select a study area of 1500 m x 1500 m considering the time and effort involved. The area has been further divided into nine grids each of 500 m² for detailed flora investigation. Figure 3.2 illustrates the study area as per Google images (http://www.googleearth.com). It was decided to sample the vegetation in each grid by using transect cum quadrat method (Sameer Ali *et al*., 2007). A transect of 180 m length and Quadrats of 20×20 m area were laid along the transect, alternately on either side of the transect for trees (figure 3.3); sub-quadrats were laid within the tree quadrats for study of shrub layer and herb layer. An inter-quadrat distance of 20 m was maintained between the tree quadrats. Species-area relationship was worked out to appropriate number of sampling units - quadrats for trees, shrubs and herbs.

3.3.1 Sampling of Trees: In each quadrat of 20 m×20 m all the trees having girth ≥ 30 cm above the ground were enumerated. The girth at breast height (GBH) of every tree was measured in cm using a measuring tape, and approximate height recorded in m. The climbers and epiphytes associated with the trees were noted.

3.3.2 Sampling of Ground vegetation: The ground layer of shrubs (+1 m height but with GBH < 30 cm) were sampled using two sub quadrats of 5×5 m each, located within the tree quadrat, as shown in Figure 3.3. Tree saplings and shrubs as well as tall herbs were enumerated in these shrub quadrats.

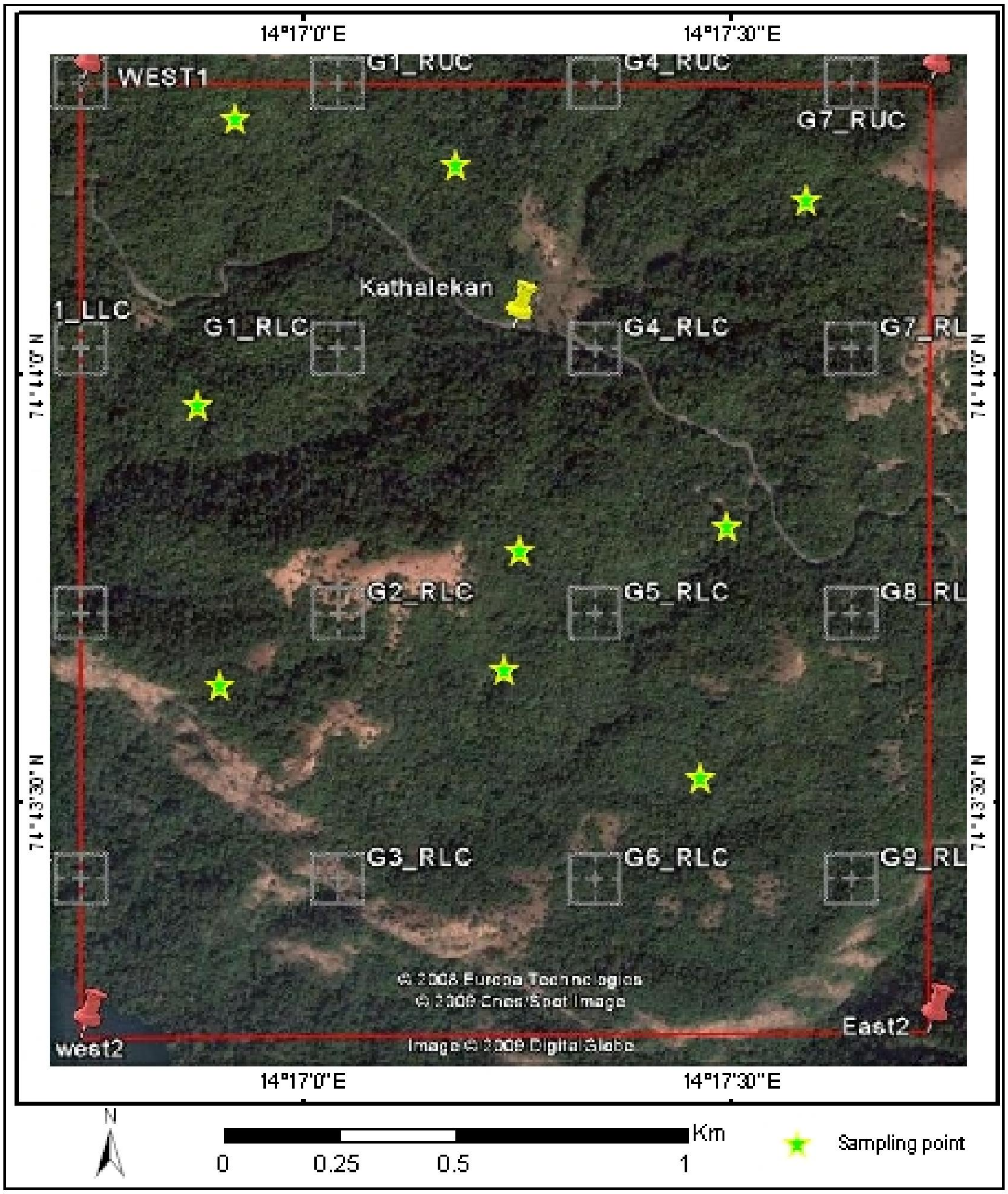

Figure 3.2: Study grids in Kathalekan as per Google image (http://www.googleearth.com)

Within the 5×5 m sub quadrats, two quadrats of one square meter each were placed diagonally as shown in Figure 3.3, for sampling the diversity of herb layer (plant less than 1 m height). The herb layer included herbs, tree seedlings as well as well as young ones of climbers and lianas. Due to practical constraints of time, repeated sampling to enumerate the seasonal herbs was not possible.

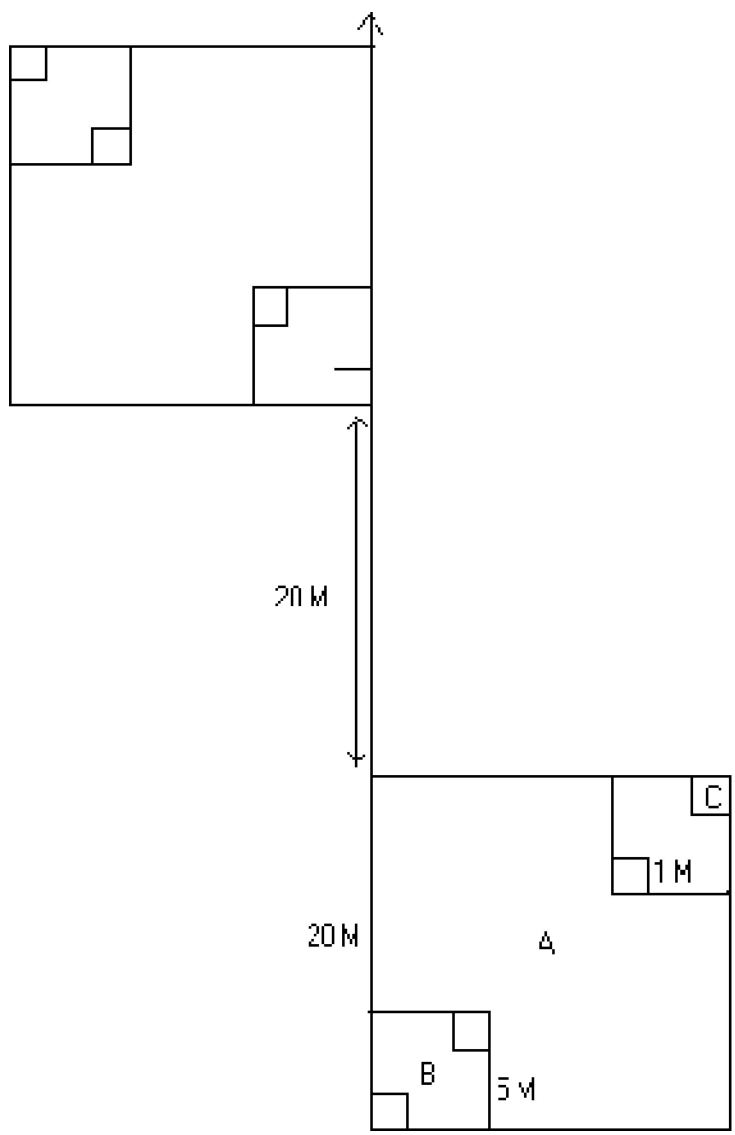

Figure* 3.3 *Transect with quadrats for sampling vegetation: A-Trees, B- Shrubs, C-Herbs

3.4 Description of the study localities: The following general details were recorded in field data book from each sampled locality.

i) Location: Grid no and any local name existing for the Grid.
ii) Patch type: Evergreen, semi evergreen, moist deciduous, scrub, savanna etc
iii) Transect number
iv) Nature of terrain: Steep slope/ Moderate/ Low to flat/Undulating
v) Rock outcrops, or rockiness: High// Moderate/ Poor to nil
vi) Nature of rock: Lateritic /Non-lateritic
vii) The occurrence of stream associated with the site
viii) Soil erosion on the site: High/ Moderate/ Least
ix) Nearest human habitation (distance)
x) Notes on human interference viz., lopping, tree cutting, burning, fuel extraction, litter collection, cattle grazing and any other activities .
xi) Sacred value
xii) Non-Timber Forest Produce (NTFP) collection

3.5 Collection of Secondary Data: The ecological history of the region was compiled from published literature and books as well as based on interviews with the local people. The study by Chandran (1993, 1997) constitutes the basic reference literature for this work. Some historical data was gathered from the previous study conducted in the area, as well as from field observations (such as old roads, timber-skidding areas, savanna-grasslands used earlier as shifting cultivation sites, patterns of forest succession etc.)

3.6 Mapping: An aerial imagery of the study area was downloaded from Google images website (http://www.googleearth.com). The relevant topo-maps available at the Energy and Wetlands Research Group (EWRG), Centre for Ecological Sciences (CES), Indian Institute of Science (IISc) field Station at Kumta taluk, Uttara Kannada district, Karnataka 581343, were referred to. Latitudes and longitudes of the sampling points at field were noted with the help of Global Positioning System (GPS). These points were plotted in the map with the help of GIS (Geographic Information System) software - MapInfo (7.5 version).

3.6 Ecological Measurements: Various ecological indices were computed to understand the diversity, relative abundance and dominance of species (Sameer Ali, *et al.* 2007). Indices include:

3.6.1. Species diversity (Shannon-Weiner Diversity Index): Diversity is an indicator of status of an ecosystem. It consists of two components, the variety and the relative abundance of species. The higher value indicates higher diversity. Diversity of trees and shrubs were estimated using the Shannon Weiner's method. (Ludwig and Reynolds, 1988).The value ranges between 1.5 and 3.5 and rarely surpasses 4.5. Shannon Weiner's index of diversity is calculated by the formula

$$\mathbf{H' = \Sigma\ [(n_i/N)\ ln\ (n_i/N)]}$$

Where, H' = Shannon's diversity index

n_i = Number of individuals belonging to the 'i' species

N = Total number of individuals in the sample.

3.6.2 Species dominance (Simpson's Index): The species dominance is estimated by using Simpson's index of dominance. It is suggested that the diversity was inversely related to the probability that two individual picked up at random belong to the same species. (Krebs, 1988)

Simpson's Dominance, $\mathbf{D = \Sigma\ (P_i)^2}$

Where P_i = Proportion of species 'i' in the community

3.6.3 Species evenness Index (Pielou, 1996): Evenness index give an idea about the evenness in the species distribution. E approach to '0' as single species become more dominant and this value increases when species become more evenly distributed. It is calculated by.

$$E = H' / \ln(S)$$

Where, H' = Shannon's index

S = Species richness (Total number of species)

3.6.4 Other parameters (Sameer Ali, *et al*., 2007)

1. **Density** $\frac{\text{Number of species A}}{\text{Area sampled } (m^2)}$ (Elzinga et al, 2001)

2. **Relative density** $\frac{\text{Number of species A} \times 100}{\text{Total density of all species}}$

3. **Dominance** $\frac{\text{Basal area of a species A}}{\text{Area sampled } (m^2)}$

4 **Relative dominance** $\frac{\text{Dominance of a species A} \times 100}{\text{Total Dominance of all species}}$

5 **Frequency** $\frac{\text{Number of quadrats with species A}}{\text{Total number of quadrats sampled}}$

6. **Relative frequency** $\frac{\text{Frequency of species A} \times 100}{\text{Total frequency of all species}}$

3.6.5 Importance Value Index (IVI): Importance Value Index is a significant parameter in any ecological assessment. It is an indicator of ecological success of the species. IVI was calculated according to Curtis and Macintosh (1951) and the formula is given below.

IVI = Relative density + Relative dominance + Relative frequency.

4. RESULTS AND DISCUSSION

4.1 Kathalekan- Glimpses of Ecological History

Western Ghats, one of the richest centers of biodiversity on the earth is also one of the most threatened regions due to high degree of anthropogenic influents. Any plans for conservation, utilization and management of the bio-recourses here have to take in the account the historical background of the region with respect to human impact. According to Dargavel (1988), the history of forests in tropical Asia raises the great question of development and environment in their most acute and urgent form. These ecologically richest forests are also home for forest dwelling communities; there are rapidly growing population, transmigration, forest clearing, destructive logging and environmental degradation. This necessitates appropriate forest management strategies to ensure sustainability of these ecologically fragile forests.

4.1.1 Agricultural colonization and alteration of primary forest: The early human caused vegetation change in the Western Ghats probably date back to a period of agri-pastoralism during the Neolithic or New stone Age in the Deccan (5000-3000 years BP). Forests were systematically cleared during the Megalithic period (3000-2000 years BP) when the west coast was rather intensely settled. Iron implements introduced during this period would help forest clearance, especially for shifting cultivation. Hallur, on the bank of Thungabhadra River, in the Haveri district close to Siddapur-Sirsi taluk of Uttara Kannada witnessed the first iron implement in South India (Chandran, 1997). Palynological study by Caratini *et al*. (2001) shows that there was a decline in pollen from forest tree species and increase in savanna pollen during the middle of fourth millennium BP. Although this was argued to be the result of climatic charge towards aridity in the Indian sub-continent, Chandran (1997) attributes the increase in savanna plants to the introduction of agriculture in the forest area after slashing and burning of vegetation. In fact Caratini's Palynological study showed the occurrence of *Dipterocarpus* as north as the Karwar. The very presence in good number of this hygrophilous tree species in the *kan* sacred groves such as Karikan and Kathalekan in

Honnavar and Siddapur taluk respectively to this day, clearly indicates that it could have been clearance of forest by human and not climatic change that increased savanna species such as grasses. Not only *Dipterocarpus* even Myristica swamp are associated with some of the sacred *kans*.

4.1.2 Shifting cultivation in the Western Ghats: Shifting cultivation was one of the earliest forms of agriculture in the Western Ghats. The shifting cultivators seem to have normally occupied a zone below 1000 m (Bourdillon, 1893), perhaps avoiding the colder and wind-swept heights. Thin human population and long fallows often permitted the return of the forest (Cleghorn, 1891 and Bourdillon, 1893). Shifting cultivation in the humid hill tops and slopes had its own implication. The exposed soil of tropical regions is fragile, being prone to severe erosion and loss of fertility. Shifting cultivation was a major form of land use in the Western Ghats including the study area. Francis Buchanan made a study on the traditional land use in the Western Ghats in 1801 by touring in to Malabar and Canara region. At Gokarna in Uttara Kannada he found records of 1450s relating to tax on shifting cultivation. Coastal hills of Uttara Kannada were formed to terraces for cultivation of gingelly and black gram. In the interior hills in the first season after burning the woods, were sown ragi (*Eleucine coracana*), red gram (*Cajanus cajan*), and castor (*Ricinus communis*). Next year on the same ground was raised a crop of shammy (*Panicum sumatrense*) (Buchanan, 1870). The tribals of Travancore hills planted rice, cowpea, gingelly, tapioca, yams, cucurbits, brinjal, chilly and plantain with cleared forest patches (Bourdillon, 1893). The shifting cultivation evolved as a form of land use to circumvent major problems of tropical agriculture like soil erosion, low nutrient status and pest pressures. Slashing and burning through the millennia could be one of the major reasons for the decline of primary forest and it leading to the formation of large tracts of secondary forests and savanna. ‘Kumri’, ‘hakkal’, etc were the vernacular names for such cultivation practices. By the close of 19^{th} century the British rulers banned such cultivation and since then secondary deciduous forest started turning evergreen as role of fire as an ecological factor diminished considerably (Chandran, 1993).

4.1.3 Conservation by pre-colonial farmers: A variety of regulatory measures has been an integral part of utilization of biological resources by most human societies. Such measures have ranged over quotas as to how much material is harvested, restriction of harvests to certain season or life history stages, restriction on harvesting techniques employed, to complete protection to certain biological communities in areas set aside as refugia (Gadgil and Berkes, 1991). The shifting cultivation on the hill tops and slopes by clearance of the primary forest caused inevitable loss of species rich evergreen forest. It also meant impoverishment of the resource base which would have prompted these early peasants to leave untouched patches of evergreen forests in the vicinity of their settlement. These distinct forest block locally known as *kans*, are present in hundreds even today in Uttara Kannada and neighboring districts (Chandran and Gadgil, 1993). Regionally these sacred *kans* are known as Devarakadus (Coorg), Kavu (Kerala), etc. These *kan* forests were the early centers of folk worship. Activities like extraction of forest products were restricted by local taboos. In some area these taboos continue to this day and the groves represent relics of the erstwhile forest and Kan centered culture continues although in a diminished form.

4.1.4 Significance of kan forest in traditional land use management: The kans probably date back to an ancient era of nature worship by primitive societies and therefore are of high biological significance. In Uttara Kannada of pre British period, kans existed with the ordinary supply forests and cultivation fallows creating greater landscape heterogeneity favourable also for richness of wildlife including corridors, edges and various land features which support the wildlife richness. The traditional land use and resource management systems underwent radical changes in the course of 19th century with the state claiming the common property resource like forests grazing and even shifting cultivation lands (Chandran, 1993). The goods and services provided by kan forests in the traditional land use system were many. *The kans* acted as local centers of biodiversity, and as a green belt preventing fire, providing good water shed value and also various non timber products of subsistence value. Pepper that was exported once in large scale from Uttara Kannada was mainly a product of *kans.*

4.1.4.1 *Kans- a local center of biodiversity*: *Kans* have been protected through generation on account of sacredness and they functioned literally safety forests. *Kans* promoted good biodiversity because they were preserved pieces of primeval nature. Their forming a mosaic with the adjoining forest, and other landscape elements created heterogeneity. Landscape ecology stresses the high positive correlation between landscape heterogeneity and biodiversity. Such a landscape contains an extensive amount of edge habitat with edge species and also animals that use more than one ecosystem in close proximity, say for breeding, feeding and resting (Forman and Gordon, 1986). Spatial extent of *Kans* ranging from part of a hectare to few hundred hectares and protected from time immemorial, may be considered as the best samples of climax forest of the region. Even the smaller sacred groves often harbour some old and magnificent specimens of the trees and climbers (Chandran and Gadgil, 1993; Gadgil and Vartak (1975). In the *kan* forest there exists a favourable climatic condition without any considerable changes. This matters for the rich assemblage of flora and fauna in such forest. Many of the individuals are endemic and rare in the area. Wingate (1888), the forest settlement officer of Uttara Kannada, noted that the *kans* were of "great economic and climatic importance. They favour the existence of springs, and perennial streams, and generally indicate the proximity of valuable spice gardens, which derive from them both shade and moisture". Among the rare evergreen trees found in *kan* forests were *Dipterocarpus indicus, Mesua ferrea, Vateria indica, Palaquium ellipticum* etc. The *kan* forest is found to be a seed bank for numerous species, ideally helping forest regeneration. These sacred groves also often serve to this day as the last refugia for many arboreal birds and mammals and no doubt for other forest loving animals as well. (Chandran and Gadgil, 1993).

4.1.4.2 *Watershed value*: Sacred groves act as microwater shed in local areas. The sacred groves are always associated with a fresh water ecosystem used to trap and collect the rain water for the local water supply. If they are destroyed or disrupted the water cycle would be interrupted. Heavy canopy and undergrowth along with the litter of the sacred groves is helpful in reducing the impact of rain drops directly falling on the earth surface (Pushpangadan et al 1998). This reduces soil erosion and helps in recharging of ground water table by enhancing filtration. The Government of Bombay (1923) highlighted the water shed value of the kans of Uttara Kannada as "Throughout the area, both in Sirsi and Siddapur, there are few tanks and few deep wells and the people depend much on springs…In the midst of heavy evergreen forest during the dry season the flow of water from any spring continues, even though no rain water not fallen for several months…"

4.1.4.3 ***Fire proof system:*** The evergreen forest patches of sacred groves usually form a green fire proof barrier. If there is any incidence of fire in the forest, this evergreen forest act as fire proof system and halts the spread of fire into the other forest patches, human settlement and cultivation.

4.1.4.4 ***Subsistence***: Kan forests once supplemented the major livelihood of local communities who depended on the non wood products for subsistence and sale. *Kans* harboured till today have plants which are economically and medicinally important. Their produce included edible fruit from trees like *Mangifera indica, Artocarpus heterophyllus, A. hirsutus, Garcinia indica, Syzigium cumini*, etc. *Kans* were once important centers of black pepper (Piper nigrum) that was major export commodity. *Myristica malabarica*, *Murraya koenigii, Garcinia cambogea, and G. indica, and* honey were important products that people harvested from *kans.* Toddy tapping from the palm *Caryota urens* was a major occupation of 'Kan Divars'. Many medicinal plants and resources such as *Pandanus Ochlandra, Calamus etc.* widely used for mat weaving were found in the *kans*.

4.1.5 British colonization and Forest reservation: The British domination of the Western Ghats began early in 19th century. The traditional management of the forest didn't impress them. Madras Government banned the shifting cultivation in 1860 and in Uttara Kannada the Govt of Bombay banned it late in the 19th century. Only little land area was allotted to the habitual shifting cultivators like Kunbis and Marattis in few places (Chandran, 1997). In the early stage of British forestry, concentration was mainly on deciduous timbers like teak. The ban on shifting cultivation minimized fire as an ecological factor. This promoted the recovery of evergreens and regeneration of teak was reduced under the evergreens. Due to the increased demand for teak wood, the foresters started teak monoculture in the Western Ghats by massive clearance of the evergreens causing intensive vegetational changes in the Western Ghats. (Dixit, 1985; Gadgil and Chandran, 1989). The State domination over the forest resulted in the local community losing the hold over their sacred *kans*. Under the Indian Forest Act 1878, most *kans* came under state control. The people were prohibited from collecting forest products except some dry fuel wood as in eastern part of Sirsi and Siddapur (Govt. of Bombay, 1923). In the higher altitude forest the state policy was to promote commercial cultivations like, coffee, tea, wattle and Eucalyptus. The spurt in commercialization of natural resources and commodity production also attracted an exodus of migrant laborers with overall serious ecological consequence on the biota (Prabhakar, 1994). The forest reservation resulted in many of the *kans* losing their special identity and got merged with the secondary forests.

4.1.6 Industrial exploitation of the forest: In the early 1940's, during the Second World War opportunistic felling of both deciduous and evergreen timbers had happened due to the relaxation of the exploitable girth of many plants (Gadgil and Chandran, 1989). The expansion of railway net work and escalating demand for industrial timber were too taxing on Western Ghats forest. During the 1940's *Dipterocarpus indicus*, found sheltered in some of the kans, was supplied to the railways and plywood company (Shanmukhappa, 1977). A working plan for the forests of Sirsi and Siddapur brought under it, 73 kans also totaling an area of over 4000 hectares, for felling of industrial timber (Shanmukhappa, 1966). Gadgil and Chandran (1989) who documented the environmental impact of forest based industries in Uttara Kannada point out the industrial sector became more influential and dominant during 1950's and selective felling of trees in the evergreen forest reached peak in 1960's to 1980's period. The timber exploitation in the evergreen forest severely affects the equilibrium of the forest ecosystem. The selective felling of large trees created many canopy gaps in the forest with tumultuous effect on the evergreen forest ecosystem as a whole, adversely affecting the faunal species also. Logging affect the ground layer vegetation also and promoting weeds and heliophilous commonplace pioneer species. Felling of trees having large canopy cover always created vast opened area. Tolerant deciduous species are more promoted in such open area as the seeds of evergreen species are more sensitive to the sunlight and could not survive in such condition in the intense light. In many cases, large scale logging resulted in the deterioration of microclimatic conditions and also resulted in soil erosion.

4.1.7 Recovery of the forest: Logging in the evergreen forest was banned in 1986 (Gadgil and Guha, 1992), resulting in the reduction of disturbances in the forest, favouring the recovery of forests in the logged area. During the current study, it was noticed that due to the stoppage of industrial logging (about two decades past), the forest are on the road to recovery.

4.1.8 Kathlekan - a sacred grove: Kathalekan is considered to be a *kan* forest in the central Western Ghats. It is a patch of evergreen forest blessed with rich diversity of flora and fauna and good number of them are endemic to Western Ghats. A preliminary survey of the region reveals some glimpses of the ecological history of the forest. The landscape element of the forest reflects the passage of forest history. The elements documented are dense evergreen forest, grass land, streams and swamps, rocky formation, agricultural and human settlement area, etc. There are many canopy gaps here, which are yet to close fully. On the whole large emergent trees are lesser in number, however there is a profusion of young growth in the forest floor. Young evergreen tree of different species are found competing with each other to come up in the canopy gaps. Savannas on some of the hill slopes (is grid nos.5, 7, 8, and 9) were under shifting cultivation (kumri) and one bears the epithet 'Seven year kumri (meaning seven year shifting cultivation cycle). Forest from the valleys was found advancing towards summit of these grassland covered hills in Kathlekan and its adjoining areas. Pioneer colonising shrub and trees was found as the forerunners of vegetational re-establishment followed by late successional species and climax species such as *Dipterocarpus indicus* and *Syzygium gardneri*. These constitute a good part of Kathalekan, especially in the valleys. Kathalekan was a sacred grove (*Kan*) because of the following reasons:

- The presence of less modified forest elements such as Myristica swamps and there adjoining areas rich in southern endemic climax species such as *Dipterocarpus* *indicus, Palaquium ellipticum, Semicarpus kathlekanensis, Pinanga dicksonii, Mesua ferrea, Cyathea nilagirica* (tree fern*), etc.*

- Part of the swamps near to a woodland deity (in grid no 8) is still being worshipped by few families form adjoining villages.
- In spite of the Bangalore road passing through almost the heart of Kathlekan the roadside forest itself has the look of primeval forest, true to its name 'Kathale-*kan'* that means 'dark sacred grove'.

4.2 Species Composition of the *Kan* Forest

Species composition is regarded as an identity of every community. Deciphering of the species composition pertaining to a particular community is the crucial procedure in any ecological inventorying. In this endeavor species composition of a *kan* forest, Kathalekan of 2.25 km^2 area was studied. Nine transects with 45 quadrats covering an area of 1.8 ha were laid, which provide a good profile of the forest. This profile unveils the species composition of Kathlekan and ecosystem value specially as a *kan* forest, a refugia of vast variety of species, mainly Western Ghat endemics, several of them being RET species. The forest may be considered as a relic of the primary forest of the Western Ghats. Sampling was done in both tree layer and ground layer (shrub/herb layer), as mentioned in the methodology. Number of species in tree, shrubs and herb layers encountered during the field survey are listed in Table 4.2.1. Altogether 185 species, 109 trees, 39 shrubs, 12 herbs and 25 of climbers were documented from transects. In the 104 species of tree layer species having GBH ≥30 cm, were 99 species of trees 5 of lianas. Saplings of 80 species of trees dominated the shrub layer. Shrubs constituted only 34 species and 3 were tall herbs. The 17 species of climbers included young lianas and herbaceous climbers. In the study area, out of 100 sp in the herb layer only 11 were herbs. Poverty of herbs in the ground layer in rain forests have been found generally, which can be attributed to the presence of good canopy casting its shade on to forest floor.

Tab: 4.2.1 No. of species in tree and ground layers of Kathlekan.

Layer	Sampled area(ha)	Total species	Tree species	Shrub species	Herb species	Climbers/ Liana
Tree layer	1.8	104	99	Nil	Nil	5
Shrub layer*	0.225	134	80	34	3	17
Herb layer**	0.009	100	63	20	11	6

* includes shrubs and saplings of trees < 30 cm girth and > 1m height
** Includes juveniles of trees. Shrubs and climbers < 1 m height.

The entire study area was dominated by evergreen tree species with good canopy covering that checks light filtration in to the forest floor substantially. Understandably various microclimatic conditions are changed also favouring survival of mostly climax species. It was only in disturbed areas, canopy gaps and forest edges herbs and shrubs are able to proliferate. The occurrence of many tree species in all the vertical layers indicates that the forest has attained climax state. Examples of such climax tree species are *Dipterocarpus indicus, Hopea ponga, Holigarna grahamii, Syzygium Gardneri, Knema attenuata, Palaquium ellipticum etc*.

4.2.1 Sampling effort: Species area curve of total sampled area of 1.8 ha (by pooling together nine transect cum quadrats each form a grid of 500×500m) given in Figure 4.2.1. The curve reaches near saturation with the addition of 7th grid sample.

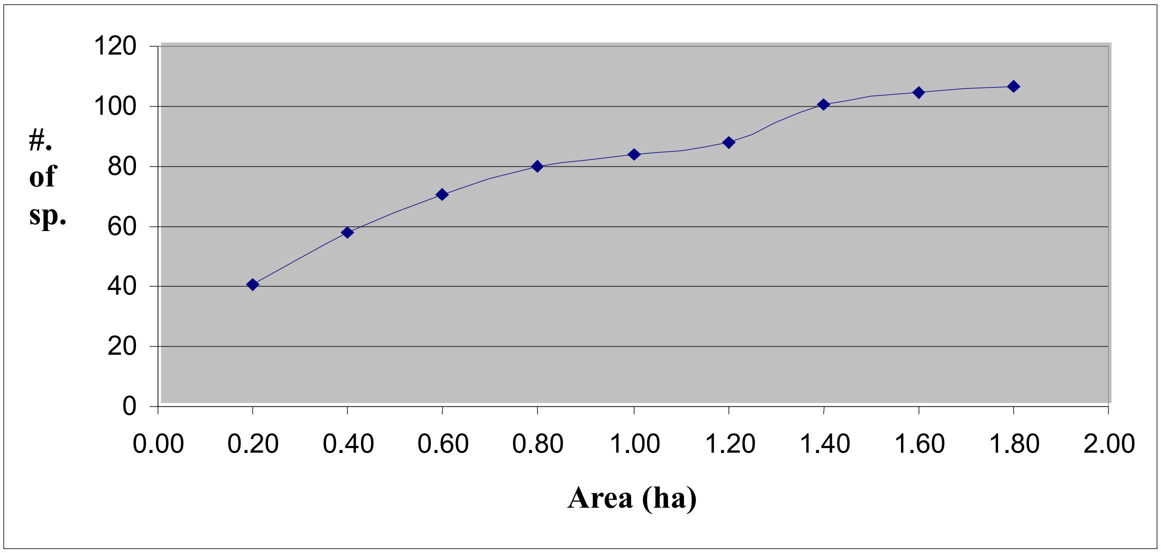

Figure 4.2.1: Species area curve for the trees in 9 grids of Kathalekan

It has been argued that the productivity of the system and structural complexity or heterogeneity determine species richness in the community (Brown 1981). However neither ecosystem productivity nor structural complexities seem sufficient on their own to explain the observed pattern of species richness (Putman, 1994). Slobodkin and Sanders (1969) opined that species richness of any community is a function of severity, variability and predictability of the environment in which it develops. Therefore, diversity tends to increase as the environment becomes more favorable and more predictable (Putman 1994). In the sacred groves it seems that the favorable climatic conditions of the area and protection over a long period of time have played a major role in making these forest patches highly complex and species-rich (Upadhaaya, et al, 2003). Obviously favourable conditions such as good rainfall, undisturbed soil with much moisture content and an excellent litter cover, have also benefited Kathalekan ecosystem.

4.2.2 Familywise species distribution: Table 4.2.2 lists family wise number of species found in the sampled area. The 185 species found during sampling (excluding fully unidentified species) belong to 51 families and about 135 genera of flowering plants, (Table 4.2.2)

Table 4.2.2: Family wise species distribution

Sl.No	Family	No. of genera	No. of species
1	Euphorbiaceae	16	21
2	Lauraceae	8	12
3	Rubiaceae	8	12
4	Myrtaceae	1	7
5	Annonaceae	5	6
6	Celastraceae	5	6
7	Rutaceae	6	6
8	Clusiaceae	3	5
9	Ebenaceae	1	5
10	Flacourtiaceae	3	5
11	Myristicaceae	3	5
12	Zingiberaceae	4	5
13	Anacardiaceae	3	4
14	Arecaceae	4	5
15	Meliaceae	2	4
16	Rhamnaceae	4	4
17	Acanthaceae	3	3
18	Moraceae	2	3
19	Poaceae	3	3
20	Smilacaceae	2	3
21	Araceae	2	2
22	Combretaceae	2	2
23	Dioscoriaceae	2	2
24	Dipterocarpaceae	2	2
25	Icacinaceae	2	2
26	Loganaceae	2	2
27	Oleaceae	2	2
28	Sapindaceae	2	2
29	Sapotaceae	2	2
30	Verbenaceae	2	2
31	Agavaceae	1	1
32	Ancistrocladaceae	1	1
33	Apocynaceae	1	1
34	Asclepiadaceae	1	1
35	Burseraceae	1	1
36	Capparaceae	1	1
37	Connaraceae	1	1
38	Cornaceae	1	1
39	Cyperaceae	1	1
40	Datiscaceae	1	1

41	Dichapetalaceae	1	1
42	Elaeocarpaceae	1	1
43	Fabaceae	1	1
44	Faboidae	1	1
45	Gnetaceae	1	1
46	Lecythidaceae	1	1
47	Leeaceae	1	1
48	Lythraceae	1	1
49	Malvaceae	1	1
50	Melastomaceae	1	1
51	Menispermaceae	1	1
52	Pandanaceae	1	1
53	Piperaceae	1	1
54	Rhizophoraceae	1	1
55	Sterculiaceae	1	1
56	Symplocaceae	1	1
57	Tiliaceae	1	1
58	Ulmaceae	1	1
59	Vitaceae	1	1

Euphorbiaceae dominated with 16 genera and 21 species having representation among trees, shrubs and herbs. It was followed by Rubiaceae and Lauraceae each having 8 genera and 12 species each. Rutaceae (6 genera, 6 species), Celastraceae and Annonaceae (5 genera and 6 species), Zingiberaceae and Arecaceae (4 genera and 5 species), Rhamnaceae (4 genera and 4 species each) are the other notable families enclosing more individuals. There are 28 families represented only by single species. However the genus *Syzygium* of Myrtaceae were found with 7 species.

4.2.3 Tree composition: As mentioned earlier within the study area 109 tree species (including 10 unidentified species) were recorded. The tree species recorded here belonged to 34 families with 71 genera and 99 species (about 10 unidentified excluded) .Among the families more number of genera was recorded in Euphorbiaceae, with 10 genera followed by Lauraceae (8). Anacardiaceae, Annonaceae, Celastraceae, Clusiaceae, Flacourtiaceae, Myristicaceae, and Rubiaceae having (3 each). Euphorbiaceae was leading in species no. too and Lauraceae with (12) followed by Myrtaceae (7), Ebenaceae, Myristicaceae and Clusiaceae (5 each), Anacardiaceae, Celastraceae, Meliaceae had 4 species each and some families were represented by only one species.

Among them species like *Hopea ponga, Dipterocarpus indicus, Holigarna grahamii, Knema attenuata, Syzigium sp, Aglaia roxburghiana* have more frequent distribution in almost every grid studied, followed by *Olea dioica, Syzygium gardneri Dimocarpus longan*, *Calophyllum tomentosum*, *Garcinia talbotii*, P*alaquium ellipticum, Actinodaphne hookeri, Diospyros candolleana, Litsea sp.* etc. Regarding the no. of individuals per species *Hopea ponga* is coming in first place with 208 individuals in the sampled area, followed by *Dipterocarpus indicus* (120), *Olea dioica* (98), *Knema attenuata* (87), *Holigarna grahamii* (67), *Aglaia roxburghiana* (52), *Syzygium gardneri* (45), *Dimocarpus longan* (43). One of the striking features noticed here is the gregarious occurrence of *Dipterocarpus indicus,* a climax species. This indicates the primary nature of the forest. In the present study in Kathalekan, 120 *Dipterocarpus* trees were recorded from the totaled sampled area of 1.8 ha. Kathalekan is the northern limit of occurrence of this species in addition to Karikan in to the adjoining Honnavar taluk. In Karikan, a sacred forest, close to the shrine of the forest deity the same species occurs in abundance almost like a primeval forest. Chandran, (1993) recorded in a one ha plot of Karikan, 151 trees, of which 18 were reported to be 200 years old.

4.2.4 Shrub composition: The shrubs belonged to 39 species and 22 families. Euphorbiaceae dominated here too with 5 genera and 6 species. It was followed by Rubiacaeae with 3 genera and 7 species, then Rutaceae, Rhamnaceae, Celastraceae and Icacinaceae having 2 genera and 2 species each and others having one each. *Dichapetalum gelonioides* with 160 individuals was the most populous shrub and was found in all the grids. The gregarious occurrence *Pinanga dicksonii* a slender endemic under growth palm is one of the noticeable features of Kathlekan shrub layer. The abundance of this species in most of the grids indicates rich moisture content in the soil. *Psychotria flavida, Memecylon terminale, Glycosmis pentaphylla*, etc. are the other species having more abundance. The shrubs like *Nothapodytes foetida, Microtopis wallichiana, Hibiscus furcatus*, etc were represented by only one individual each in the sampled area.

4.2.5 Herb composition: Dense evergreen forests are known for poverty of herbs. This study vindicates same scenario. Only 12 species of herbs were recorded from the forest floor. These belonged to 7 families and 10 genera. Among the families Zingiberaceae dominated with 3 genera and 4 species followed by Acanthaceae with 2 genera and 2 species. Cyperaceae, Rubiacaeae, Araceae Poaceae and Agavaceae, had single genera and single species only. *Alpinia malaccensis, Boesenbergia pulcherrima, Cyrtococcum oxyphyllum, Dracaena terniflora, Justicia simplex, Lagenandra ovata, Ophiorrhiza hirsutula, Rungia pectinata* were among the species. However forest edges receiving more light had greater number of herbs. In the short duration of this study the edge herbs and seasonal herbs could not be recorded. No special studies were also made of epiphytes.

4.2.6 Lianas and herbaceous climbers: Lianas and climbers are the plants which rooted in ground but for climbing they need a mechanical support of neighboring tree for climbing. Woody climbers are generally described as lianas. They have an important role in the scheming of the forest structure. Except few (5) unidentified species, the lianas and climbers present in the study area is represented by total of 20 species belong to 20 families including Annonaceae, Menispermaceae, Rutaceae, Ancistrocladaceae, Gnetaceae, Loganaceae, Rhamnaceae, Piperaceae, Arecaceae etc, among them Rutaceae is predominating with 2 genera and 2 species followed by Smilacaceae and Arecaceae with one genera and two species and all other families having one genera and one species each., Wild pepper (*Piper spp*), *Pothos* are commonly associated with forest trees. They act as indicator species because they are very sensitive to canopy opening. Pepper was one of the important species obtained ones mainly from the Kans of the Uttara Kannada. Wild pepper was taken care of in the *kans* by local villagers during pre British period (Chandran and Gadgil 1993). *Calamus thwaitesii* and *Calamus sp*. also have good number of individuals. Although this spiny climber indicates the disturbances in the forest by human interferences or cattle grazing (Pascal, 1988), moderate presence is characteristic of the undisturbed evergreen. *Ancistrocladus heyneanus, Ventilago madraspatana, Combretum latifolium, Smilax zeylanica, Strychnos sp*. etc are other important climbers noticed. The climbers occur abundantly in disturbed area and especially in canopy openings.

4.2.7 Species heterogeneity (diversity, dominance and evenness) among trees: Species heterogeneity gives a measure of community organization related to how the relative abundance varies among the different species in the community. This is estimated on the basis of diversity, dominance and evenness of the species in a community. For the diversity measurement most commonly used Shannon index (H') is adopted and Simpson index is used for dominance and for evenness Pielou index is also calculated. High value of H' indicates a large number of species with similar abundances, a low value indicates domination by few species. Lower value of Simpson's dominance indicates the higher diversity and high evenness in the distribution. In these instances the Pielou index is higher. The grid wise result is presented in the Table 4.2.3 along with pooled result for the entire study area.

Tab 4.2.3 Diversity, dominance and evenness indices for trees

Sl.No	Grid	Total individual	Total species	Shannon diversity	Simpson's Dominance	Pielou evenness
1	GI	143	41	3.39	0.043	0.91
2	G2	173	39	3.18	0.060	0.87
3	G3	104	37	3.42	0.038	0.95
4	G4	129	38	3.12	0.069	0.86
5	G5	158	39	3.16	0.065	0.86
6	G6	165	23	2.39	0.140	0.76
7	G7	141	44	3.36	0.05	0.89
8	G8	113	34	2.91	0.10	0.82
9	G9	186	18	1.77	0.318	0.61
10	**Pooled**	**1312**	**104**	**3.58**	**0.05**	**0.77**

4.7.1 Species diversity for trees: The Shannon index of diversity for the area was 3.58, which is fairly good for the forest. The result indicates the existence of good diversity in the forest. These results are found to be in accordance with the diversity of various other

Kan forests in the Sirsi Forest division, of Uttara Kannada, (Devar,2008).The diversity in the sacred groves of Kerala (3.1-3.6) estimated by Rajendraprasad (1995) also matches with that of Kathlekan.

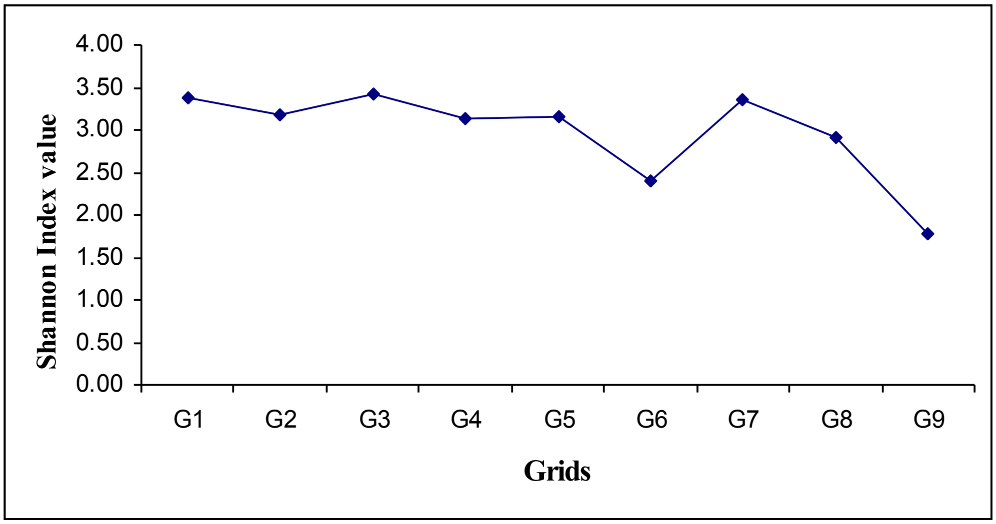

Fig 4.2.2 Shannon index for the 9 grids

From the Fig (4.2.2) it is clear that diversity is varying from the value of 1.77 to 3.42 across transects. The highest diversity is present in Grid 3 and the Grid 9 having lower diversity followed by Grid 6. In other grids diversity is more or less comparable. This can explained with Dominance and Evenness of species.

4.7.2 Species dominance and evenness: Dominance and diversity are inversely proportional to each other. It points out the consistency of a species in a community. For both these parameters the values lie between 0-1. In general, Simpson Diversity estimated in Kathlekan is 0.05 with evenness (Pielou index) value of 0.77. This result reflects that species are distributed uniformly with very least dominance. This matters for the persistence of high diversity in the forest. Figure 4.2.3 illustrates a grid wise analysis of these parameters.

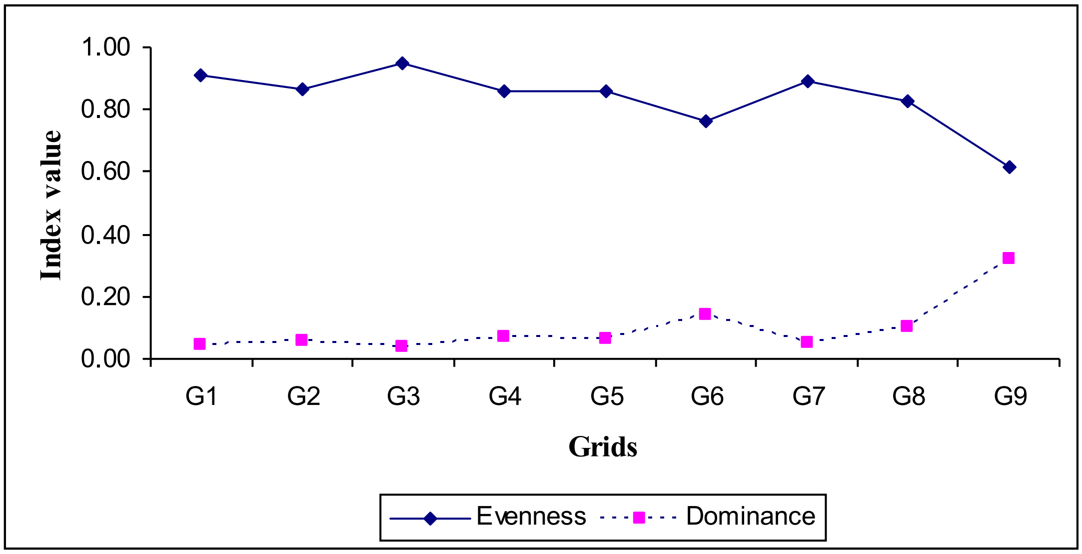

Fig. 4.2.3 Evenness and Dominance in the tree community of Kathlekan

Figure 4.2.3 depicts the dominance and evenness of the vegetation. Grid 3 is found to be more diverse and species are distributed more evenly with less dominance. This part having rocky formation, leading to the deep gorge of Sharavathi River, has micro-heterogeneity and therefore good number of species and more evenness Compared to other area this is not much explored. The evenness sharply declines in the grid 6 (less species richness - 23 species) due to domination of few species. Even though there is a higher abundance of species, grid 9 has least diversity. This grid also merges with the deep gorge of a river. Gregarious occurrence of *Hopea ponga,* which is more adapted to the edges having good mechanical resistance against wind because of its fibrous wood. In effect, the flourishing of such species in these areas provides shelter to more sensitive species. *Olea dioica* follows closely in number having more abundance here.

4.3 Landscape Elements and Vegetation

Documenting the flora of a region provides the complete range of plant species there. The vegetation consists of assemblage of plant species forming a green mantle, an almost continuous and conspicuous plant cover over the land surface with the deserts and rocky surfaces being exceptions. The units of vegetation are the individual plant species composition, structure, physiognomy, spatial patterns, temporal patterns are the variable properties of the vegetation. (Chandran, 1993). Vegetation structure for ecological purposes is considered at a number of levels. Physiognomy (for example height), floristic (species richness and composition), stratification (layering of different types of plants on height characteristics), life forms (trees, shrubs, etc) distribution and abundance of species are some of the structural variables usually considered (Puri et al, 1983; Causton, 1988; Mac Nally.1989).

4.3.1 Landscape elements: A landscape is a panoramic view that one can get form a high place and usually is a composite of various units called elements. These elements of landscape may incorporate water bodies as well. Landscape ecology stresses the high correlation between landscape heterogeneity and biodiversity (Forman and Gordon, 1986). Figure 3.2 portrays the elements that compose the landscape of Kathalekan, which include:

i) ***Evergreen forest***: Most of Kathalekan is dominated by evergreen species.
ii) ***Streams and swamps:*** The landscape is traversed by a network of streams. Some of the streams are perennial (as in grids 1, 2, 4, 5, and 7). Seasonal streams are found in all grids. Streams that run through flat valleys turn sluggish, and swampy. Such swamps are found in grids 2, 5, 7 and 8. The streams are overtopped by the evergreen forests itself. The stream beds and edges have species like *Homonoia riparia*, *Phyllanthus spp., Blachia denudata, Ochlandra spp., Pandanus canarana, Pinanga dicksonii, Elaeocarpus tuberculatus, Calamus spp., Arenga wightii*, etc. Thallus like growth of Podostemonaceae is found firmly adhering stream rocks. The swamps dominated specially by the members of Myristicaceae are described

separately in chapter 4.5. Apparently some of the extensive areas under swamps have been reclaimed for agriculture in grids 4 and 8. Bunding of streams and diversion of their ways to agricultural area are threatening factors for characteristic swamp species

iii) ***Savanna and rocky formations***: Savannas in Indian subcontinent are believed to be formations derived from woodland ecosystem through variety of human interventions (Gadgil and Meher-Homji, 1986). Savannization in Kathalekan was apparently due to kumri cultivation (a form of shifting cultivation in the hill tops and slopes) in the past by agri-pastoralists. Forests were slashed and burned in patches and abandoned after cultivating for one or two years. After a fallow period of varied no. of years the Kumri cycle was repeated. The British stopped this cultivation on Uttara Kannada by close of 19^{th} century giving a chance for forest recovery (Chandran, 2003). In Kathalekan savanna in grid 2 and 4 even now has known to the locals as 7 years Kumri area. The slashing and burning wipe out the soil fertility and drastically change the microclimatic condition. Repeated burning of the forest can create grasslands. A vegetational study of savanna in Kathalekan is given in this chapter.

iv) ***Agriculture / horticulture***: Valleys with perennial water sources have always been targeted in the Western Ghats for cultivation. At present in Kathalekan two such cultivation areas have been located. The large one (Grid 4) has an area of about 2 ha. and the smaller one in grid 8, has an area of 1 ha. The crops grown are mainly arecanut, banana, pepper, vegetable, paddy and some fruit trees.

v) ***Road***: The Honnavar – Bangalore road passes through Grids 1, 4 and 8. The road has increased the forest edge and paved the way for many light loving edge species such as *Carvia callosa, Strobilanthus sp., Callicarpa, Lea indica, Ficus* sp., *Glochidion* sp., *Actinodaphne hookeri, Calycopteris floribounda, Calamus* sp., *Combretum* etc,. Many grasses and herbs are also characteristic of the roadside vegetatation. The weed *Chromolaena odorata* is found to grow prolifically in many places.

4.3.1 Evergreenness of the Forest: The forest of Kathalekan is dominated by evergreen trees. Almost 97.3% of total trees recorded are evergreens and hence this forest is considered as high evergreen forest. This forest was maintained as a *kan* forest, since time immemorial. The word '*kan*' appended to the forest (Kathalekan means 'dark forest' in Kannada). In later times the forest came under the State forest department and lost its sacred grove status. Nevertheless some of the local people still worship the deity of the *kan* in a portion of a Myristica swamp. Despite selection felling of trees during 1940-1985 periods the *kan* continues to be of heavy evergreen in composition. Figure 4.3.1 shows that that the grid 3 has lesser percentage of evergreen trees (91%) compared to other grids, due to the presence of deciduous trees like *Terminalia paniculata*, *Tetrameles nudiflora*, *Careya arborea* etc. Nevertheless, their number is negligible in the entire forest. Deciduous species include *Terminalia paniculata, Tetrameles nudiflora, Careya arborea, Lagerstroemia microcarpa* etc.

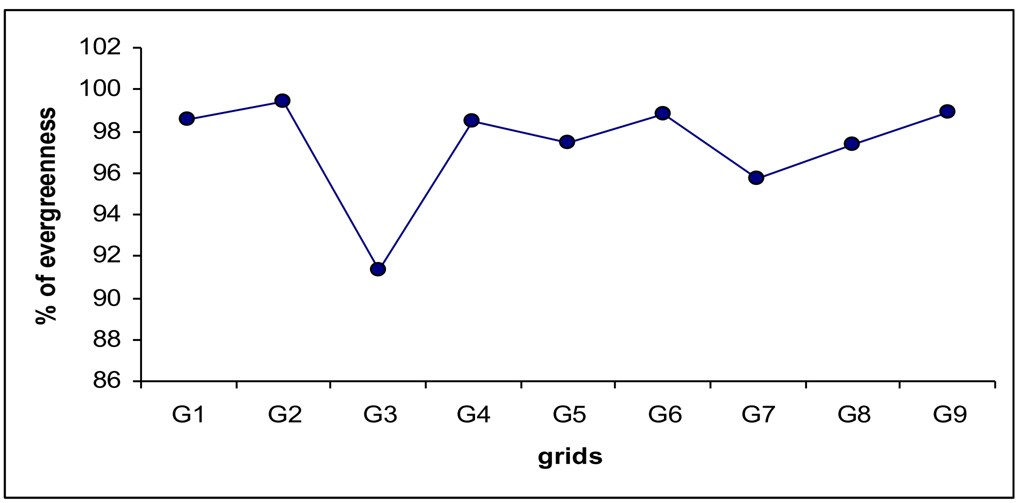

Fig. 4.3.1 Percentage of evergreenness in different grids

4.3.2 Structural features of the forest: Mainly trees determine the architecture and microclimatic conditions of the forest and hence changes in tree community may strongly affect the other ecological processes (Didham et al, 1996). It is very hard to get a natural vertical stratification of the forest patch. The human interferences that happened in the past in the form of selection felling during the period of 1940-1985 changed the genuine nature of the forest and its vertical stratification. Tallest trees having huge girth were extracted causing decline of emergent trees and creating large canopy gaps. This is the reason for the lower distribution of trees in the height more than 30 m. Emergent species having good timber value like *Dipterocarpus indicus*, *Calophyllum tomentosum*, *Palaquium ellipticum*, *Artocarpus hirsuta*, *Mesua ferrea* etc. had suffered a lot during especially post independence period (Gadgil and Chandran, 1989). The logging in the evergreen forest of India was banned in 1986 (Gadgil and Guha, 1992) and hence these evergreen forests are passing through a recovery phase. It is observed that those logged trees have reasonable regeneration now. Shifting cultivation in the forest also played a major role in the deterioration of the forest structure. Cutting and burning for the cultivation purpose wiped out much of the original vegetation mainly in the elevated part of the forest. Repeated burning reduces soil fertility increases soil compactness and erosion. This makes forest recovery difficult mainly in savanna lands. The savannized lands are fit for few fire resistant deciduous trees only.

In order to depict vertical stratification of the forest, the whole vegetation is assigned to different strata based on height classes. Each of the species within the community has large measure of its structural and functional individualism and has more or less different ecological amplitude (Singh and Joshi, 1979). Based on the height class distribution of tree species, three stratas have been identified in different range of height among the tree species. The ground layer vegetation constituted by shrubs, herbs and juvenile form of tree species, form the base of the stratification.

Top strata in the forest is composed of emergent trees having a height of 20 m and above. The second strata is constituted by medium height (10-20 m). Trees having the height below 10 m are included in the third strata and a very few trees have height less than 5m.

The study of Pascal (1988) in the kan patches in the Karnataka distinguished two types of formations i.e., *Diospyros spp -Dysoxylum malabaricum-Persea macrantha* type which corresponds to the Sorab region and another one the *Dipterocarpus indicus-Persea macrantha* type of the hill ranges situated to the west of Shimoga which is considered as a Kan forest. Kathalekan it found to be *Hopea ponga-Dipterocarpus indicus-Holigarna* *grahamii* type of formation. These species are more frequently distributed and having high importance value index (Table 4.3.1). The occurrence of *Dipterocarpus indicus* shows the primeval nature of the forest, as this species is absent in most of the secondary forests in Uttara Kannada and northern forests (Chandran, 1997). Its occurrence in Uttara Kannada is mainly restricted to the primary evergreen forest, mainly the *kans* (Kathalekan and Karikan (in Honnavar). The spread of *Hopea ponga* in the neighboring district of Dakshina Kannada in the last few years is striking. This evergreen species which may exceed 30 m under favourable conditions occupies regions disturbed by recent exploitations and there was a noticeable increase in its area (Pascal, 1988). The three species mentioned in the type of formation are also included in RET (IUCN) category. This draws greater attention to the forest from conservation point of view. Kathalekan is also home to *Myristica* swamp and newly discovered critically endangered tree *Semecarpus kathalekanensis* (Dasappa and Swaminath, 2000).

- ***Strata 1-Emergent trees:*** The emergent trees form uppermost layer in a forest and in Kathalekan most of them have adequate regeneration highlighting climax status. Major emergent species formed here are *Dipterocarpus indicus, Calophyllum tomentosum, Holigarna grahamii, Syzygium travancoricum, Mesua ferrea, Palaquium ellipticum, Artocarpus hirsutus, Ficus nervosa, Syzygium gardneri, Canarium strictum, Lophopetalum wightianum, Diospyros crumenata,* etc, Among them Syzigium gardneri reaches the maximum height of 40 m. Selective felling badly affected these type of trees because most of them have good timber value.
- ***Strata-2-Canopy trees:*** The plants under this category provide good canopy cover to the forest. Canopy cover is more or less continuous except in some logged area and in those exposed spot secondary species is emerging. Trees having height within the range of 10-20 m are considered as canopy trees. The species include *Symplocos racemosa, Syzigium spp., Actinodaphne hookeri, Ixora brachiata, Mangifera indica, Aglaia anamallayana Dimocarpus longan, Phobae catheae, Syzigium cumini, Antidesma menasu, Litsea spp., Garcinia talboti,*

Dimorphocalyx spp., Nothopegia colebroockiana etc. Emergent trees in this height range also provide dense canopy cover to the forest.

- ***Strata-3- trees:*** These are the smallest trees which make up the third layer in a vertical stratification profile of a forest. Trees having height below 10 m are included in this category. Trees which are habitually coming under this category are very few in number but in most samples this strata is filled by regenerating forms of the larger trees. The species like *Ervatamia heyneana, Mitrephora heyneana, Meiogyne pannosa, Syzigium laetum, Syzigium macrophylla, and Dimorphocalyx lawianus* are the frequently distributed trees within theses range.
- ***Shrubs/Herbs:*** The microclimatic condition of the forest floor is decisive in the composition of ground layer. Light intensity is a critical factor in the rain forest regime. In the dense canopied forest like Kathalekan, the light intensity is quite low favouring only shade loving shrubs and herbs and the numbers of which are limited. Grasses are nearly absent. This study uncovers a total of 38 species of shrubs and 11 species of herbs from the sampled area. There of course could some more species in the sampled area. However the juvenile forms of the trees are the major contributors to this layer. In the shrubs layer are *Agrostistachis indicus*, *Atalantia racemosa, Blachia denudata, Canthium rheedii, Dichapetalum gelonioides, Memecylon terminale, Ochlandra sp, Pinanga dicksonii, Psychotria flavida. Scutia myrtina and Strobilanthus heynianus* are the common shrubs. *Pinanga dicksonii,* a slender endemic palm that grows gregariously in association with streams, swamps and wet shaded soils. *Ochlandra sp.* also found Strobilanthus heyneanus is very common in moist semi shaded areas. It is an under growth of the forest edges advancing into savannized hill tops. *Alpinia malaccensis, Cyrtococcum oxyphyllum, Dracaena terniflora, Justicia simplex, Ophiorrhiza hirsutula, Lagenandra ovata, and Boesenbergia pulcherrima* are the main herbs of the forest floor.
- ***Climbers and Lianas:*** Climbers and lianas also have an integral role in constituting complex evergreen forest structure. They vary from slender herbaceous ones to large lianas which are literally climbing trees. Lianas like

Ancistrocladus heyneanus, Combretum latifolium, Gnetum scandens, etc. are notable among them.

- ***Palms in the undergrowth:*** Tropical forests are well known for palms. In Kathalekan few species of palms which occur are *Pinanga dicksonii, Arenga wighitii, Caryota urens . and* some species of *Calamus*. Gregarious growth of *Pinanga* in this forest indicates the high moisture content of the soil.

4.3.3 Species with root modification: Roots of many rain forest trees are known for their diverse morphology to suit their heterogeneous environment. Stilt root, pneumatophores, knee roots, floating roots flying buttresses and buttresses are the common adaptations. Buttress formation and serpentine roots are found in trees which may be considered as adaptation to wind but it is not always found in every tall tree like *Dipterocarpus indicus* (Pascal, 1988). Stilt roots furnish additional anchorage in soft soils. E.g., *Myristica fatua*, *Myristica malabarica, Syzygium gardneri*. *Gymnacranthera canarica,* a tree of Myristica swamp produces loop like pneumatophores full of large lenticels. *Semecarpus kathalekanensis*, a newly discovered critically endangered endemic tree produces knee like protrusions, studded with lenticels, which help in gaseous exchange in swampy condition. Serpentine roots of *Lophopetalum wightianum* spread over the surface of soft swampy soil and provide additional anchorage and help in root respiration. *Syzygium gardneri*, *Ficus nervosa, Elaeocarpus tuberculatus, Tetrameles nudiflora*, etc. produce large buttresses from the base of their trunks to provide additional mechanical support.

4.3.4 Height distribution: Figure 4.3.2 depicts height classes of trees (sampled in nine transects). Individuals positioned in lower class as well as in upper class are comparatively very low. Very few individual were found in the placed in the 0-5 m category composed of some small trees like *Ervatamia heyneana, Ixora brachiata* and juveniles of the larger trees. Maximum individuals (466) are in 10-14 m range. A declining trend is seen in the succeeding ranges. There are 421 individuals in 15-19m range followed by 224 and 99trees in height classes of 20-24 m and 25-29 m respectively. Only 8 individuals had height exceeding 35 m. *Syzygium gardneri* was the tallest among all. The extraction of timber during 1940-1985 periods apparently had telling effect on especially larger trees

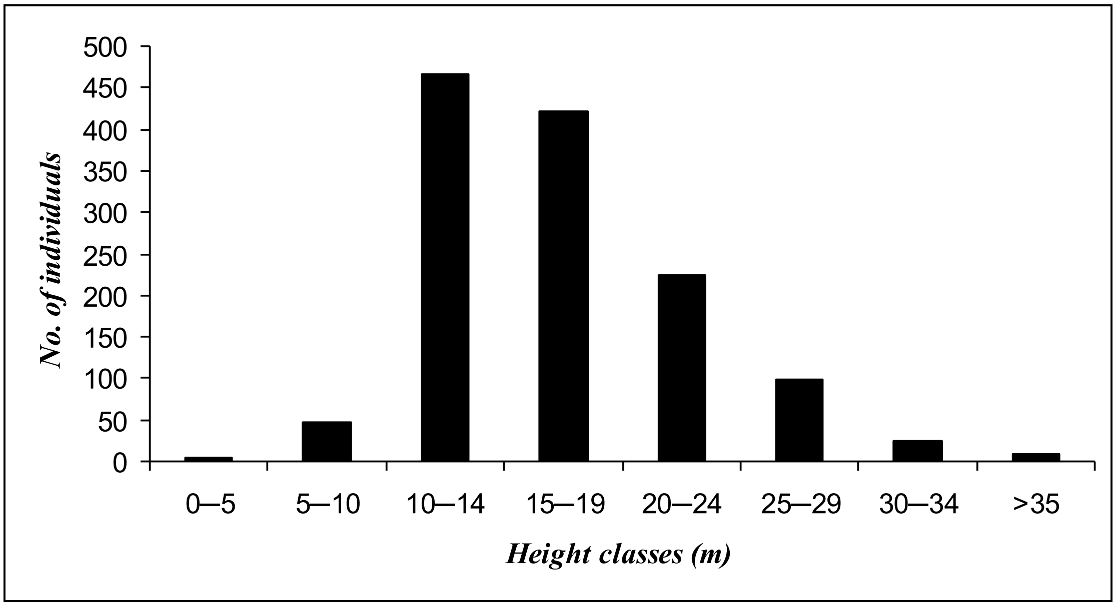

Fig. 4.3.2 Height classes of trees from 9 transects

4.3.5 Tree species density: Total trees density of Kathlekan is found to be 724 trees/ha and a total of 751 stems/ ha. *Hopea ponga* has an estimated density of 116 trees/ha. followed by *Dipterocarpus indicus* (66.7), *Olea dioica* (54.4), *Knema attenuata* (48.3), *Holigarna grahamii* (37.2), *Aglaia roxburghiana* (28.9), *Syzygium gardneri* (25), *and Dimocarpus longan* (23.9). Species like *Cinnamomum macrocarpum, Ficus callosa, Walsura trifolia*, etc having least density (only 2 individual in the sampled area) followed by *Randia rhugosa, Tetrameles nudiflora, Murraya paniculata*, etc having one individual in the sampled area.

4.3.6 Basal area: Kathlekan forest has an average basal area of 39.16 m^2/ha. (considered only trees having GBH ≥ 30 cm). Species wise basal area ranges from 0.0072 m^2/ ha to 7.27 m^2/ha. *Hopea ponga* has the highest basal area of 7.27m2/ha followed by *Olea dioica* (6.83m2/ha), *Dipterocarpus indicus* (6.76 m^2/ha), *Syzygium gardneri* (6.2 m^2/ha), *Holigarna grahamii* (3.60m2/ha) *Calophyllum tomentosum* (3.34m2/ha) and least basal area was recorded for *Randia rhugosa* (0.07 m^2/ha). The total basal area for 11 unidentified species is 0.75 m^2/ha and for lianas (≥ 30 cm GBH) it was 0.11 m^2/ha.

The mean basal area of 39.16 m^2/ha. of Kathalekan is closer to the basal area of *Kan* forest with moderate rain fall range of Uttara Kannada (42.94 m^2/ha), in Devar's (2008) study. A *kan* forest of Sorab in neighboring Shimoga district studied by Pascal (1988) showed a high basal area of 70.1 m^2 /ha. having a density of 663 trees/ha. It is due to the high density of big trees. Such abnormality in high basal area for central Western Ghats region could be exceptional or due to extrapolation from small sample size. Larger trees contribute disproportionately to the basal area (Pomeroy, 2003). In Kathalekan, of the estimated 751 stems/ha., most of the trees were in lower girth class so there is relatively less basal area. Industrial logging in the past obviously extracted several large trees in every hectare (Gadgil and Chandran, 1989). *Hopea ponga* account for highest basal area due to higher number of individuals. Although *Syzygium gardneri*, is lesser in density, had a more basal area because of larger size. In the low land and mid elevation evergreen forest of the Western Ghats of India (Pascal, 1988; Chandrasekhara and Ramakrishnan, 1994) the range of basal area is from 32.67m^2 /ha. and 83.83 m^2 /ha. Chandrasekhara and Sankar (1997) reported 51 tree species from Iringole kavu in Kerala with *Hopea ponga* and *Artocarpus hirsutus* as the dominant ones. This sacred grove had a basal area of 37.37 m^2 /ha with 3341 stems/ha. Detailed study by Chandran (1993) various plots of Uttara Kannada district showed that in a plot of Karikan, a well preserved Kan forest of Honnavar taluk the basal area was 62.81 m^2 /ha. In a somewhat degraded part of Karikan the basal area was only 40.48 m^2/ha. This clearly indicates how disturbance such as logging can adversely affect on the vegetation structure. According to his study in Kathalekan the basal area of the forest of that time was found to be 34.77 m^2 /ha, in the current study it is 39.2 m^2 /ha, showing a green signal of forest recovery, as a result of stoppage of timber extraction from mid 1980's.

4.3.7 Relative frequency: Of the 88 identified tree species of Kathalekan (≥ 30 cm), *Aglaia roxburghiana, Dipterocarpus indicus, Holigarna grahamii, Hopea ponga, Knema attenuata, and Syzigium sp.* were most frequently distributed each with 2.94 % of relative frequency. These species were represented in all the grids. It shows the ecological amplitude of these species and pervasiveness of suitable soil and climatic conditions within the forest. *Dimocarpus longan Diospyros candolleana and Olea dioica,* with 2.69% and *Actinodaphne hookeri, Nothopegia colebrookeana, Persea macrantha* with 2.29% of RF follow closely. Species rare in the forest such as *Tetrameles nudiflora*, *Lepisanthes deficiens, Elaeocarpus tuberculatus*, *Carallia brachiata*, etc have relative frequency 0.33 %.(Table 4.3.1)

4.3.8 Important Value Index: Important Value Index is a measure of ecological success of species in an ecosystem. Based on the relative density, relative basal area and relative measures IVI can be calculated. In the current study the *Hopea ponga* was found to be having highest IVI value of 29.32, followed by *Dipterocarpus indicus* (21.77), *Olea dioica* (19.83), *Syzygium gardneri* (14.22), *Holigarna grahamii* (13.2), *Knema attenuata* (12.8), *Aglaia roxburghiana* (10.83), *Dimocarpus longan* (10.29), *Calophyllum tomentosum* (8.24), etc. And species having lesser IVI includes, *Lagerstroemia microcarpa* (0.78) *Mitrephora heyneana* (0.70), *Careya arborea* (0.53), *Carallia brachiata* (0.47), *Elaeocarpus tuberculatus* (0.46), *Syzygium macrophylla* (0.42), *Randia rhugosa* (0.41) and so on (Table 4.3.2). Based on the IVI values grid-wise typification of the forest has been attempted here on the model found in Pascal (1988). In each grid two or three top IVI species have been considered for assigning the type.

Grid 1 *Litsea floribunda-Dimocarpus longan* type
Grid 2 *Syzigium gardneri-Hopea ponga-Knema attenuata* type
Grid 4 *Syzigium gardneri-Dipterocarpus indicus* type
Grid 4 *Dipterocarpus indicus-Hopea ponga-Dimocarpus longan* type
Grid 5 *Knema attenuata-Dipterocarpus indicus-Syzigium gardneri* type
Grid 6 *Olea dioica-Dipterocarpus indicus* type
Grid 7 *Dipterocarpus indicus-Holigarna grahamii-Aglaia anamallayana* type
Grid 8 *Hopea ponga-Olea dioica-Syzigium travancoricum type*
Grid 9 *Hopea ponga-Olea dioica type*

One of the significant finding of this study is the high prevalence of *Dipterocarpus* indicus in five of the 9 grids. This hygrophilous, climax evergreen and endemic tree species of Western Ghats is more characteristic of southern forest form 8º N to 13º N. the paucity of these species and its confinement to some of its southern most *kan* forest patches were reported by Chandran (1997) in the Central Western Ghats (Uttara Kannada). The present study reveals that protection as was given to the *kans* by local communities in the pre-colonial time resulted in persistence of Dipterocarpus. Such *kans* are the centers of endemism which was substantially adversely affected in the other forests under anthropogenic pressure. Not only that in Kathlekan and its peripheral forest regeneration of *Dipterocarpus* was found to be promising. The role of *kans* in regeneration of secondary forests has been alluded to by Chandran and Gadgil (1993).

Table 4.3.1: Vegetation structure of tree species in Kathalekan.

Sl.No	**Species**	**BA (m^2)**	**RD Ind/ha**	**RB (m^2)**	**RF (%)**	**IVI (%)**
1	*Hopea ponga*	7.290	16.028	10.355	2.941	29.32
2	*Dipterocarpus indicus*	6.776	9.202	9.626	2.941	21.77
3	*Olea dioica*	6.830	7.515	9.703	2.614	19.83
4	*Syzygium gardneri*	6.202	3.451	8.811	1.961	14.22
5	*Holigarna grahamii*	3.607	5.138	5.124	2.941	13.20
6	*Knema attenuata*	2.242	6.672	3.184	2.941	12.80
7	*Aglaia roxburghiana*	2.749	3.988	3.905	2.941	10.83
8	*Dimocarpus longan*	3.083	3.298	4.379	2.614	10.29
9	*Calophyllum tomentosum*	3.342	1.534	4.747	1.961	8.24
10	*Syzigium sp.*	0.909	2.301	1.291	2.941	6.53
11	*Garcinia talbotii*	1.781	1.994	2.529	1.961	6.48
12	*Palaquium ellipticum*	1.700	1.994	2.414	1.634	6.04
13	*Diospyros candolleana*	0.576	2.071	0.818	2.614	5.50
14	*Litsea sp.*	0.759	1.610	1.079	1.961	4.65
15	*Persia macrantha*	1.006	0.920	1.429	2.288	4.64
16	*Actinodaphne hookeri*	0.677	1.380	0.962	2.288	4.63
17	*Nothopegia colebrookeana*	0.325	1.457	0.462	2.288	4.21
18	*Litsea floribunda*	0.863	1.610	1.226	1.307	4.14
19	*Aglaia anamallayana*	0.672	1.380	0.954	1.634	3.97
20	*Symplocos racemosa*	0.629	1.380	0.893	1.634	3.91
21	*Syzigium hemisphericum*	1.389	0.613	1.973	0.980	3.57
22	*Syzigium sp.*	1.671	0.690	2.374	0.327	3.39
23	*Caryota urens*	0.483	0.690	0.686	1.961	3.34
24	*Syzygium cumini*	1.291	0.613	1.834	0.654	3.10
25	*Garcinia cambojia*	0.433	0.844	0.615	1.634	3.09
26	*Ixora brachiata*	0.359	1.534	0.510	0.980	3.02

27	*Diospyros crumenata*	0.524	0.920	0.744	1.307	2.97
28	*Callicarpa tomentosa*	0.212	0.997	0.301	1.634	2.93
29	*Diospyros paniculata*	0.418	0.690	0.594	1.634	2.92
30	*Holigarna ferruginea*	0.524	0.844	0.744	1.307	2.89
31	*Myristica dactyloides*	0.542	0.690	0.770	1.307	2.77
32	*Mesua ferrea*	0.741	0.460	1.053	0.980	2.49
33	*Mangifera indica*	0.236	0.383	0.335	1.634	2.35
34	*Artocarpus hirsutus*	0.906	0.383	1.287	0.654	2.32
35	*Beilschmiedia fagifolia*	0.456	0.613	0.647	0.980	2.24
36	*diospyros sp*	0.162	0.690	0.230	1.307	2.23
37	*Diospyros saldhanae*	0.067	0.460	0.095	1.634	2.19
38	*Dimorphocalyx lawianus*	0.146	0.920	0.208	0.980	2.11
39	*Lophopetalum wightianum*	0.725	0.307	1.029	0.654	1.99
40	*Myristica fatua*	0.507	0.537	0.720	0.654	1.91
41	*Cleidion javanicum*	0.121	0.383	0.172	1.307	1.86
42	*Ficus nervosa*	0.414	0.230	0.588	0.980	1.80
43	*Drypetes elata*	0.328	0.613	0.466	0.654	1.73
44	*Syzigium laetum*	0.072	0.537	0.102	0.980	1.62
45	*Canthium dicoccum*	0.172	0.383	0.244	0.980	1.61
46	*Vepris bilocularis*	0.453	0.230	0.643	0.654	1.53
47	*Flacourtia montana*	0.111	0.383	0.158	0.980	1.52
48	*Polyalthia fragrans*	0.318	0.383	0.452	0.654	1.49
49	*Ficus callosa*	0.432	0.153	0.614	0.654	1.42
50	*Macaranga peltata*	0.086	0.307	0.123	0.980	1.41
51	*Gymnocranthera canarica*	0.400	0.153	0.568	0.654	1.37
52	*Ervatamia heyneana*	0.045	0.307	0.065	0.980	1.35
53	*Glochedion javanicum*	0.077	0.230	0.109	0.980	1.32
54	*Garcinia morella*	0.091	0.537	0.129	0.654	1.32
55	*Canarium strictum*	0.406	0.230	0.577	0.327	1.13
56	*Meiogyne pannosa*	0.057	0.383	0.081	0.654	1.12
57	*Cinnamomum macrocarpum*	0.214	0.153	0.304	0.654	1.11
58	*Mastixia arborea*	0.153	0.230	0.217	0.654	1.10
59	*Myristica malabarica*	0.094	0.307	0.133	0.654	1.09
60	*Pterospermum diversifolium*	0.081	0.230	0.115	0.654	1.00
61	*Antidesma menasu*	0.079	0.230	0.112	0.654	1.00
62	*Terminalia paniculata*	0.189	0.307	0.269	0.327	0.90
63	*Mimusops elengi*	0.049	0.153	0.070	0.654	0.88
64	*Diospyros oocarpa*	0.042	0.153	0.060	0.654	0.87
65	*Walsura trifolia*	0.038	0.153	0.053	0.654	0.86
66	*Euonymus indicus*	0.034	0.153	0.048	0.654	0.86
67	*Hydnocarpus pentandra*	0.172	0.230	0.245	0.327	0.80
68	*Hydnocarpus laurifolia*	0.167	0.230	0.237	0.327	0.79
69	*Lagerstroemia microcarpa*	0.212	0.153	0.302	0.327	0.78
70	*Mitrephora heyneana*	0.047	0.307	0.067	0.327	0.70
71	*Phoebe cathia*	0.086	0.230	0.121	0.327	0.68
72	*Cassine glauca*	0.189	0.077	0.268	0.327	0.67
73	*Careya arborea*	0.038	0.153	0.055	0.327	0.53
74	*aglaia sp*	0.037	0.153	0.052	0.327	0.53

75	*Murraya paniculata*	0.070	0.077	0.100	0.327	0.50
76	*Carallia brachiata*	0.047	0.077	0.067	0.327	0.47
77	*Celtis cinnomomea*	0.042	0.077	0.060	0.327	0.46
78	*Elaeocarpus tuberculatus*	0.039	0.077	0.055	0.327	0.46
79	*Fahrenhetia zeylanica*	0.024	0.077	0.034	0.327	0.44
80	*Cassine sp*	0.022	0.077	0.031	0.327	0.43
81	*Litsea ghatica*	0.015	0.077	0.022	0.327	0.43
82	*drypetes sp*	0.013	0.077	0.019	0.327	0.42
83	*Tetrameles nudiflora*	0.013	0.077	0.018	0.327	0.42
84	*Casearia sp.*	0.010	0.077	0.015	0.327	0.42
85	*Syzygium macrophylla*	0.009	0.077	0.013	0.327	0.42
86	*Lepisanthes deficiens*	0.008	0.077	0.012	0.327	0.42
87	*Polyalthia sp*	0.008	0.077	0.012	0.327	0.42
88	*Randia rugulosa*	0.007	0.077	0.010	0.327	0.41

BA-Basal Area, RB- Relative Basal area, RD- Relative Density, RF-Relative Frequency IVI- Importance Value Index, Ind/ha- Individuals/ha.

Table 4.3.2: Vegetational composition of savanna in Grid 5.

Area sampled (ha)	BA/ ha (m^2)	Total Species	Shannon Diversity	Simpson dominance	Pielou Evenness
0.2	1.5916	5	1.523	0.235	0.946

4.3.8 Savanna vegetation composition: A transect was laid in Grid no5 exclusively for studying savanna. The species were found to be very few; just 3 species of dwarf trees, 10 species of shrubs and 12 species of herbs were recorded. Trees belong to fire tolerants like *Careya arborea, Terminalia chebula, Glochidion javanicum* and shrubs were *Scutia myrtina, Ziziphus rugulosa, Flemingia strobilifera, Randia rugulosa, Phoenix humilis, etc*. Trees and shrubs are sparsely distributed in savanna. Most of the herbs were grasses. Here Shannon index is found to be 1.523 and the species were evenly distributed with least dominance. The exposed soils of savanna are compact and dry. These extreme conditions in the elevated part of the forest .In the absence of shifting cultivation for over century the forest from valleys are found to advance towards the savanna. The pioneer species towards the exposed edge are *Olea dioica, Glochidion, Carvia callosa, Strobilanthus sp, Fleminga congesta*, etc. Exposed rocky area is also found along the rim of Sharavathi river gorge. These rocky areas have almost same vegetation as in savanna.

4.4 Status of endemism

Endemism, one of the main and easily identifiable components of biodiversity is the occurrence of a species with restricted range. While biodiversity is the biological Capital of the Earth, endemic flora and fauna (which includes genes, species and ecosystem) of a region or a nation are the exclusive biological capital of that region or nation (Nayar,1996). Endemic elements of region gives a picture of the biogeography centers of speciation, refugia, areas of extinction, vicariance and adaptive evolution of the flora and fauna of that region. The extent pattern of distribution of plants and animals in area is largely influenced by the biogeographic condition prevailing in that area.

Endemism encompasses taxonomic units of any rank or taxa (includes all life forms) which occur in a biological area usually isolated by geographical, ecological or temporal barriers. The degree of endemism increases with the increase in size of a homogenous biogeographical area having the same floristic history and ecological condition but the areas of endemism may be small or large (Nayar, 1996). In most of the cases the endemic flora present in a particular area like mountains, islands, peninsula etc are the remnants of the ancient flora of that area. At the global level endemic areas are of high conservation priority because if unique species are lost they can never be replaced (WCMC, 1992). The Western Ghats is included in the 35 biodiversity hotspots all over the world (Myers 2000) due to the abundance of endemic species- 57 genera and about 1600 species of flowering plants are endemic to Western Ghats. Among the endemic woody genera are *Memecylon* (16 spp.), *Litsea* (15 spp.), *Symplocos* (14 spp), *Cinnamomum* (12 spp), *Syzigium* (11 spp.), *Actinodaphne* (9 spp,), *Glochidion and Grewia* (9 spp each) *Diospyros* (8 spp), *Dalbergia and jambosa* (7 sp.each), *Hopea and Mallotus* (6 sp.each), *Aglaia, Cryptocareya, Euonymus, Garcinia, Holigarna, Humboldtia and Terminalia* (5 sp each) and several others. Of these 57 endemic genera, 46 are monotypic (Nair and Daniel.1986). The family Poaceae has 13 endemic genera and about 155 species (Karthikeyan, 1983). Families like Orchidaceae and Acanthaceae also have number of endemics. A good proportion of the 356 species of Impatiens is believed to be endemics to the Western Ghats (Nair and Daniels, 1986). Kathlekan is an important centre of endemism in Central Western Ghats. Of the 185 species of flowering plants noticed in the samples 60 are endemics. A good number of unidentified are also likely to be endemic.

4.4.1 Endemism among trees: Sacred groves are some of the last refugia of flora and fauna is evident from the results presented so far: 59 % of the total tree population in the 1.8 ha. were endemics. Endemism refers to the percentage of endemic individuals with in the total no. of individuals. Among the 104 tree species inventoried, 38 species (36.5 %) (number may slightly increase because of some unidentified plants) is found to be endemic to the Western Ghats. Table 4.4.1 lists the grid wise distribution of tree endemism that helps in assigning the conservation priorities of the region within the forest.

Tab.4.4.1 Endemism among the tree layer

Grid No.	Total Species	Endemic Species	% of end. Species.	Total Individual	Total Endemics	Degree of Endemism (%)
1	41	17	41.5	141	76	54.61
2	39	19	48.7	173	105	61.85
3	37	17	46	104	60	60.58
4	38	14	37	129	75	58.91
5	38	18	47.3	158	88	55.70
6	23	11	49	165	84	50.91
7	44	17	38.6	141	70	52.482
8	34	14	41	113	68	60.177
9	18	9	50	186	145	77.96

The percent of endemism varies between of 51% (in grid 6) to 78% (in grid 9).This study brings to the fore that the percentage of endemics tree species (not individuals) at the Kathalekan (36.5 %) compares well with Pascal's (1988) range of 34.1 to 37.4 % for Western Ghats north of the Palghat gap. In the population of endemics within any species *Hopea ponga* was leading in numericity with 209 individuals in the sampled area. It was followed by *Dipterocarpus indicus* (109). *Holigarna grahamii, Knema attenuata, Garcinia talbotii, Palaquium ellipticum, Diospyros candolleana, Actinodaphne hookeri, Litsea floribunda* and *Aglaia anamallayana*. Trees such as *Cinnamomum macrocarpum,* *Mastixia arborea, Myristica malabarica, Euonymus indicus, Hydnocarpus pentandra, Hydnocarpus laurifolia, Litsea ghatica and Syzigium macrophylla* are rare endemics.

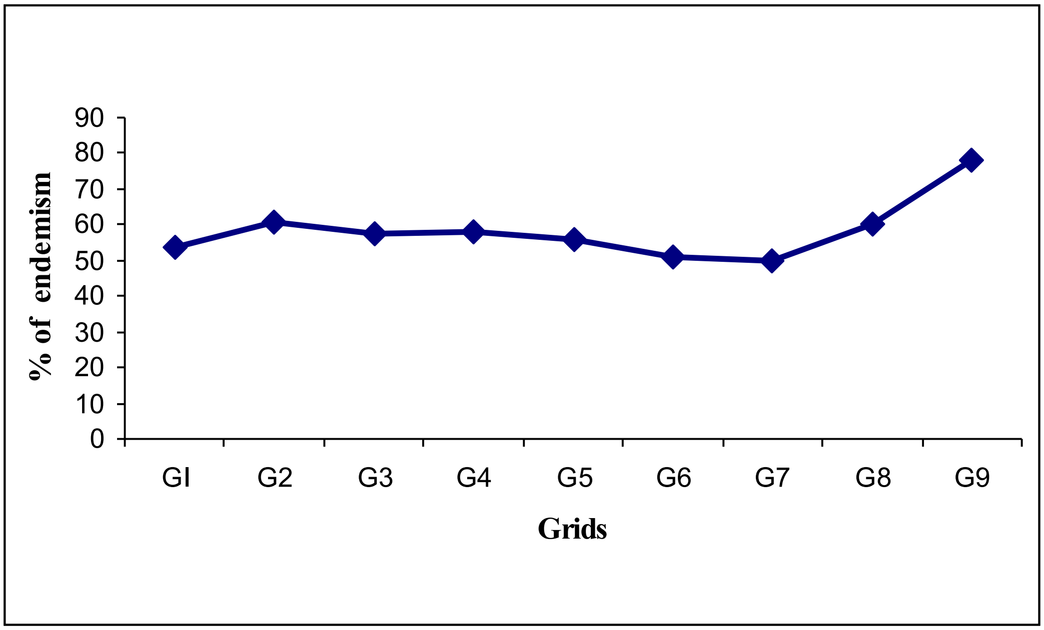

Figure 4.4.1: Grid wise percentage of endemism in Kathalekan

The distribution of tree endemism within the grid is more or less uniform except for grid 9 where the high number (100) of *Hopea ponga* was the reason for high percentage of endemism, though the grid had only 9 endemic species. In Fig (4.4.2) is given with number of tree species (based on the sample) and the number of endemic species. Interestingly the grid no 9 which account for largest number of endemics in the tree population has the smallest number of tree species (18).

Table 4.4.2 lists endemic flowering plant species, family wise that occurred in the grid wise sampling in Kathlekan. Lauraceae with 6 tree species and Ebenaceae, Myrtaceae with 3 species are found in the region. Considering higher number of individuals, Dipterocarpaceae (329) and Myristicaceae (98) and Anacardiaceae (78) are the leading families.

Table 4.4.2. Endemic tree species in Kathalekan

Sl.No	Species	Family
1	*Holigarna arnotiana**	Anacardiaceae
2	*Holigarna ferruginea*	Anacardiaceae
3	*Holigarna grahamii*	Anacardiaceae
4	*Meiogyne pannosa*	Annonaceae
5	*Polyalthia fragrans*	Annonaceae
6	*Segaria laurifolia**	Annonaceae
7	*Ervatamia heyneana*	Apocynaceae
8	*Arenga wighitii*	Arecaceae
9	*Euonymus indicus*	Celastraceae
10	*Garcinia gummi gutta*	Clusiaceae
11	*Garcinia talbotii**	Clusiaceae
12	*Mastixia arborea*	Cornaceae
13	*Dipterocarpus indicus*	Dipterocarpaceae
14	*Hopea ponga*	Dipterocarpaceae
15	*Diospyros candolleana*	Ebenaceae
16	*Diospyros paniculata*	Ebenaceae
17	*Diospyros saldhanae*	Ebenaceae
18	*Dimorphocalyx lawianus*	Euphorbiaceae
19	*Drypetes elata*	Euphorbiaceae
20	*Mallotus stenanthus**	Euphorbiaceae
21	*Flacourtia montana*	Flacourtiaceae
22	*Hydnocarpus laurifolia*	Flacourtiaceae
23	*Hydnocarpus pentandra*	Flacourtiaceae
24	*Actinodaphne hookeri*	Lauraceae
25	*Beilschmiedia fagifolia*	Lauraceae
26	*Cinnamomum macrocarpum*	Lauraceae
27	*Litsea floribunda*	Lauraceae
28	*Litsea ghatica*	Lauraceae
29	*Litsea laevigata**	Lauraceae
30	*Lagerstroemia microcarpa*	Lythraceae
31	*Aglaia anamallayana*	Meliaceae
32	*Artocarpus hirsutus*	Moraceae
33	*Knema attenuata*	Myristicaceae
34	*Myristica fatua*	Myristicaceae
35	*Myristica malabarica*	Myristicaceae
36	*Syzigium laetum*	Myrtaceae
37	*Syzygium macrophylla*	Myrtaceae
38	*Syzigium travancoricum*	Myrtaceae
39	*Strombosia zeylanica**	Oleaceae
40	*Ixora brachiata*	Rubiaceae
41	*Vepris bilocularis*	Rutaceae
42	*Mitrephora heyneana*	Sapotaceae

43	*Palaquium ellipticum*	Sapotaceae

* *found in juvenile form only.*

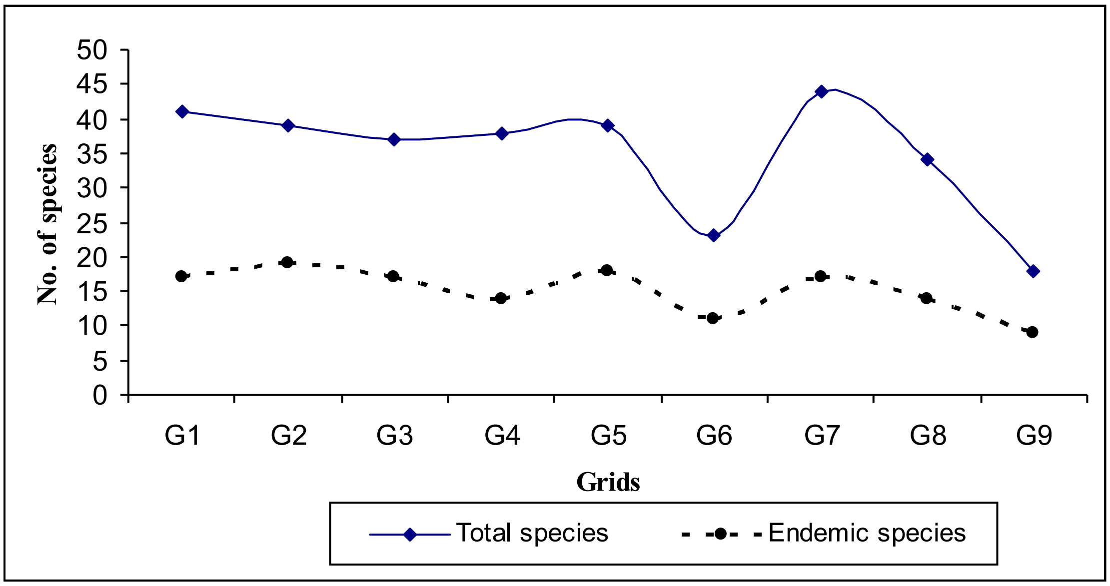

Figure 4.4.2: Grid wise total tree species and endemic species

4.4.1.1 *Endemic tree species throughout the Western Ghats*: Kathalekan harbours several endemic species such as *Meiogyne pannosa, Knema attenuata, Myristica malabarica, Diospyros paniculata, Lagerstroemia microcarpa, Syzigium laetum, Euonymus indicus, Dimorphocalyx lawianus, Mallotus stenanthus, Holigarna arnottiana, Holigarna grahamii, Vepris bilocularis, Arenga wighitii* etc. with widespread distribution in the Western Ghats..

4.4.1.2. *Rare endemic species*: *Myristica fatua*, *Gymnocranthera canarica* and *Mastixia arborea* are the rare endemic trees confined to the swamps and streams. *Semecarpus kathalekanensis* is an altogether new tree species discovered from the *Myristica* swamps of Kathalekan (Dasappa and Swaminath, 2000).

4.4.2. Endemism in the ground layer: About 56.9 % of endemism was observed in the ground layer community, which are listed in Table 4.4.3. A total of 172 flowering plant species (including juveniles of trees and lianas) were enumerated in the ground layer samples. Of the total 39 shrub species 11 were endemics and of the 11 species of herbs 3 were endemics. Saplings and seedlings of endemic trees dominated the ground layer and if adequate protection is given especially from forest encroachers that growing stock will restore a promising forest for future. Kathalekan forest could turn out to be in the near future a gene bank of endemic species, especially for Central Western Ghats. Gregarious occurrence of slender, endemic palm species *Pinanga dicksonii* and promising presence of juveniles of *Dipterocarpus indicus* are good indicators of the future of the forest as a centre of endemism.

Table 4.4.3 Endemic species in the ground layer

Sl.No	Species	Family
Shrubs		
1	*Blachia denudata*	Euphorbiaceae
2	*Canthium parviflorum*	Rubiaceae
3	*Croton gibsonianus*	Euphorbiaceae
4	*Dichapetalum gelonioides*	Dichapetalaceae
5	*Gymnosporia rothiana*	Celastraceae
6	*Ixora polyantha*	Rubiaceae
7	*Memecylon terminale*	Melastomaceae
8	*Pinanga dicksonii*	Arecaceae
9	*Psychotria flavida*	Rubiaceae
10	*Ixora polyantha*	Rubiaceae
11	*Strobilanthus heynianus*	Acanthaceae
Herbs		
1	*Boesenbergia pulcherrima*	Zingiberaceae
2	*Ophiorrhiza hirsutula*	Rubiaceae
3	*Zingiber cernum*	Zingiberaceae
Lianas/Climbers		
1	*Ancistrocladus heyneanus*	Ancistrocladaceae
2	*Calamus sp*	Arecaceae
3	*Calamus thwaitesii*	Arecaceae
4	*Cyclea peltata*	Menispermaceae

4.5 *Myristica* swamps of Kathalekan

A *Myristica* swamp is a fresh water swamp dominated by members of the family Myristicaceae. *Myristica fatua* var.*magnifica* and *Gymnacranthera* of this family are exclusive to such swamps. Krishnamurthy (1960) first reported the occurrence of Myristica swamps from the Travancore region of Kerala and classified them under a newly introduced category 'Myristica Swamp Forests' under the sub group 4C of Champion and Seth (1968). As far as Uttara Kannada district is concerned a lone locality near Malemane in Siddapur taluk has been mentioned in the *Forest Flora of the Bombay Presidency and Sind* (vol, 2), by Talbot (1909) as having *Myristica magnifica* (presently *M. fatua* var.*magnifica*). This locality obviously could have been nothing other than Kathalekan (which is a part of Malemane revenue village). Saldanha (1984), in the *Flora of Karnataka* (vol, 2) reports *Myristica fatua* var *magnifica* as 'occasional in the swampy areas of evergreen forest of Uttara Kannada. Probably alternative localities were never found when this flora was prepared.

Gadgil and Chandran (1989) observed that the Myristica swamp of Kathlekan in Malemane Ghats as the only one of its kind in the district where *Myristica fatua* occurred. Varghese (1992) and Varghese and Kumar (1997) and Varghese and Menon (1999) made various floristic and ecological observations of the Myristica swamps of southern Kerala. A more detailed study later by Chandran *et al* (1999) in Uttara Kannada district listed *Myristica* swamps in 51 localities. Of these 49 were in Siddapur and just two in Honnavar taluk, both towards south of the district. Most of these swamps were fractions of a hectare in area, which obviously could have been the last fragments of larger swamps that occurred before severe human impacts. *Myristica* Swamps of Kathlekan are also dealt with in the *Cumulative Impact Assessment of the Sharavathi River Basin*, prepared by Ramachandra *et al.* (2002-03). Chandran and Mesta (2001) characterizes *Myristica* swamps as the only sites of occurrence of certain members of the ancient family Myristicaceae such as *Myristica fatua* var *magnifica* and *Gymnacranthera canarica.* These swamps of high watershed value, with their little known biota, were described as "virtually live museum of ancient life of great interest to biologists."

These pioneering works referred to created widespread interest in the various aspects of *Myristica* swamps. Dasappa and Swaminath (2000) named a new species of tree of the genus *Semecarpus*, discovered in the Kathalekan swamps, as *Semecarpus kathalekanensis.* Vasudeva *et al* (2001) investigated the population structure, reproductive biology and conservation of *S. kathalekanensis.* Ganesan (2002) documented the 'evergreen forest swamps' and their plant species diversity from Kalakad-Mundanthurai Tiger Reserve of southern Western Ghats. Sasidharan (2003) and Roby and Nair (2007) found out *Myristica* swamps as the prime habitats of the critically endangered tree *Syzygium travancoricum.* The faunal diversity of the *Myristica* swamps of southern Kerala was documented by Jose et al (2007a, b, c). A detailed work on mapping the biodiversity of the *Myristica* swamps in southern Kerala has been carried out by Nair et al. (1997).

4.5.1 Distribution of Myristica swamps: The swamps are associated with flat bottomed or gently slopping valleys with deep soil amidst hills of Western Ghats heavily forested with evergreen forests. Rock below the soil layer by preventing percolation downwards, probably help in developing swampy conditions. Slow seepage of water from the side hills in to the valley throughout the year, heavy annual rainfall averaging 3000mm and temperature ranging from 20-30ºC promote the occurrence of such swamps (Varghese, 1992; Chandran et. al., 1999). Hence these Swamps are highly restricted in distribution.

During the present study in Kathalekan, *Myristica* swamps were observed in the Grids 1, 2, 3, 4 and 8 occurring along the water-logged portions of sluggish perennial streams. The swamps occur intermittently within the Kathalekan forests wherever suitable edaphic conditions along the stream-sides. Due to the availability of water in swamps, these places are subjected to the agricultural encroachment mainly for the paddy cultivation (grid 2). This feature is clearly visible in some location where the swamp is on the edge of vanishing. One swamp is lying in the Linear Tree Increment plot of Karnataka forest Department and is relatively well protected. Another Swamp is dominated with *Semecarpus kathlekanensis* (grid 4).

4.5.2 Vegetational composition: Myristicaceae in the Western Ghats have altogether three genera and five species all of which are evergreen trees. Of these *Gymnacranthera canarica* and *M. fatua* var.*magnifica* are found only in swampy conditions. *Myristica dactyloides, M. malabarica* and *Knema attenuata* are non-swamp species. Gadgil and Chandran (1989) reported the presence of *Myristica magnifica* and the endemic palm *Pinanga dicksonii* as the most notable of Kathalekan swamps. In fact this slender palm occurs as gregarious undergrowth away from swamps as well, but only in moist and shaded soils. *Myristica fatua* is more restricted in distribution than *Gymnacranthera canarica*, present almost in every swamp. Other members of Myristicaceae such as *M. dactyloides, M. malabarica* and *Knema attenuata* are not habitually confined to swampy places. Most notable of the non-Myristicaceae tree notable in a portion of Kathalekan swamp was the newly discovered *Semecarpus kathalekanensis.* Of the other non-Myristicaceae may be mentioned *Mastixia arborea, Syzigium hemisphericum, Syzygium* spp., *Lophopetalum wightianum Pandanus canarana* etc. Close to the swamps were also noticed various tree species like *Dipterocarpus indicus, Hopea ponga, Holigarna grahamii, Nothopegia colebrookeana, Agrostistachys indica* etc. On the whole trees exclusively confined to the swamps are very few in number, and they are leading a precarious existence, always under the shadow of threat from humans. The wetness of the swamps and their immediate surroundings favour various pteridophytes like *Angiopteris evecta*, *Blechnum orientale*, *Cyathtea nilgirensis* (tree fern), *Pteridium aquilinum, Tectaria wightii* etc. Myristica swamps are unique areas at the ecosystem level than at species level as endemicity is high in these swamps though waterlogged conditions reduce species richness.

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4.5.3 Root modifications in swamp plants: The swamp plants are well adapted morphologically, anatomically and physiologically to combat the adverse conditions of water-logged soils. Most noticeable of these modifications are in the root system:

- ***Stilt roots:*** These are woody adventitious roots from the base of the main. These roots grow obliquely to reach the soil, where they branch and give firm additional anchorage to the trees. *Myristica fatua* var.*magnifica*, *M. malabarica, Elaeocarpus, Holigarna, Pandanus* etc. produce such roots. In *Myristica fatua*, as the tree becomes older these roots become more woody, flattened and resembles buttresses.

- ***Adventitious water roots***: These arise from the stem above the soil usually within the flood zone. These are designated soil water roots. By trapping debris from the water it usually forms a hummock around the base of the stem.
- ***Pneumatophores***: As in mangroves pneumatophores or breathing roots are present in Myristicaceae tree *Gymnacranthera canarica*. Profuse production of aerial loop like breathing roots studded with enlarged lenticels or air pores are seen protruding into the air from soft soils all around the parent tree. Pneumatophores enable the tree to combat the anaerobic conditions of the water-logged conditions. Pneumatophores of *S. kathalekanensis* could be seen like rude knobs that protrude into the air from the surface roots present around the tree.
- ***Serpentine roots***: Large serpentine roots protruding high into the air are characteristic of the tree *Lophopetalum wightianum.*
- ***Rhizomes***: Rhizomes are indeed below ground modifications of stems. These rhizomes have high range of tolerance against the anoxia than roots (Braendle and Crafford, 1987). The palm *Pinanga dicksonii* the aroid *Lagenandra ovata* and the zingiber *Alpinia malaccensis* produce rhizomes, which also function effectively in vegetative propagation.

4.5.4 Importance of Myristica swamps: Myristica swamps may be considered as one of the most threatened ecosystems of India. They are undoubtedly, priceless possessions for evolutionary biology. The Myristica swamp with its entanglement of aerial roots, and canopy of dark green, large leaves and high degree of endemism, is doubtlessly, the relic of one of the most primeval ecosystems of the Western Ghats (Chandran and Mesta, 2001). Since Myristica swamps are considered as one of the primeval tropical habitats of the earth, no wonder, in the Western Ghats they are associated with primary forest relics dominated by *Dipterocarpus indicus.* The swamps are treasure troves of endemic species including plants, mushrooms, mosses, pteridophytes and gymnosperms and different faunal elements. In the study area it is observed that rare or critically endangered plant spp. like *Syzigium, Semecarpus kathlekanensis, Myristica fatua* etc. are associated with these swamp area. These swamp forest in Siddapur form an important northern most refuge for the endangered primate lion tailed macaque.

4.5.5 Threats to the swamps: Most of the Myristica swamps are under anthropogenic pressures of varied kinds and can be easily converted into agricultural lands, mainly for growing areca garden and paddy cultivation. Some of such abandoned land is present in Kathalekan. The remaining part of the swamp is struggling to survive. Cultivation in the nearby plots also badly affect these swamps because of diverting stream and channalising water in to the field causing dryness of the streambed and its neighborhood. As a result of such water diversions in the upstream for agriculture or horticulture, most streams were found dry, during summer months of April and May. Cattle grazing in some pockets have resulted in lower regeneration. Most of the swampy areas are very near to national highway with accessible ways adds up the intensity of the impact on these unique habitats.

4.6 Regeneration Status of Trees

The trees are the principal components in forming the ecological framework of the forest. The microclimatic conditions persist in a forest ecosystem depend upon the abundance and size of woody plants. The nature of forest communities largely depends on the ecological characteristics of sites, species diversity and regeneration status of species. Micro environmental factors vary with seasonal changes, which affect the growth stage i.e. seedling, sapling and young trees of the plant communities that maintain the population structure of any forest. Hence, it becomes an important issue to understand the tree diversity, population structure and regeneration status of forest communities. The satisfactory natural regeneration behavior of the forests largely depends on population structure characterized by the production and germination of seed, establishment of seedlings and saplings in the forest (Rao 1988). The evaluation of the regeneration status of the woody trees is being a key element in the ecological assessment of a forest community. The sustainability and future of the ecosystem depending mainly on regeneration of trees

Regeneration of plant species in a vegetation type is an important indicator of how stable it will be in the long run (Connel, 1978). Species are occurring in various life stages from seedlings to a mature individual and forming different strata. It is distributed in various girth classes. Complete absence of seedlings and saplings of tree species in a forest indicates poor regeneration, while presence of sufficient number of young individuals in a given species population indicates successful regeneration (Saxena and Singh 1984). Tripathi and Khan (1990) stated that microsite characteristics of forest floor and micro environmental conditions under the forest canopy also influence the regeneration of trees by seeds.

Kumbhongmayum, (2003) study in four sacred groves in Manipur indicate that the occurrence of large number of species as new colonizers in the groves and have managed to reach there due to invasion of ‘new’ species through seed dispersal from other areas.

Invasion of new species to the groves may be regarded as a possible factor to the co-existence of the tree species. The overall population structure of selected woody species reveals that seedling populations dominate tree populations and the fluctuation in population density in various seasons is related to the prevailing environmental factors. Germination of freshly dispersed seeds is high for most of the species during the monsoon season. Therefore, recruitment of all the species increases in the rainy season attaining peak during June. Species diversity and population structure will be stable if all the species are represented in all stages. A stable community is known as climax community. If only adult trees are there without regeneration the community is in the process of succession.

In nine transects, each representing a grid, a total of 2000 m^2 area were sampled for enumerating trees (≥ 30 cm gbh).Therefore in nine grids together total of 1.8 ha was studied for trees. The girth class distribution in a given tree species is reflectance of its regeneration status. Figure 4.6.1 depicts collectively the girth status of all the trees from nine transects.

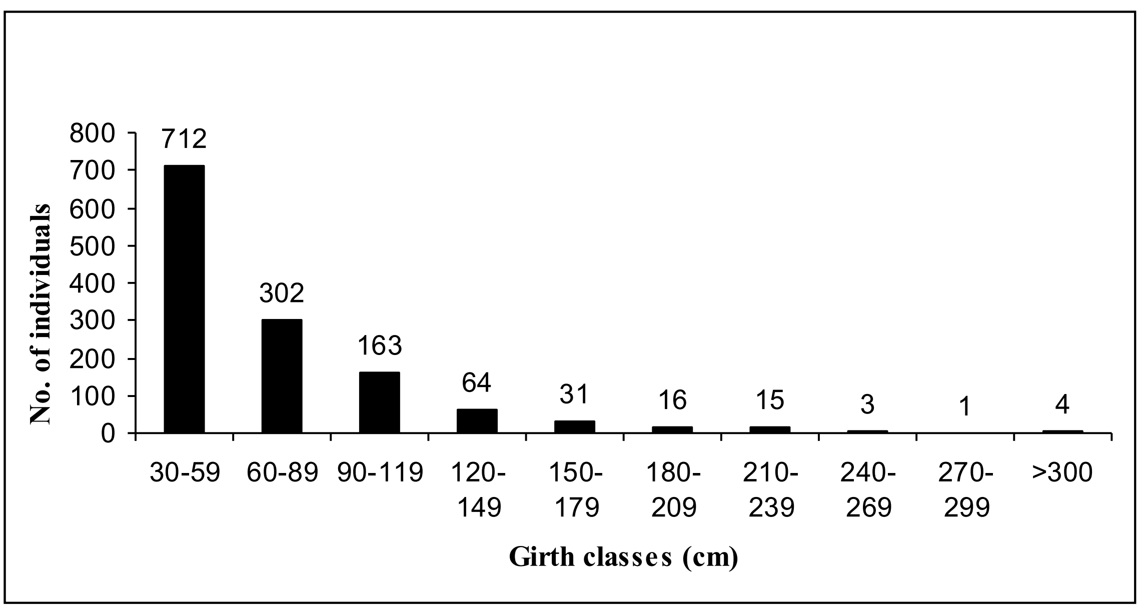

Figure 4.6.1 Girth classes of trees in Kathalekan.

The distribution pattern of trees in different girth classes produce a 'L' shaped curve According to Pascal (1988) the 'L' shaped distribution indicates the stable equilibrium of the forest, i.e. mortality being compensated by regeneration. So it can be clearly stated that Kathlekan is a well established climax forest. Moreover it harbors many well known climax evergreens of Western Ghats in all girth class. Grid wise girth classes of trees is given in Table 4.6.1. The abundance of lower girth classes especially in 30-59 cm range indicates good regeneration status. The rapid decline in higher girth classes could be attributed to the intensity of industrial logging that plagued the forest in 1940-1985 periods. Only one individual was noted in the 270-299 cm range. There were 4 individuals recorded in exceeding 300 cm. The higher girth of 407 cm was of *Syzygium gardneri.*

Table 4.6.1: Grid wise Girth classes of trees

Grids	Girth classes (cm)										Total
	30-59	60-89	90-119	120-149	150-179	180-209	210-239	240-269	270-299	>300	
G1	72	40	18	5	3	0	1	0	0	0	139
G2	99	39	26	4	1	1	3	1	0	0	174
G3	44	23	17	7	2	1	1	0	1	3	99
G4	68	29	15	7	5	4	1	0	0	0	129
G5	93	38	16	8	3	1	3	0	0	1	163
G6	97	22	18	10	6	6	2	0	0	1	162
G7	82	30	14	5	3	1	0	0	0	0	135
G8	56	22	14	6	6	2	4	2	0	0	112
G9	100	45	24	13	4	0	0	0	0	0	186

All grids have good number of younger trees. In general, regeneration of a. species is affected by anthropogenic factors (Khan and Tripathi 1989; Sukumar *et al*. 1994; Barik *et al.* 1996) and natural phenomena (Welden *et al*., 1991). As mentioned earlier due to selection felling in the past, the forest suffered lot of damage. Pomery *et al.,* (2003) who studied Kathalekan, state that the forest suffered maximum damage during 1977-84 periods with the heavy extraction of large trees. The density was reduced to 70 % of the original. By 1993, there has been some pronounced recovery. Cattle grazing was noticed during present study, which affects regeneration especially of sensitive species and fodder value species. Table 4.6.2 provides an overall summary of species-wise girth classes. It is found that regeneration status of most of the species in the forest was good. Emergent climax species like *Calophyllum tomentosum, Dipterocarpus indicus, and Syzygium gardneri* found to be having profuse regeneration. *Aglaia roxburghiana, , Dimocarpus longan, Garcinia cambojia*, *Garcinia talbotii*, *Holigarna ferruginea, Holigarna grahamii, Hopea ponga, Knema attenuata, Litsea floribunda, Lophopetalum wightianum, Mesua ferrea, Myristica fatua, Olea dioica, Palaquium ellipticum, Persea macrantha, Syzigium cumini, Syzigium hemisphericum, and Syzigium sp.*are also having good regeneration. However, there are many rare species in the area having fewer individuals.

4.6.1 Seedlings and saplings: The forest is noted for good representative of climax species in their seedling and sapling stages. The saplings of ≥1 m height (< 30 cm girth) were counted in a total area of 250 sq.m in each transect. The climax tree species like *Dipterocarpus indicus, Syzigium gardneri, Calophyllum tomentosum*, etc. are well represented in ground layer. In the ground layer, tree saplings were found to overwhelm shrubs and other juvenile plants. In fact 60% of the individuals in shrub layer and 63 % of the individuals in shrub layer and 63 % of individuals in herb layer quadrats were the progeny of trees. From this observation, it seems that status of regeneration is in a progressive state. The more similar the lower strata in a vegetation type is to the tallest stratum, the greater the chance the assemblage maintains itself in the same state or nearly so far a greater period of time (Daniels, 1989). Some tree species like *Aporosa lindleyana, Litsea laevigata, Strombosia ceylanica, Sagaeria laurifolia* and *Mallotus sp* are found to be present only in ground vegetation, they have no representatives in top layer. So it is assumed that those species may be new arrivals in to the forest recently.

Tab; 4.6.2 Girth classes of trees

Species	Family	30-59	60-89	90-119	120-149	150-179	180-209	210-239	240-269	270-299	>300
Actinodaphne hookeri	Lauraceae	9	7	1	1						
aglaia sp	Meliaceae	2									
Aglaia anamallayana	Meliaceae	10	3	5							
Aglaia roxburghiana	Meliaceae	28	11	6	5		1	1			
Antidesma menasu	Euphorbiaceae	2	1								
Artocarpus hirsutus	Moraceae	1	1	1	1					1	
Beilschmiedia fagifolia	Lauraceae	1	5	1	1						
Casearia sp.	Verbenaceae	1									
Callicarpa tomentosa	Clusiaceae	16									
Calophyllum tomentosum	Burseraceae	6	3	3	2	2	2	2			1
Canthium dicoccum	Rubiaceae	2	2	1							
Canarium strictum	Rhizophoraceae	3									
Careya arborea	Lecythidaceae	5	1	1							
Carallia integrifolia	Arecaceae		1								
Caryota urens	Flacourtiaceae	1	6	2							
Cassine glauca	Celastraceae					1					
Cassine sp	Celastraceae	1									
Celtis cinnomomea	Ulmaceae		1								
Cinnamomum macrocarpum	Lauraceae			1	1						
Cleidion javanicum	Euphorbiaceae	5									
Dimorphocalyx lawianus	Sapindaceae	12									
Dimocarpus longan	Euphorbiaceae	16	11	8	4	3		1			
Diospyros candolleana	Ebenaceae	24	3		1						
Diospyros crumenata	Ebenaceae	3	6	3							
Diospyros oocarpa	Ebenaceae	1	1								
Diospyros paniculata	Dioscoriaceae	4	3	1	1						
Diospyros saldhanae	Ebenaceae	6									
diospyros sp	Ebenaceae	7	2								
Dipterocarpus indicus	Dipterocarpaceae	71	26	7	7	6	5	1			1
Drypetes elata	Euphorbiaceae	4	2	2							
drypetes sp	Euphorbiaceae	1									
Elaeocarpus tuberculatus	Elaeocarpaceae		1								
Ervatamia heyneana	Apocynaceae	4									
Euonymus indicus	Celastraceae	2									
Fahrenhetia zeylanica	Euphorbiaceae	1									
Ficus callosa	Moraceae										
Ficus nervosa	Moraceae	1	1					1			
Flacourtia montana	Flacourtiaceae	4	1								
Garcinia cambojia	Clusiaceae	7	2	1	1						
Garcinia morella	Clusiaceae	7									
Garcinia talbotii	Clusiaceae	5	9	8	3	1					
Glochedion javanicum	Euphorbiaceae	1	2								
Gymnocranthera canarica	Myristicaceae		1					1			

Holigarna ferruginea	Anacardiaceae	4	4	2	1						
Holigarna grahamii	Anacardiaceae	27	19	14	5		1	1			
Hopea ponga	Dipterocarpaceae	128	58	19	4	3					
Hydnocarpus laurifolia	Flacourtiaceae	1		2							
Hydnocarpus pentandra	Flacourtiaceae	2			1						
Ixora brachiata	Rubiaceae	17	3								
Knema attenuata	Myristicaceae	64	14	7	2						
Lagerstroemia microcarpa	Lythraceae			1	1						
Lepisanthes deficiens	Sapindaceae	1									
Litsea floribunda	Lauraceae	14	8		1	1					
Litsea ghatica	Lauraceae	1									
Litsea sp.	Lauraceae	12	5	4							
Lophopetalum wightianum	Celastraceae	1		3		1		1			
Macaranga peltata	Euphorbiaceae	3	1								
Mangifera indica	Anacardiaceae	2	2	2							
Mastixia arborea	Cornaceae	1	1	1							
Meiogyne pannosa	Annonaceae	5									
Mesua ferrea	Clusiaceae	1	2	1		1		1			
Mimusops elengi	Sapotaceae	1	1								
Mitrephora heyneana	Annonaceae	4									
Murraya paniculata	Rutaceae			1							
Myristica dactyloides	Myristicaceae	2	3	4							
Myristica fatua	Myristicaceae	3	2	3	1						
Myristica malabarica	Myristicaceae	3	1								
Nothopegia colebrookeana	Anacardiaceae	16	3								
Olea dioica	Oleaceae	38	25	14	11	6	3	1			
Palaquium ellipticum	Sapotaceae	12	4	7	1	1	1				
Persia macrantha	Lauraceae	2	4	4	1	1					
Phoebe cathia	Lauraceae	2	1								
Polyalthia fragrans	Annonaceae		1								
Polyalthia sp	Annonaceae	1									
Pterospermum diversifolium	Sterculiaceae	3	1								
Randia rhugosa	Rubiaceae	1									
Symplocos racemosa	Symplocaceae	10	4	4							
Syzygium cumini	Myrtaceae		1	4		1	1	1			
Syzygium gardneri	Myrtaceae	18	7	10	4	1	1		1		3
Syzigium hemisphericum	Myrtaceae		3	1	1	1		1	1		
Syzigium laetum	Myrtaceae	7									
Syzygium macrophylla	Myrtaceae	1									
Syzigium sp.	Myrtaceae	23	6	1	2						
Syzigium travancoricum	Myrtaceae	3	2			1		2	1		
Terminalia paniculata	Combretaceae	1	2	1							
Tetrameles nudiflora	Datiscaceae	1									
Vepris bilocularis	Rutaceae		1	1			1				
Walsura trifolia	Meliaceae	2									

4.6.2 Regeneration status of some selected species: *Dipterocarpus indicus* is considered to be the characteristic of the climax forests of the southern Western Ghats. Extraction of the valued timber of this species for railways and industrial purposes, beginning with the 1940's from Kathlekan did not cause its elimination and regeneration (Chandran,1993). Altogether 120 trees in almost all girth classes were recorded from the sampled area (Figure 4.6.2). It was well represented in ground layer also (160 individuals from shrub layer and 11 seedling in herb layer samples). This clearly indicates that species otherwise rare in the northern latitude of 14º has safe future in Kathalekan. This sustainable regeneration is noticed in kan forest only.

Calophyllum tomentosum was another prime species that was logged from time immemorial for ship mast and later for plywood or construction purpose. Although the species represented in all girth classes the population is low. There are 21 individual encountered in the survey (Figure 4.6.3). In ground layer it was represented by 6 individuals in shrub layer and 5 in herb layer. *Syzigium gardneri* is a very large evergreen tree with huge buttress. It occurs in most of the evergreen forest of this district. It is well established because it is represented in every strata in various girth classes. In Kathalekan, 46 trees were counted 25 juveniles in the shrub layer and 8 in the herb layer (Figure 4.6.4). The largest tree in the forest was also Syzigium gardneri with a girth of 405 cm.

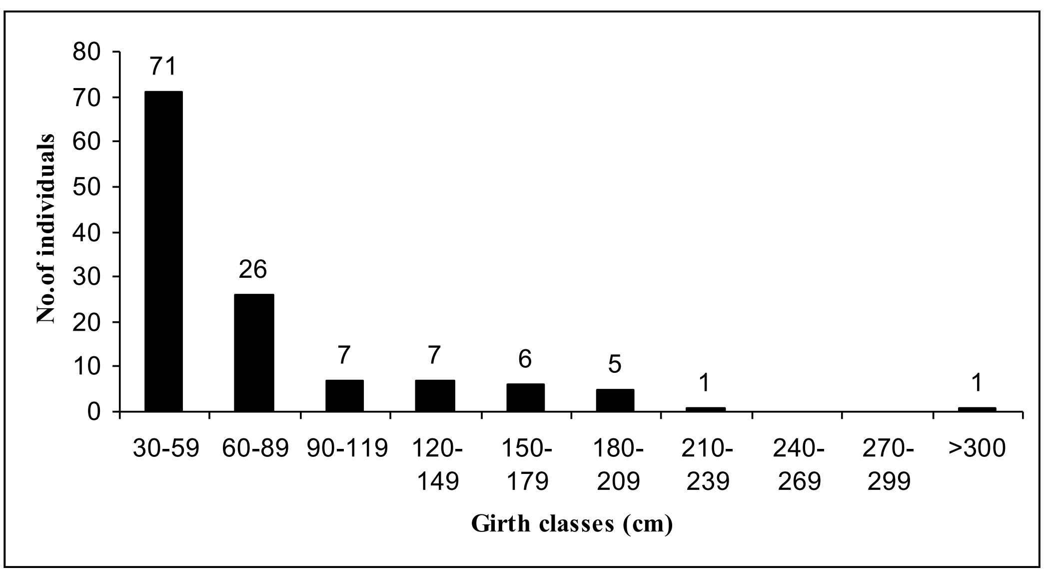

Figure 4.6.2: Girth classes of *Dipterocarpus indicus*

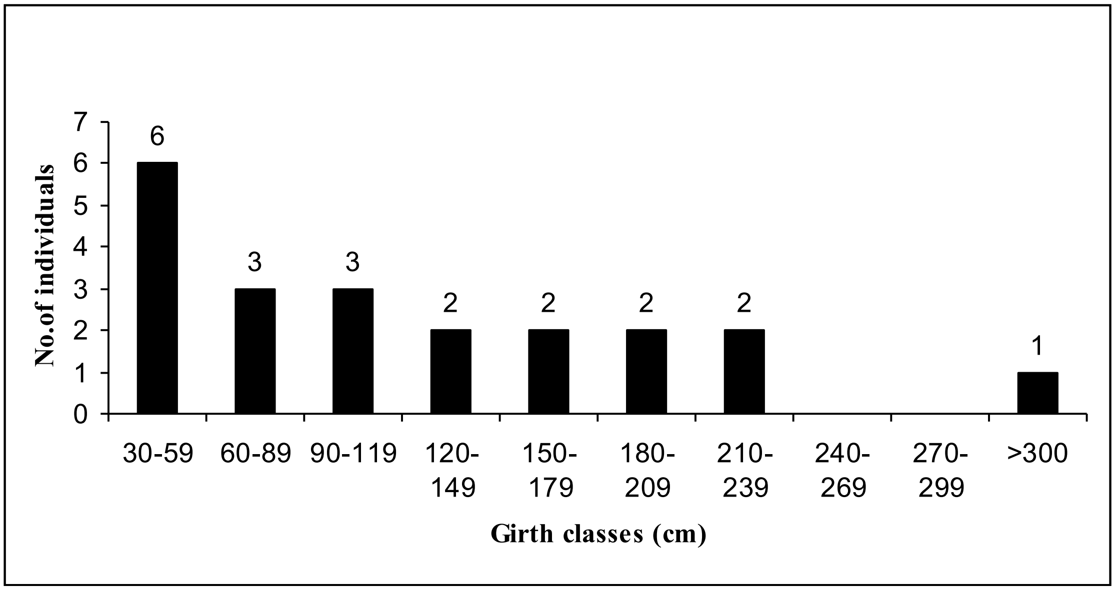

Figure 4.6.3: Girth classes of *Calophyllum tomentosum*

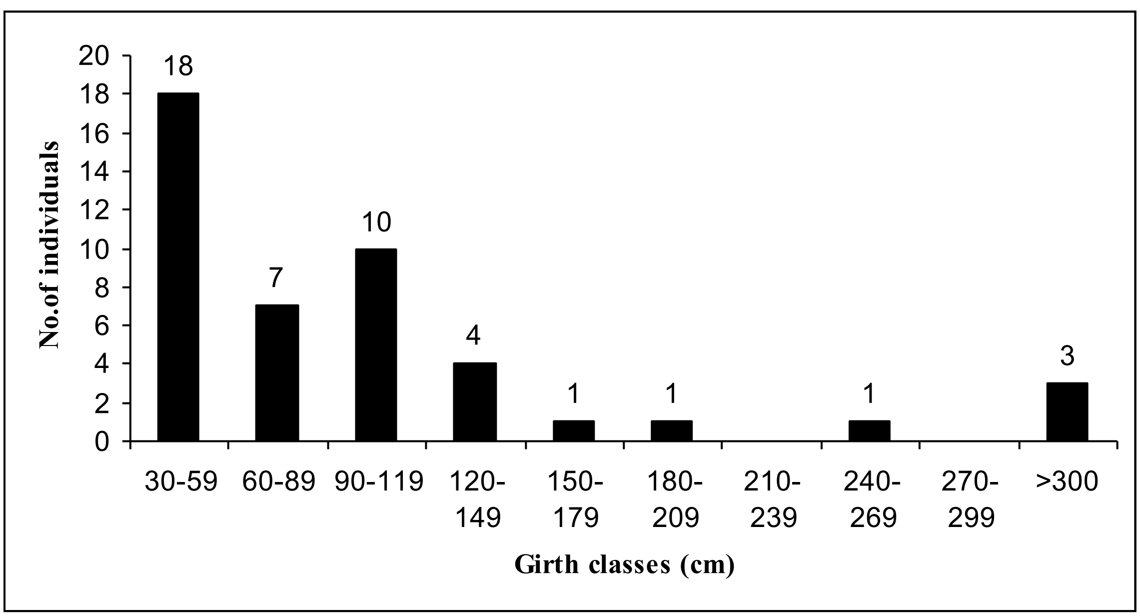

Figure 4.6.4: Girth classes of *Syzygium gardneri*

4.6.3 Tree regeneration - future scenario: From the regeneration study, it is observed that the regeneration is in progressive way. Since the occurrence of more juvenile recruitment in the ground layer indicates that the disturbance on the forest is at minimum level otherwise it will never survive. The 'L' shaped distribution of girth classes among most of the species indicating their climax nature. The flourishing regeneration of some critically endangered species is also hopeful. The rapid recovery from the past annoyance found in Kathlekan is also a good sign of future and indicates the potentiality of the forest.

4.7 **Rare, Endangered and Threatened Species (IUCN)**

Species can be classified according to their vulnerability to extinction. On the global scale, IUCN provided rigorous definitions known as the 'IUCN Red List Criteria' which attempts to classify species according to the likelihood of extinction within a given period. A list of species from Kathalekan which are under the Red listed species based on the *Red Data Book on Indian Plants* and *Report of Conservation Assessment and Management* (CAMP) are indicated in Table 4.7.1.

Table 4.7.1: RET (IUCN) species of Kathlekan

Species	**Family**	**Status (IUCN)**	**Density /ha**	**IVI**
Holigarna grahamii	Anacardiaceae	RA	37.22	13.12
*Semecarpus kathlekanensis**	Anacardiaceae	CR		NE*
Sageraea laurifolia	Annonaceae	NT		J*
Canarium strictum	Burseraceae	VU	1.67	1.13
Garcinia gummi-gutta	Clusiaceae	LR-NT	-	J
Garcinia talbotii	Clusiaceae	VU	14.44	6.44
Hopea ponga	Dipterocarpaceae	EN	116	29.18
Dipterocarpus indicus	Dipterocarpaceae	EN	66.67	21.66
Diospyros candolleana	Ebenaceae	VU	15	5.45
Diospyros paniculata	Ebenaceae	VU	5	2.89
Hydnocarpus pentandra	Flacourtiaceae	VU	1.67	0.79
Cinnamomum macrocarpum	Lauraceae	VU	1.11	1.10
Persea macrantha	Lauraceae	VU	6.67	4.59
Artocarpus hirsuta	Moraceae	VU	2.78	2.31
Knema attenuata	Myristicaceae	LR-nt	48.33	12.71
Myristica dactyloides	Myristicaceae	VU –R	5	2.74
Myristica fatua var. magnifica	Myristicaceae	EN	3.89	1.9
Vepris bilocularis	Rutaceae	RA	1.67	1.51

RA-Rare, CR-Critically endangered, EN-Endangered Nt-Near threatened, Vu-Vulnerable, VU-R-Vulnerable (regional), LR-nt-Lower Risk Near Threatened. (*CAMP Workshop,* 1997) (NE*-Not Enumerated, J*- Juveniles only)

It is found that 18 out of 111 tree species that occurred in the sampled areas come under the IUCN threat categories. *Semecarpus kathlekanensis* (though not found in the sampled transects), does occur in a part of the Myristica swamp. As the tree has been newly discovered (Dasappa and Swaminath, 2000), it is yet to gain entry into the Red List. Ecologists working in Kathalekan, however, consider it as "Critically Endangered" (Vasudeva *et al*., 2001), on account of its extreme rarity and occurrence in the threatened swamps of Kathalekan. Of the total of 18 RET species identified from Kathlekan, 14 species are found to be endemic to the Western Ghats. In fact, bulk of the RET species are found in southern Western Ghats. The occurrence of 18 RET plant species together in Kathalekan is a pointer towards the conservation value of the forest. The 18 RET species belong to 11 families and 15 genera. Prolific growth of endangered species like *Hopea ponga* and *Dipterocarpus indicus* enhances the conservation importance of Kathalekan. The endangered *Myristica fatua* has home in the *Myristica* swamps of Kathalekan. The swamps as such may be considered northernmost stronghold for the species in the Western Ghats. Among all species *Hopea ponga* has an estimated high density of 116 individuals/ha and high IVI (29.18) followed by *Dipterocarpus indicus* (67 individual/ha). Kathlekan is found to be the northernmost limit for distribution of *D. indicus* in the Western Ghats, sparing one more such locality at Karikan in the adjoining Honnavar taluk. Nine of the species are included in the "Vulnerable" category and two species i.e., *Holigarna grahamii and Vepris bilocularis* come under the "Rare" category. Lower risk species include *Garcinia gummi-gutta* and *Knema attenuata* and *Myristica dactyloides,* a regionally vulnerable species is also included in the list. As detailed studies on the herbs and epiphytes and climbers could not be undertaken due to the short term nature of the present we are not in a position to comment on RET herbs and climbers. However no RET shrubs occurred in the transect samples.

4.7.1 Regeneration status of RET species: Taking into account the girth classes of most RET species that occurred in the samples it was found that most of the RET individuals occur in lower girth classes. Trees below 30 cm in girth were not considered for this estimate. Of the 335 individuals (trees only) of RET species, only 3 individuals had girth of more than 240 cm. The 'L' shaped or inverted "J' shaped curve, as in Figure 4.7.1 indicates equilibrium condition i.e., mortality is compensated by recruitment. The species like *Sageraea laurifolia, Garcinia gummi gutta*, were found only in juvenile forms and there were no larger trees identified for these species except outside the transects.

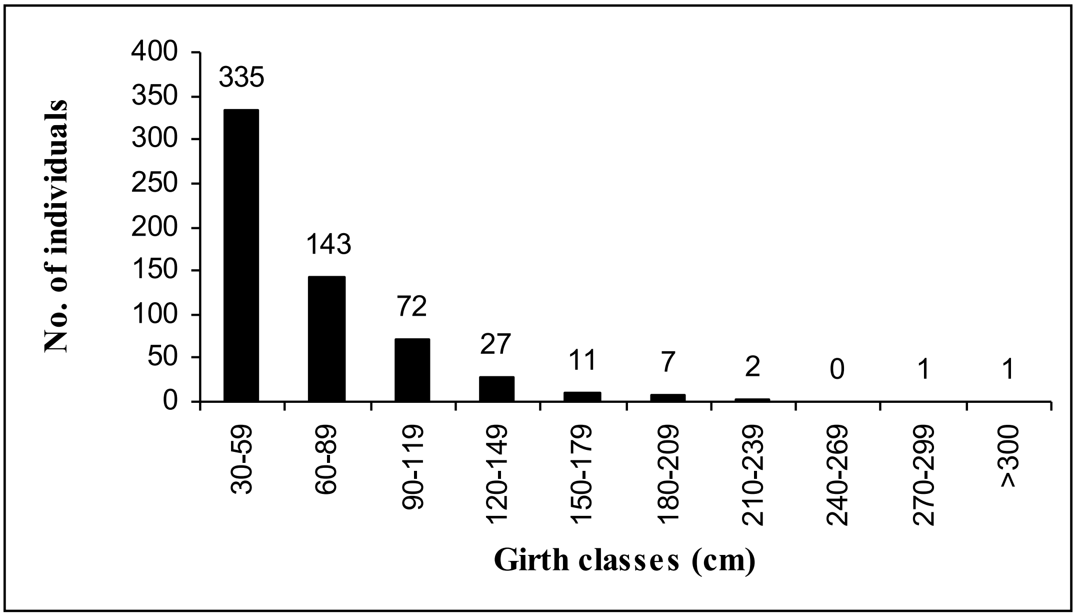

Figure 4.7.1 Girth classes of RET species in Kathalekan

Dipterocarpus indicus was found to be more frequently distributed in nearly all girth classes, indicating that Kathalekan is good refugia for it. Species lik*e Knema attenuata, Artocarpus hirsuta, Garcinia talbotii, Hopea ponga,* etc also occurred in a wide range of girth classes. Though *Semecarpus kathlekanensis* did not occur in the transects, it was found that underneath the small population of adult parental trees, there were many saplings and seedlings. The efforts to encroach its habitat by arecanut farmers became a major threat to the existence of the species. However, due to the timely intervention from the Forest Department of Karnataka such a catastrophe was prevented.

Table 4.7.2: Girth classes of RET species

Species	**Tot. Ind**	**Girth classes (cm)**									
		30-59	**60-89**	**90-119**	**120-149**	**150-179**	**180-209**	**210-239**	**240-269**	**270-299**	**>300**
Holigarna grahamii	67	27	19	14	5		1	1			
Semicarpus kathlekanensis	NE										
Sageraea laurifolia	J										
Canarium strictum	3	3									
Garcinia gummi-gutta	J										
Garcinia talbotii	26	5	9	8	3	1					
Hopea ponga	209	128	58	19	4	3					
Dipterocarpus indicus	120	71	26	7	7	6	5	1			1
Diospyros candolleana	27	24	3		1						
Diospyros paniculata	9	4	3	1	1						
Hydnocarpus pentandra	3	1		2							
Cinnamomum macrocarpum	2			1	1						
Persea macrantha	12	2	4	4	1	1					
Artocarpus hirsutus	5	1	1	1	1					1	
Knema attenuata	87	64	14	7	2						
Myristica fatua	7	3	2	3	1						
Myristica dactyloides	9	2	3	4							
Vepris bilocularis	3		1	1			1				
Total	589	335	143	72	27	11	7	2	0	1	1

NE: Not enumerated because of occurrence outside the transects, J- Juvenile form only.

5. KATHALEKAN: THREATS AND CONSERVATION

Rain forests worldwide have been suffering from various anthropogenic pressures for several decades. Demand for land and resources became augmented as result of booming population. Escalating human wants found most of the rain forests becoming victims of ruthless exploitation. In the Western Ghats, forest destruction started with the introduction of agriculture, both shifting and permanent in the valleys. Yet, as the population during the pre-British period was small, and the forests vast, by and large there was a good equilibrium between human activities and forests and wildlife. The Western Ghats is known for excellent timbers, particularly teak. Various evergreen forest trees, most of them endemics, along with associated biota were specially protected in *kans* and other kinds of sacred groves like *devarakadus* and *kavus* by local communities. Wildlife was abundant in this region during the pre and early British period.

5.1 *Kans*: past perturbations: The British domination of the Western Ghats from early 19th century marked a watershed in the forest history of the region. Unplanned forest exploitation for ship-building timbers was started by the British East India Company. Exploitation in early British period was opportunistic and confined to easily accessible places. Although the first Indian Forest Act was enacted in 1878, it was almost the end of the 19th century when the first forest working plans were formulated for systematic exploitation of forests. Selection felling and clear-felling were the norms of routine forestry both during British period and in post independence period. Clear felling in the low altitudes of Western Ghats was mainly for raising teak monocultures. After independence forests were cleared at a greater pace for raising teak monocultures. Especially in southern Western Ghats medium and high altitude forests, rich in endemic species, were cleared for raising commercial crops like tea and coffee. In southern Kerala most of the foothills were cleared off the vegetation to raise rubber plantations.

Most *kans* of central Western Ghats escaped serious interference during the 19th century, despite state monopoly over them, because of their evergreen nature, having mostly perishable softwoods. However, contract system was introduced for gathering non-timber products like pepper and cinnamon. Although these were exhaustively harvested no logging was attempted by the British until the Second World War when there was escalating demand for softwoods for the plywood industry and timbers like *Dipterocarpus* for railway sleepers.

The integrity of the *kans* were, however, slowly getting eroded as the British had not made adequate provision for meeting the biomass needs of the local communities ever since reservation of forests for the state. As the communities were alienated from the *kans,* their worship places and sources of NTFPs, and their entry prohibited as well in the timber rich secondary forests, apparently, the people resorted to extracting biomass from the *kans* themselves. Many *kans* of Sirsi-Siddapur were already infested with weeds like *Lantana* by 1920's. Dry wood collection was permitted in the *kans* by the British in eastern Sirsi and Siddapur. To meet the leaf manure demands of arecanut farmers even *kans* were allotted to them as *betta* or leaf manure forests. The *kans* away from human habitation, towards the crests of the Western Ghats, got merged with forest re-growth on shifting cultivation fallows and other secondary forests, losing their identity. Some of the notable *kans* like Kathalekan in Siddapur, Karikan in Honavar and Alsollikan in Ankola, which are treasure troves of rare and endemic biodiversity belong to this class of *kans.*

Soon after Indian independence, the *kans* like rest of the evergreen forests were caught in the grip a strong industrialization drive. Their massive timbers, hitherto untapped or underutilized, were allotted to plywood, match and packing case industries at extremely low rates. The process of extraction of industrial timbers by selection felling, carried out through a period four decades up to 1987, was too denigrating for the *kan* ecosystems. However, the prohibition on live tree felling since then has brought back new life into *kans* and their endemic biota are slowly springing back to normalcy. At the same time the *kans* are nevertheless immune from onslaughts from local communities, who resort to them for biomass extraction as well as divert the streams associated with them into their arecanut gardens and other crop lands impoverishing the regeneration of sensitive endemic species. The major threats operating in the Kathalekan reserve today are documented here.

5.2 Kathalekan: threats – past and present: As described earlier, the development of railways and the soaring demand for softwoods for industries had not spared Kathalekan as well. Many huge trees like *Dipterocarpus indicus, Calophyllum tomentosum, Artocarpus hirsutus* etc. were intensively extracted from here from 1940's to 1980's. Such extraction created enormous incidental damages in addition to exposing the forest floor with its shade and humidity loving species to the scorching tropical sun during the post-monsoon period. The outcome was largescale invasion of the gaps by weeds and other heliophilous pioneers (Gadgil and Chandran, 1989). Even after the ban on selection felling operations were carried out for collection of dead and fallen trees from the forest for some more years. Needless to say all these are expected to be detrimental on the forest ecosystem as a whole, compacting soil, exposing it to erosion, increasing evaporation and also affecting the nutrient inputs into the soil.

5.2.1 ***Cultivation within in kan***: Agriculture is the main livelihood of the people in Siddapur as is with most in the interior of Uttara Kannada. The main crops grown are areca, banana and paddy. In fact these crops require large quantity of water so the cultivators target valleys with rich supply of water from streams for starting new gardens or rice fields. The 2.25 sq.km area we have chosen for study has only three agricultural families living there (2 in Grid 4 and 1 in Grid 7). A larger area is under cultivation in Grid 4 than in Grid 7. Around the farm in Grid 4 forest has been cleared to create grazing land as well. In both the Grids the farmers have blocked the streams by making earthen bunds redircting the water to their cultivation. Because of such water diversion in Grid 4 the very sensitive *Myristica* swamps downstream in Grids 2 and 5 are affected. Due to inadequate water in the swamps of these grids, during summer months, the regeneration potential of aseasonal evergreen swamp trees like *Myristica fatua, Gymnacranthera canarica* and *Semecarpus kathalekanensis* (the last one in Grid 5) are at stake. *Myristica* swamps have been described as one of the primeval ecosystems in the Western Ghats (Chandran, *et al,* 2001).

In Grid 1 of Kathalekan, there is an abandoned paddy field within the domain of the swamp. Because of the easiness in converting the swamp into paddy field, such conversions might have taken place widely erasing perhaps scores of *Myristica* swamps from the vegetation map of Western Ghats. Even in the Grid 4 the paddy field obviously was formerly a *Myristica* swamp. Two isolated large individuals of *G. canarica* on the bund are all that remain of a former swamp. A good perennial stream running through a *Myristica* swamp in Grid 7 has been bunded and its water diverted into a newly made horticultural garden. During reconnaissance study the stream blocking near to this plot was noticed. This part is found to be more cleared having poor forest cover. Another vulnerable area was found in grid 8 where cultivation of crops like areca and banana was observed. This garden itself is the outcome of reclaiming a swamp. In a small grove of *Gymnacranthera* trees in this garden could be seen an ancient worshipping place, proving that the swamp was a larger sacred grove once. The stream diversion has imperiled many swamp loving rare species. A good *Myristica* swamp with some important species is surviving here. The depletion of water due to overuse for growing crops has not only affected the swamp species but its implications should be for the forest as a whole due adverse effects on its soil moisture regime.

5.2.2 *Encroachment*: Small scale encroachments that have taken place periodically within the forest, especially in the swamp areas, apparently were not prevented on time. Each such encroachment has left indelible imprint on the extent of the swamp, even though some such encroachments have been cleared by the Forest Department. Taking this as an advantage this type of encroachment is very common. Grid 4 is found to be more encroached for grazing and settlement. In Grid 8 encroachment is mainly for expanding the cultivation of arecanut. Some areas also were found to be encroached nearer to highway but now they are in abandoned

5.2.3 *Cattle grazing*: Cattle grazing within the forest was observed during the survey. People from nearby places allow cattle to graze in the forest. Cattle were found to wander even in the interior part of the forests. Trampling by the cattle expectedly would be a hazard for sensitive species. If cattle grazing goes on uncontrolled there could be a selection pressure favouring only browsing tolerant species in the future. The former logging roads help villagers to move within the forest along with their cattle.

5.2.4 *Lopping:* Lopping the ground plants, mainly tree saplings and shrubs for the green manure purpose has been indulged in, causing serious depletion of ground flora especially in Grid 3. Many sensitive tree species are thereby affected adversely. Shrubs and small trees are cutting for fencing stakes and poles as well, with adverse effects on the growing stock.

5.2.5 *Road*: Honnavar-Bangalore National High way is passing through the heart of Kathlekan. Road construction through the forest is one of the major threats in many parts of the Western Ghats. The infrastructural developments became an inevitable need of the time. However optional routes could have been found out instead of sacrificing precious swamps and Dipterocarpus forests for road making. Road breaks the continuity of forest and create edges along it. The road also becomes a certain barrier for animal movements. In the rainy season many endemic amphibians particularly get crushed under the wheels of vehicles.

5.3 Conservation and Management plan for Kathalekan

Kans are considered as relic forest (Pascal, 1988). The case of Kathalekan as a relic forest is much stronger perhaps than any such *kans* of central Western Ghats. Here we find high degree of plant endemism, resembling forests of more southern Western Ghats. The *Myristica* swamp resembling those of south Travancore, and the rest of evergreen forest liberally sprinkled with southern climax species such as *Dipterocarpus indicus, Palaquium ellipticum, Mesua ferrea, Syzygium spp*, etc with rich under growth of especially the slender palm *Pinanga dicksonii* and clumps of *Ochlandra* are a visual demonstration of congenial microclimatic condition and rich soil with high water conservation values. The swamps being the peak expression of the high water content, the *Myristica* swamps are also sources of perennial streams and have some of the most ancient land biodiversity of the earth dating back to the Gondwanaland.

That such a forest also having some savanna regions and gorge of the River Sharavathi having tremendous micro and macro heterogeneity should fall prey to cater to escalating human wants for industrial timbers, speaks about the slighting attitude that we have developed towards pieces of primeval nature. This short term study therefore has become helpful for formulating a conservation and management plan for Kathlekan.

i) ***Declaring as biodiversity heritage site***: According to the Biodiversity act, 2002, there is a provision to declare locally unique areas as heritage sites. This study, though primarily focus on plant ecology, nevertheless is sufficient proof of the biological richness of the forest, the rarity of its element and the high potential of water shed conservation. The fauna particularly Lion tailed Macaque, endemic amphibians, rare hornbills and Imperial Pigeon, etc. strengthen the cause of endowing such special status.

ii) ***Management of water courses***: Perennial water sources flanked by swamps in many places are unique to this forest. But as such there is no appreciation of these vital arteries of the forest that has resulted in drastic reduction in summer time water flow. The swamp biota including the newly discovered critically endangered tree species *Semecarpus kathlekanensis* is facing extinction. This situation has arisen because few families living in Kathalekan area have steadily expanded their holdings to the species rich forest for growing primarily arecanut and banana. Streams that should be running through the swamps have been diverted in to these farmland with scanty concern shown for the regeneration and survival of sensitive species. The indiscriminate use of stream water, particularly in summer months also could have caused less water input into Sharavathi River which has a power generating station down stream at Gersoppa. The farm products from just few acres of arecanut and banana are trifles compared to the invaluable plant and animal species of great antiquity and rarity. Therefore it is recommended that the quantum of water used by the few farmers be regulated, especially during summer months. Irrigation if at all required during March to May period should be from wells than from forest streams. Stream bunding and diversion during summer months need to be prohibited.

iii) ***Maintenance of Savanna***: Savannas on hill tops in and around Kathlekan enhance landscape heterogeneity and promote wild life. They need to be maintained as such without bringing under afforestation schemes.

iv) ***Regulation of cattle grazing***: Cattle including buffaloes were found roaming unattended to through forest paths. Especially the entry into the swamp and streams results in trampling of the fragile saplings, destruction through browsing and water pollution from the dung. There should be awareness creation among the locals about especially sparing the swamps from the depredations of cattle.

v) ***Prevention of encroachment***: periodically attempts have been made in the past to clear the patches of forest especially near swamps and streams, for apparently for raising arecanut gardens. These encroachments have created indelible marks especially in *Myristica* swamps and *Semecarpus* patch. If vigilance was strong such damages could have been prevented. Therefore, it is suggested that monitoring by the forest department staff should be carried out on regular basis.

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Appendix-1: List of total species in the sampled area of Kathlekan

Sl. No	*Species name*	Family	Habit	Distribution
1	*Strobilanthus heynianus*	Acanthaceae	Shrub	Oriental- W.Ghats
2	*Justicia simplex*	Acanthaceae	Herb	Eafrica,India,Malaysia
3	*Rungia pectinata*	Acanthaceae	Herb	Oriental-India,Sri Lanka,Myanmar
4	*Dracaena terniflora*	Agavaceae	Herb	Oriental-India,S.E.Asia
5	*Holigarna ferruginea*	Anacardiaceae	Tree	Oriental-W.Ghats
6	*Holigarna grahamii*	Anacardiaceae	Tree	Oriental-W.Ghats
7	*Mangifera indica*	Anacardiaceae	Tree	Oriental-W.Ghats
8	*Nothopegia colebrookeana*	Anacardiaceae	Tree	South india and Sri Lanka
9	*Ancistrocladus heyneanus*	Ancistrocladaceae	Climber	Oriental-W.Ghats
10	*Meiogyne pannosa*	Annonaceae	Tree	Oriental-W.Ghats
11	*Mitrephora heyneana*	Annonaceae	Tree	Oriental-W.Ghats
12	*Polyalthia fragrans*	Annonaceae	Tree	Oriental-W.Ghats
13	*Polyalthia sp*	Annonaceae	Tree	
14	*Sageraea laurifolia*	Annonaceae	Tree	Oriental-W.Ghats
15	*Orophea zeylanica*	Annonaceae	Shrub	India and Sri Lanka
16	*Artabotrys zeylanica*	Annonaceae	Climber	Peninsular India and Sri Lanka
17	*Ervatamia heyneana*	Apocynaceae	Tree	Oriental-W.Ghats
18	*Lagenandra ovata*	Araceae	Herb	India- Sri Lanka
19	*Pothos scandens*	Araceae	Climber	Oriental-India,Sri Lanka
20	*Pothos scandens*	Araceae	Climber	Oriental-India,Sri Lanka
21	*Caryota urens*	Arecaceae	Tree	Oriental-W.Ghats
22	*arenga whiti*	Arecaceae	Palm	Oriental- W.Ghats
23	*Pinanga dicksonii*	Arecaceae	Shrub	Oriental- W.Ghats
24	*Calamus sp*	Arecaceae	Climber	
25	*Calamus thwaitesii*	Arecaceae	Climber	India and Sri Lanka
26	*Hemidesmus indicus*	Asclepiadaceae	Climber	Oriental-India,Sri Lanka
27	*Canarium strictum*	Burseraceae	Tree	India and Upper Myanmar
28	*Capparis sp.*	Capparaceae	Shrub	
29	*Cassine glauca*	Celastraceae	Tree	Oriental-Indomalaysia
30	*Cassine sp*	Celastraceae	Tree	
31	*Euonymus indicus*	Celastraceae	Tree	Oriental-W.Ghats
32	*Lophopetalum wightianum*	Celastraceae	Tree	Oriental-Indomalaysia
33	*Gymnosporia rothiana*	Celastraceae	Shrub	Oriental-W.Ghats
34	*Microtropis wallichiana*	Celastraceae	Shrub	Indo- Malesia
35	*Calophyllum tomentosum*	Clusiaceae	Tree	Oriental,paleoarctic
36	*Garcinia cambogia*	Clusiaceae	Tree	South india and Sri Lanka
37	*Garcinia morella*	Clusiaceae	Tree	Oriental-Indomalaysia
38	*Garcinia talbotii*	Clusiaceae	Tree	Oriental-W.Ghats
39	*Mesua ferrea*	Clusiaceae	Tree	Oriental-Indomalaysia
40	*Terminalia paniculata*	Combretaceae	Tree	Oriental-Peninsular India

41	*Combretum latifolium*	Combretaceae	Climber	Oriental-Indomalaysia
42	*Connaraceae member*	Connaraceae	Shrub	
43	*Mastixia arborea*	Cornaceae	Tree	Oriental-W.Ghats
44	*Carex sp.*	Cyperaceae	Herb	
45	*Tetrameles nudiflora*	Datiscaceae	Tree	Oriental-India,Sri Lanka
46	*Dichapetalum gelonioides*	Dichapetalaceae	Shrub	Oriental-W.Ghats
47	*Dioscorea bulbifera*	Dioscroreaceae	Climber	Oriental-India,Sri Lanka
48	*Dipterocarpus indicus*	Dipterocarpaceae	Tree	Oriental-W.Ghats
49	*Hopea ponga*	Dipterocarpaceae	Tree	Oriental- W.Ghats
50	*Diospyros candolleana*	Ebenaceae	Tree	Oriental-W.Ghats
51	*Diospyros crumenata*	Ebenaceae	Tree	Oriental-W.Ghats and Sri Lanka
52	*Diospyros oocarpa*	Ebenaceae	Tree	South india and Sri Lanka
53	*Diospyros paniculata*	Ebenaceae	Tree	Oriental- W.Ghats
54	*Diospyros saldanhae*	Ebenaceae	Tree	Oriental- South India
55	*Diospyros sp*	Ebenaceae	Tree	
56	*Elaeocarpus tuberculatus*	Elaeocarpaceae	Tree	Oriental-Indomalaysia
57	*Antidesma menasu*	Euphorbiaceae	Tree	Indomalesia and east Himalayas
58	*Cleidion javanicum*	Euphorbiaceae	Tree	Oriental-Indomalaysia
59	*Dimorphocalyx lawianus*	Euphorbiaceae	Tree	Oriental- W.Ghats
60	*Drypetes elata*	Euphorbiaceae	Tree	Oriental-W.Ghats
61	*Drypetes sp(1)*	Euphorbiaceae	Tree	
62	*Drypetes sp (2)*	Euphorbiaceae	Tree	
63	*Fahrenhetia zeylanica*	Euphorbiaceae	Tree	Oriental-W.Ghats, Sri Lanka
64	*Glochidion javanicum*	Euphorbiaceae	Tree	
65	*Macaranga peltata*	Euphorbiaceae	Tree	Oriental-W.Ghats,Sri Lanka
66	*Euphorbiaceae-1*	Euphorbiaceae	Tree	
67	*Mallotus sp.*	Euphorbiaceae	Tree	
68	*Aporosa lindleyana*	Euphorbiaceae	Tree	Penisular India and Sri Lanka
69	*Mallotus philippensis*	Euphorbiaceae	Tree	China,Indomalaysia to Australia
70	*Mallotus stenanthus*	Euphorbiaceae	Tree	Penisular India
71	*Mallotus sp*	Euphorbiaceae	Tree	
72	*Agrostistaches indicus*	Euphorbiaceae	Shrub	
73	*Blachia denudata*	Euphorbiaceae	Shrub	Oriental- W.Ghats
74	*Briedelia stipularis*	Euphorbiaceae	Shrub	Peninsular India
75	*Croton gibsonianus*	Euphorbiaceae	Shrub	Oriental-W.Ghats
76	*Croton sp.*	Euphorbiaceae	Shrub	
77	*Phyllanthus lawii*	Euphorbiaceae	Shrub	
78	*Atylosia sp*	Fabaceae	Climber	
79	*Flemingia strobilifera*	Faboideae	Shrub	Oriental-Indomalaysia
80	*Casearia sp.*	Flacourthidace	Tree	
81	*Flacourtia montana*	Flacourtiaceae	Tree	Oriental-W.Ghats
82	*Flacourtia sp*	Flacourtiaceae	Tree	
83	*Hydnocarpus laurifolia*	Flacourtiaceae	Tree	Oriental-W.Ghats
84	*Hydnocarpus pentandra*	Flacourtiaceae	Tree	Oriental- W.Ghats
85	*Gnetum scandens*	Gnetaceae	Climber	

86	*Gomphandra axillaris*	Icacinaceae	Shrub	South and South east Asia, China
87	*Nothapodytes foetida*	Icacinaceae	Shrub	Indo-Malesia and China
88	*Actinodaphne hookeri*	Lauraceae	Tree	Southern W.Ghats
89	*Beilschmiedia fagifolia*	Lauraceae	Tree	Oriental-W.Ghats
90	*Cinnamomum macrocarpum*	Lauraceae	Tree	Oriental-W.Ghats
91	*Litsea floribunda*	Lauraceae	Tree	Oriental-W.Ghats
92	*Litsea ghatica*	Lauraceae	Tree	Oriental- W.Ghats
93	*Litsea sp.*	Lauraceae	Tree	
94	*Persea macrantha*	Lauraceae	Tree	Penisular India and Sri Lanka
95	*Phoebe cathia*	Lauraceae	Tree	Oriental-W.Ghats,C Himalayas to Myanmar
96	*Euphorbiaceae-2*	Lauraceae	Tree	
97	*Litsea laevigata*	Lauraceae	Tree	Oriental-W.Ghats
98	*Neolitsea zeylanica*	Lauraceae	Tree	Oriental-W.Ghats
99	*Litsea sp.(2)*	Lauraceae	Tree	
100	*Careya arborea*	Lecythidaceae	Tree	Oriental- Tropical Asia
101	*Leea indica*	Leeaceae	Shrub	Oriental-India,China To Australia
102	*Strycnos sp.*	Loganaceae	Shrub	
103	*Strychnos climber*	Loganaceae	Climber	
104	*Lagerstroemia microcarpa*	Lythraceae	Tree	Oriental-W.Ghats
105	*Hibiscus furcatus*	Malvaceae	Shrub	Tropical Africa,Tropical Asia
106	*Aglaia sp*	Melaceae	Tree	
107	*Aglaia anamallayana*	Melaceae	Tree	Southern W.Ghats
108	*Aglaia roxburghiana*	Melaceae	Tree	Indomalesia to pacific Islands
109	*Memecylon terminale*	Melastomataceae	Shrub	Oriental-W.Ghats
110	*Walsura trifolia*	Meliaceae	Tree	India and Pakistan
111	*Cyclea peltata*	Menispermaceae	Climber	Oriental-W.Ghats
112	*Artocarpus hirsutus*	Moraceae	Tree	Oriental- South W.Ghats
113	*Ficus callosa*	Moraceae	Tree	Oriental- Indo- Malesia
114	*Ficus nervosa*	Moraceae	Tree	Oriental-India to Vietnam
115	*Gymnacranthera canarica*	Myristicaceae	Tree	Oriental- Indo Malaya
116	*Knema attenuata*	Myristicaceae	Tree	Oriental-W.Ghats
117	*Myristica dactyloides*	Myristicaceae	Tree	Oriental-W.Ghats,Sri Lanka
118	*Myristica fatua*	Myristicaceae	Tree	Oriental- Southern W.Ghats
119	*Myristica malabarica*	Myristicaceae	Tree	Oriental-W.Ghats
120	*Syzygium cumini*	Myrtaceae	Tree	Oriental-Indomalaysia
121	*Syzygium gardneri*	Myrtaceae	Tree	Oriental-W.Ghats,Sri Lanka
122	*Syzigium hemisphericum*	Myrtaceae	Tree	South india and Sri Lanka
123	*Syzigium laetum*	Myrtaceae	Tree	Oriental-W.Ghats
124	*Syzygium macrophylla*	Myrtaceae	Tree	
125	*Syzigium sp(1)*	Myrtaceae	Tree	
126	*Syzigium sp(2)*	Myrtaceae	Tree	Southern W.Ghats
127	*Strombosia ceylanica*	Olacaceae	Tree	Oriental-W.Ghats
128	*Olea dioica*	Oleaceae	Tree	Oriental-NE India, S W India
129	*Pandanus sp*	Pandanaceae	Shrub	
130	*Piper sp.*	Piperaceae	Climber	

131	*Ochlandra sp*	Poaceae	Shrub	
132	*Cyrtococcum oxyphyllum*	Poaceae	Herb	Oriental-Indomalaysia
133	*Scutia myrtina*	Rhamnaceae	Shrub	Oriental-Myanmar,India
134	*Ziziphus rugosa*	Rhamnaceae	Shrub	Oriental-India,Sri Lanka
135	*Ventilago maderaspatana*	Rhamnaceae	Climber	Oriental-W-Ghats,Sri Lanka,Java
136	*Carallia brachiata*	Rhizophoraceae	Tree	Indo Malesia and Australia
137	*Canthium dicoccum*	Rubiaceae	Tree	South India,Myamnar
138	*Ixora brachiata*	Rubiaceae	Tree	Oriental-W.Ghats
139	*Randia ruugosa*	Rubiaceae	Tree	
140	*Ixora nigricans*	Rubiaceae	Shrub	Indo- Malesia
141	*Ixora parviflora*	Rubiaceae	Shrub	India, Sri Lanka and Bangladesh
142	*Ixora polyantha*	Rubiaceae	Shrub	Oriental-W.Ghats
143	*Ixora sp.*	Rubiaceae	Shrub	
144	*Canthium sp.*	Rubiaceae	Shrub	
145	*Canthium rheedei*	Rubiaceae	Shrub	Peninsular India
146	*Psychotria flavida*	Rubiaceae	Shrub	Oriental-W.Ghats
147	*Ophiorrhiza hirsutula*	Rubiaceae	Herb	Oriental-W.Ghats
148	*Randia rugulosa*	Rubiaceae	Climber	Oriental-W-Ghats,Sri Lanka,Java
149	*Murraya paniculata*	Rutaceae	Tree	Oriental-Indomalaysia
150	*Vepris bilocularis*	Rutaceae	Tree	Oriental-W.Ghats
151	*Atalantia racemosa*	Rutaceae	Shrub	Sri Lanka and Peninsular India
152	*Glycosmis pentaphylla*	Rutaceae	Shrub	Oriental-India,Sri Lanka
153	*Luvunga sarmentosa*	Rutaceae	Climber	Oriental-Sri Lanka,Java
154	*Todalia asiatica*	Rutaceae	Climber	Oriental-South India
155	*Dimocarpus longan*	Sapindaceae	Tree	Oriental-Tropics
156	*Lepisanthes deficiens*	Sapindaceae	Tree	Indo- Malesia and Africa
157	*Mimusops elengi*	Sapotaceae	Tree	Oriental-Indomalaysia
158	*Palaquium ellipticum*	Sapotaceae	Tree	Oriental-W.Ghats
159	*Smilax zeylanica*	Smilacaceae	Climber	Oriental-South E.Asia
160	*Smilax spp*	Smilacaceae	Climber	
161	*Pterospermum diversifolium*	Sterculiaceae	Tree	Oriental-W.Ghats,Java,Philippines,Malaysia
162	*Symplocos racemosa*	Symplocaceae	Tree	Oriental-W.Ghats
163	*Tiliaceae member*	Tiliaceae	Shrub	
164	*Celtis cinnomomea*	Ulmaceae	Tree	Oriental-Indomalaysia
165	*Clerodendrum viscosum*	Verbenaceae	Shrub	Oriental-Indomalaysia
166	*Callicarpa tomentosa*	Verbinaceae	Tree	Oriental-South India
167	*Vitaceae member*	Vitaceae	Shrub	
168	*Alpinia malaccensis*	Zingiberaceae	Herb	Oriental-Indomalaysia
169	*Boesenbergia pulcherrima*	Zingiberaceae	Herb	Oriental-W.Ghats
170	*Zingiber sp.*	Zingiberaceae	Herb	
171	*Zingiberaceae*	Zingiberaceae	Herb	
172	*Zingiber cernum*	Zingiberaceae	Herb	Oriental-W.Ghats

Discovery of Two Critically Endangered Tree Species and Issues Related to Relic Forests of the Western Ghats

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Abstract: *Madhuca bourdillonii* (Gamble) Lam. and *Syzygium travancoricum* Gamble, considered almost extinct but later found to be occurring in small numbers in their home range in Western Ghats, south of Palghat Gap, have been now discovered in some of the relic primeval evergreen forests of Uttara Kannada, over 700 km north. These relic forests also shelter scores of other rare endemic elements of flora and fauna. These findings highlight the need for making intensive efforts for locating more of such relic forests and documenting their biota. Also, biologists need to restrain from the tendencies of considering any novel occurrences of species away from their home ranges as new species, before ruling out the possibilities that these could be the relics of ancient populations or their morphological variants. Presence of relic forests does reveal the legacy of erstwhile contiguous forests, which is now fragmented due to rapid land use changes. Conservationists handling biodiversity hotspots should be able to distinguish between relics of primeval forests and advanced stages of secondary successions. Lack of such understanding will result in imperceptible extinctions of many endemic species.

Keywords: *Madhuca bourdillonii*, *Syzygium travancoricum*, critically endangered, relic forests, *Myristica* swamps, local extinction, Uttara Kannada, Western Ghats.

INTRODUCTION

The Western Ghats is one among the 34 global hotspots of biodiversity and it lies in the western part of peninsular India in a series of hills stretching over a distance of 1,600 km from north to south and covering an area of about 1,60,000 sq.km. In the course of our ecological studies in the Uttara Kannada (formerly North Kanara) district of central Western Ghats, we came across two critically endangered tree species, far away from their home range much in the south. These trees *viz*., *Madhuca bourdillonii* (Gamble) Lam. and *Syzygium travancoricum* Gamble, were even considered almost extinct. Their rare presence in some of the relic evergreen forests of Uttara Kannada, over 700 km towards the north of their original home range, in southern Western Ghats, that too beyond the geographical barrier of the Palghat Gap, which halts the continuity of several sensitive endemics, throws up before us fresh questions regarding conventional approach to conservation, which has not given due merit to the ecological history of the region. These tree species occur in the vicinity of some of the *Myristica* swamps of the district, which are obviously part of the relic patches of primeval low altitude evergreen forests that survived human impacts to some degree. Historically, the overall forest disturbance in the Western Ghats increased in spatial extent as well as in intensity, during the post World war era, with the emphasis on industrialization and economic development. Forest based industries coupled with large scale hydroelectric projects and conversions of forest land for agriculture have contributed significantly in the decline of primeval forests. The *Myristica* swamps did not get enough attention until Chandran and Mesta [1] reported them as highly threatened relics of primeval forests of the Western Ghats. These swamps have high watershed value and are associated with perennial water courses. They also act as a treasure trove of endemic plants and animals of ancient lineage. These swamps are dominated by species of Myristicaceae (nutmeg family), one of the most ancient families of flowering plants. *Myristica fatua* var. *magnifica* (Bedd) Sinclair and *Gymnacranthera canarica* (King) Warburg, are tree species exclusive to the swamps. Recent discovery of *Semecarpus kathalekanensis*, an altogether new tree species of the mango family Anacardiaceae [2], in these swamps has created ripples in the conservation circles.

The micro-heterogeneity of these relic evergreen forests has several more endemic and interesting plant species, which include the trees *Dipterocarpus indicus, Mastixia arborea, Agrostystachys longifolia* and *Myristica malabarica* (Fig. **1**); an undergrowth palm *Pinanga dicksonii,* a species of pepper *Piper hookerii,* a tree fern *Cyathea nilgirica,* etc. Lion-tailed macaque, an endemic endangered primate of the Western Ghats, has its northern-most range in the relic evergreen forests of southern Uttara Kannada, which also often harbour *Myristica* swamps. In addition are several other rare endemic animal species, which include amphibian genera like *Nyctibatrachus* and *Micrixalus*. The *Myristica* swamps of southern Uttara Kannada are found to harbour 29 species of amphibians of which 19 are Western Ghat endemics. Birds like Wyanad laughing thrush and Malabar pied hornbill associated with these swamp forests are also endemics. *Phylloneura westersmanii,* a damselfly of endemic monospecific genus *Phylloneura* was recently found in *Myristica* swamps of Siddapur (14.5° N), the northern range of which was earlier considered to be Coorg (12° N) district [3].

The *Myristica* swamps, which are sure indicators of relics of primeval forests of the Western Ghats, today occur in iso-

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lated patches; the southern-most swamps are found in Travancore region and the northern-most occur in Goa. Due to ever increasing human impacts, over the last few centuries, most of the primeval forests have given way to secondary forests, savannas, monoculture tree plantations, cash crops such as tea, coffee and rubber, rice fields, arecanut gardens, etc [4,5]. In addition, developmental projects such as hydel, and nuclear power plants, mining, etc., have mushroomed especially during the post-independence period. Nevertheless, the remains of numerous ancient sacred groves, specially preserved pepper forests of the past and many forest patches with difficult approach are serving as repositories of the endemic biodiversity of Western Ghats. Recent study of Western Ghats using WiFs (wide field sensor with spatial resolution of 70 m) remote sensing data mapped certain unique evergreen forest patches, which coincided with *Myristica* swamps, *Ochlandra* reed ecosystems and *Nagea wallichiana* facies [6], which are obviously relics of primary evergreen forests.

Myristica swamps are considered as priceless possessions for evolutionary biology. The swamp, with its entanglement of aerial roots, and canopy of dark green large leaves, and high degree of endemism, is doubtlessly, the relic of one of the most primeval ecosystems of the Western Ghats. As much remained undone regarding the diversity and ecology of these swamps, they are considered "virtually live museum of ancient life of great interest to biologists"[1,4]. With the presumption that the *Myristica* swamps and their immediate surroundings, studded with *Dipterocarpus* trees (Fig. **1**), could shed some light on the nature of the primeval low altitude evergreen forests of Uttara Kannada district, we began surveying these forest relics more systematically. Our search resulted in the discovery of two critically endangered tree species *viz.*, *Madhuca bourdillonii* (Gamble) Lam. and *Syzygium travancoricum* (Gamble). We consider the occurrence of these species in Uttara Kannada as very significant due to the following reasons:

- These species were originally reported only from Travancore region [7].
- They were feared to be extinct according to the *Red Data Book of Indian Plants* [8,9].
- Subsequent investigations revealed their rare presence in southern Western Ghats, but only towards the south of the Palghat Gap [10,11].
- The *Myristica* swamps near which we found these species had the status of *kan* forests. The *kans* were safety forests cum sacred groves during the pre-colonial times [12].

Madhuca bourdillonii (Gamble) Lam.

Bourdillon [7], the discoverer of this species in Travancore during 1894-95 described it as a "rare tree of medium size occurring in the Ariankavu and Shenduruny valleys, but not seen elsewhere". Gamble [13], quoting Bourdillon, also described it in the *Flora of the Presidency of Madras* (vol.2). The *Red Data Book of Indian Plants* considered its status as "possibly extinct", since the species was not collected after Bourdillon's observation. The book states [9], "Indiscriminate and steady destruction of its natural habitats, compounded by selective felling of *Madhuca* trees in the past for their purported all round value, accounts for the present day state of scarcity in the Western Ghats region". Sasidharan and Sivarajan [10] found this species in the forests of Thrissur district (10.66° N, 76.25° E), to the north of the type localities. Later, it was also found in its type localities namely Arainkavu and Shenduruny valley and was reported [11] as "rare".

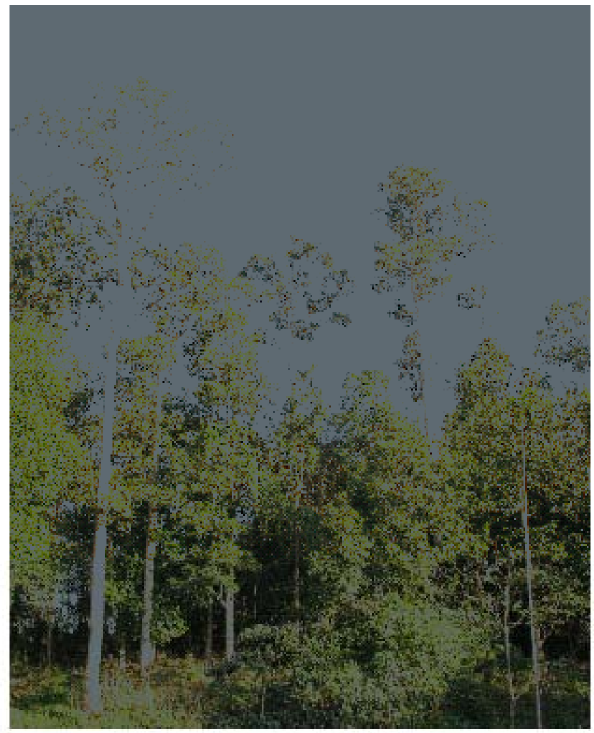

Fig. (1). A relic forest with *Dipterocarpus indicus.*

OCCURRENCE OF *M. BOURDILLONII* IN UTTARA KANNADA

Notably all the findings of the species hitherto were towards the south of Palghat Gap, until we came across a rare population in Ankola taluk (14.7° N), of Uttara Kannada district, in the central Western Ghats. Our find extends the northern limit of the species by about 500 km; but more significantly, this is the first report of the species from north of the Palghat Gap. Fig. (**2**) depicts these locations along with the earlier sightings. There were only 13 trees of this critically endangered species dispersed within a stretch of evergreen forests. Three of them exceeded 30 m in height and were about 2 m in girth while others were much smaller. These trees occurred in a relic forest characterised by a *Myristica* swamp and endemic trees such as *Aglaia anamallayana, Dipterocarpus indicus, Garcinia talbotii, Holigarna* spp., *Gymnacranthera canarica, Knema attenuata, Myristica malabarica*, etc. Incidentally, this site is also a northward extension for *D. indicus* by about 30 km, from the previous report [14].

DESCRIPTION OF *M. BOURDILLONII*

Madhuca bourdillonii is a medium to large tree exceeding 30 m height at maturity (Fig. **3a**). Though described as an evergreen [9], it has a brief period of leaf-fall, which is not strictly season bound. Flowering is simultaneous with leaf-fall and new flush that follows is mingled with late

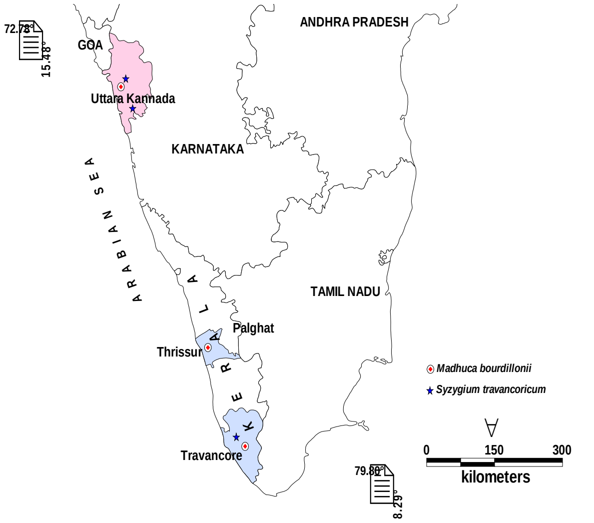

Fig. (2). Distribution map of *Madhuca bourdillonii* and *Syzygium travancoricum* in the South-west India.

blooming flowers and early fruits. The trees have grayish brown, longitudinally fissured and flaky bark with a pinkish interior (Fig. **3b**). The plant parts have milky latex like other species of *Madhuca*. Young shoots, including young leaves, are densely covered with brownish-orange, wooly hairs. In the mature leaves the undersurface of veins retains the hairs. In other related species like *M. longifolia* var. *longifolia* and *M. longifolia* var. *latifolia* and *M. neriifolia* mature leaves are not hairy. The leaves are simple (Fig. **3a**) reaching dimensions of 20-32 x 6-10 cm and crowded towards the tips of branchlets. They have conical base and bluntly acute to narrowing tips. In having 20-25 pairs of lateral nerves *M. bourdillonii* stands apart from its close associates *M. longifolia* var. *longifolia* (10-12 pairs) and *M. longifolia* var. *latifolia* (10-14 pairs). Flowers appear in dense clusters (Fig. **3c**) from the axils of fallen leaves or of older leaves that are about to fall. When the tree is in full bloom, clusters of young leaves appear from the tips of branchlets. The stalks of flowers, 1.5-2 cm long, are also covered with dense hairs. Sepals are 4, ovate and hairy outside. Corolla consists of 12 united petals. Stamens are often twice the number of petals, in two whorls. The anther is tipped with a narrow outgrowth.

Genus *Madhuca* produces berries (Fig. **3d**) with one to few seeds. Globose fruit is a key distinguishing character of *M. bourdillonii. Madhuca longifolia* var. *latifolia* has globose fruit, with oblique apex [15] and *M. longifolia* var. *longifolia* has ovoid fruit. Both these varieties have 1 or 2 seeds whereas *M. bourdillonii* has 2-3 seeds (Fig. **3e**). Table **1** compares the various *Madhuca* spp. of South India.

Syzygium travancoricum Gamble

The tree was first discovered in the swampy lowlands (altitude <65 m) of Travancore by Bourdillon in 1894. Gamble [17] described it in 1918 in the *Kew Bulletin* and in the *Flora of the Presidency of Madras* in 1919. The *Red Data Book of Indian Plants* [8], quoting Nair and Mohanan [18], states: "Apparently no tree is surviving in the type locality. Recently only four trees have been spotted in a sacred grove of Aikad in Quilon district". However, Sasidharan [11] rediscovered it in the type locality - Shenduruny Wildlife Sanctuary. According to him this species, endemic to southern Western Ghats of Kerala, is associated with the *Myristica* swamp forests.

OCCURRENCE OF *S. TRAVANCORICUMIN* UTTARA KANNADA

We came across about 35 trees of this species in association with some of the *Myristica* swamps of Siddapur taluk (14.4° N). The tree occurred along with several other Western Ghat endemics such as *Aglaia anamallayana*, *Calophyllum apetalum*, *Diospyros paniculata*, *D. pruriens*, *Dipterocarpus indicus*, *Gymnocranthera canarica*, *Holigarna grahamii*, *Hydnocarpus pentandra*, *Hopea ponga*, *Mastixia arborea*, *Myristica fatua* var. *magnifica*, *Pinanga dicksonii*, etc. In Ankola taluk, a single tree was observed in a *Myristica* swamp (Fig. **4a**). Some bushy forms, obviously coppice shoots (Fig. **4b**), occurred close to it. The occurrence of the species in Ankola is a range extension for it by about 700 km from Travancore (Fig. **2**), where it was considered to be restricted.

DESCRIPTION OF *S. TRAVANCORICUM*

Gamble [17] described the species as medium sized or large tree, while, Sasidharan [11] found only small trees. The largest trees that we observed were about 30 m in height. Two of the trees had girths of 253 and 254 cm respectively. The older trees have buttresses at the base. The young branchlets are 4-angled; in the saplings the angles are winged. Stream side trees have floating water roots, an adaptation to swampy habitat (Fig. **4c**). Leaves are simple, opposite, ovate and bluntly acute towards the tip. The leaf base is shortly decurrent (continued) on the 2 cm long petiole. Leaf measures 9-18 cm in length and 6-9 cm in breadth. It has 12-15 pairs of lateral nerves. Flowers occur in the axils of leaves in corymbose cymes of 5-8 cm long (Fig. **4d**). They are very small, only 3 mm across. The white petals form a calyptra (cap) in the bud enclosing the stamens. Fruits 0.7-1 cm across, purplish to maroon-red (Fig. **4e**). Fruits ripen in May-June. None of the floras provide the description of the fruit although it is sketched in the flora of Shenduruny Wildlife Sanctuary [11].

THE VALUE OF FOREST PATCHES

The impact of forest fragmentation is severe in the tropics, where biodiversity is rich, and human populations are rapidly growing. Studies show decline of forest birds [19], large wide ranging species [20] and more specifically specialised species [21] that require unique habitat for survival. It also influences distribution and availability of spatial resources, forest connectivity and edge characteristics, which are important for species persistence [22-24]. Also, trees in the fragmented habitats have higher annual tree mortality rates due to vagaries of wind [25]. Fragmentation effects cascade through the community, modifying inter-specific interactions, providing predator or competitive release, altering social relationships and movement of individuals, exacerbating edge effects, modifying nutrient flows, and potentially even affecting the composition of local population [26]. In many tropical regions, rain forest is restricted to small (<100 ha), isolated fragments. The conservation of such smaller fragments had not merited much attention till recent years. In regions like Western Ghats, there is not much hope for creation of more and more large-sized protected area systems due to social, economic and political

Fig. (3). a) *Madhuca bourdillonii* in flush; **b**) An old tree of *M. bourdillonii* – showing fissured and flaky bark; **c**) flower; **d**) fruit and **e**) seeds.

Table 1. Comparative Morphology of Different Species of *Madhuca*

Characters	*M. bourdillonii*	*M. longifolia var. longifolia*	*M. longifolia var. latifolia*	*M. neeriifolia*	*M. insignis*
Tree height	Large (>25 m)	Large (>25 m)	Large (>25 m)	Small (8-10 m)	Moderate
Bark	Grayish brown, fissured and flaky	Dark brown, scaly	Dark, fissured and scaly	Dark, scaly	
Leaf size (cm)	20-32 x 6-10	5.5-12 x 1.5-4	7-22 x 5-14	7-24 x 3-6	9-13 x 4-6
Leaf hairiness (mature leaf)	Petioles and underside of veins with brownish-orange, wooly hairs	Glabrous	Glabrous	Glabrous	Glabrous
No. of lateral nerves (pairs)	20-25	10-12	10-14	14-25	11-13
Ovary	Glabrous	Hairy	Hairy	Glabrous	
Fruit shape	Globose	Oblong	Globose with oblique apex	Fusiform, beaked	Fusiform-ovoid
Surface of mature fruit	Glabrous	Hairy	Hairy	Glabrous	Glabrous
No. of seeds	2-3	1-4	1-4	1	1

Table based on observations by authors and floras of Bourdillon [7], Gamble [13], Saldanha [15], Sasidharan and Sivarajan [10], Sasidharan [11], Bhat [16].

constraints [27, 28]. Also, the presence of roads, power lines and substantial nearby human population has prevented the recovery [29]. 'Forest patches' include a diversity of habitats which are in close proximity forming a mosaic, or even in isolation like a sacred forest in the middle of a village or small town. Investigations into the ecological history of the Western Ghats reveal that the forests here, especially of altitudes below 1000 m, constitute a mosaic of patches of varied nature and ages.

In the Uttara Kannada district of central Western Ghats, where we conducted our present study, this landscape mosaic, according to traditional pre and early colonial land use, typically consisted of sacred forests (*kans* or *devarabana*), ordinary forests (*kadu* or *adavi*), shifting cultivation areas (*kumri* or *hakkalu*), leaf manure forests (*betta*), grazing lands (*bena*), etc., in addition to lands under permanent agriculture and horticulture. Such traditional mosaic within it might contain streams, ponds, waterfalls and rivers, gorges and steeps and rocky pinnacles, each with its own characteristic species composition [12, 27-28, 30]. Sacred forest fragments are shelters of biodiversity, meeting the needs of non-timber forest produce requirement and are best protected by local communities [31]. The lower altitudes of pre-historical Western Ghats, before the beginning of shifting cultivation, around 3,000 years ago, would have been covered with pristine ecosystems, more or less untrammeled by man, except by hunter-gatherers, who seldom if at all, indulged in forest alterations. Especially due to the heavy rainfall, western facing portions of the mountains would have been covered with tropical evergreen forests, laced with water courses and swamps [24,27]. Earlier studies in the Western Ghats also showed that remnants foster successional processes in natural restoration of rainforests [32]. Shifting cultivation was a major activity of forest dwelling tribals, throughout the Western Ghats, sparing only the higher altitudes. Carried out through centuries this might have altered substantially the primary evergreen forests. In sparsely populated interior places of South Indian Western Ghats, the forests would regrow and through time get back most of the original elements of the flora barring a few, as the fallow period was long (sometimes the tribes never returned to the original areas). As fire was an important factor in shifting cultivation, it may be that hygrophilous endemic tree species such as *Dipterocarpus indicus* and *Vateria indica*, failed to regenerate on slash and burn areas, but survived in protected areas like the sacred forests. The same could be true of *Madhuca bourdillonii* and *Syzygium travancoricum* (Fig. **5**).

DISCUSSION

Forest history of Uttara Kannada reveals that shifting cultivation was a decisive force that altered the primary forests substantially, creating vast stretches of secondary forests. The early agricultural communities, however, left behind a great legacy of sacred forests (*kans*) in Uttara Kannada and other adjoining districts. Many of these *kans* to this day are relics of the primary forests of the Western Ghats and are centers of endemism for both plants and animals. *Myristica* swamps are associated with some of these sacred forests [1,12,27,28]. These relics lost their special identity as sacred forests and got merged with the state reserve forests during the British administration [27]. Subsequently, they were subjected to commercial timber harvests, tree monocultures, etc. In many places, the *kans* were cut down for expansion of cultivation or converted into leaf manure forests or subjected to other kinds of human impacts [28, 29].

Our finding of *Dipterocarpus* in Ankola (14.7° N) goes to substantiate Caratini *et al*. [33], who have reported the presence of its pollen in marine core samples close to Kali River estuary (14.8° N). This is incidentally range extension of present distribution of *Dipterocarpus* towards north by 30

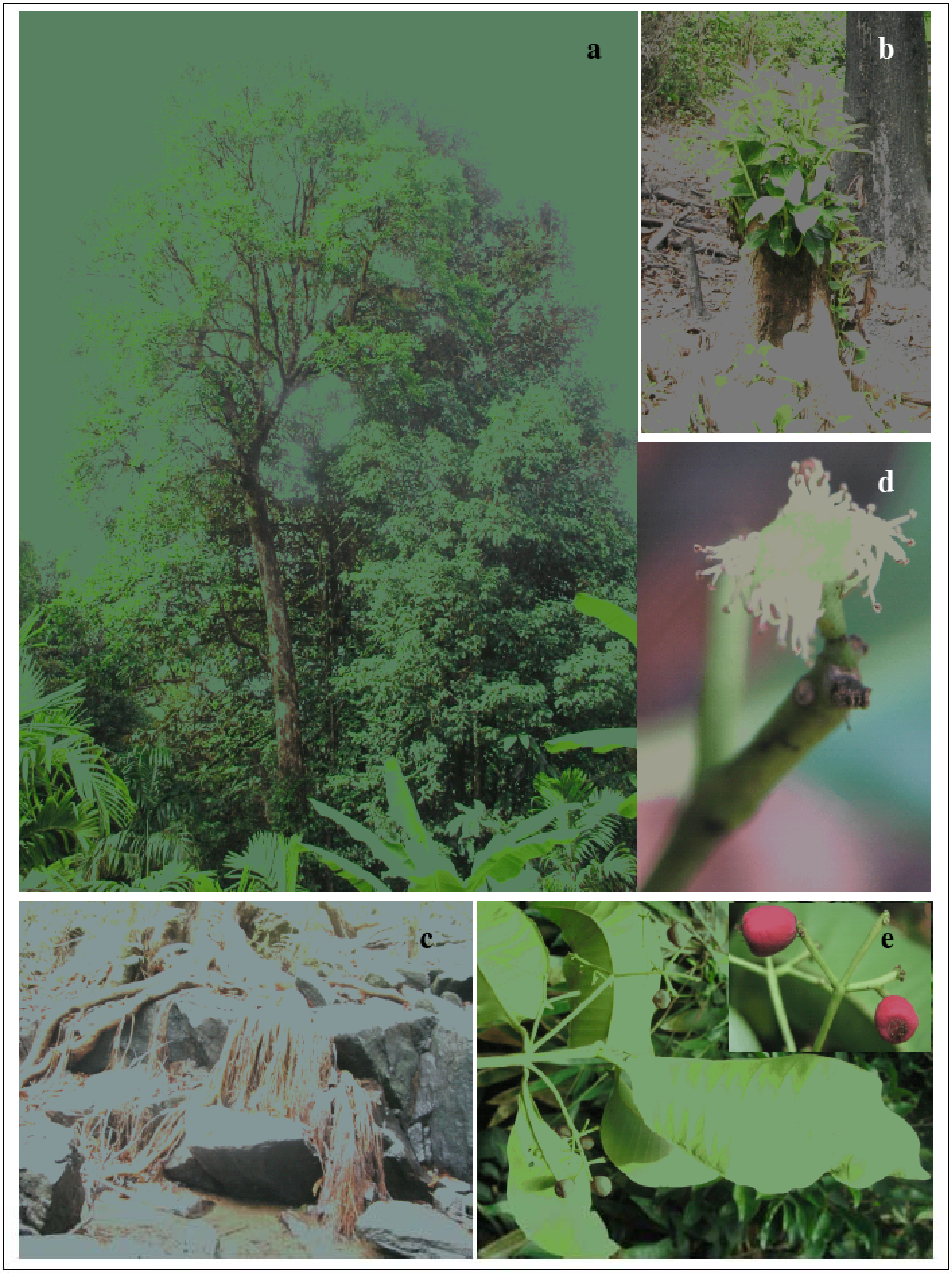

Fig. (4). a) *Syzygium travancoricum* – habit; **b**) coppicing stump; **c**) floating water roots; **d**) a single flower and **e**) twig with fruits.

Fig. (5). The habitat of *Syzygium travancoricum* – under threat from encroachment.

km. The *Dipterocarpus* patch in Ankola was obviously part of a sacred *kan* forest. A small *Myristica* swamp is also associated with it. Same could be stated about *Syzygium travancoricum*, a stately tree, thought to be extinct once, but rediscovered later, only in southern Western Ghats. Our findings of this critically endangered tree in Siddapur of Uttara Kannada and a single individual in Ankola, in forest patches of ancient antiquity, is very significant. The Siddapur relic forests are also home to recently discovered new tree species *Semecarpus kathalekanensis* [2]. However, biologists should restrain themselves from the general tendency of naming any apparent novel occurrences of plants or animals that they might come across in relic forests as new species; these could as well be the relics of ancient populations or their morphological variants.

The occurrence of *Madhuca bourdillonii* and *Syzygium travancoricum* in Uttara Kannada forests of central Western Ghats, along with *Myristica* swamps and *Dipterocarpus*, clearly goes to prove that low altitude climax evergreen forests with the entire gamut of endemic species of flora and fauna, had more northern ranges for their distribution. Their present day disjunct distribution is largely on account of human impacts on the primeval forests, which have been largely wiped out. Several authors also consider that the current discontinuity of some faunal species in India, might represent relics of a former continuous distribution [34-37]. Karanth [38] considers climatic change and deforestation might be the major causes for present day disjunct distribution and aggregation of the endemic and endangered primate lion-tailed macaque (*Macaca silenus*) in the relics of wet evergreen forest patches of the South Indian Western Ghats.

The view is strengthening among the conservationists about the importance of protecting also smaller patches of forests in the tropics that lie outside large reserves as a substantial number of forest species can persist for decades in fragmented forest [6,38-40]. Inevitably, small fragments will become the last refuges of many rainforest species that are on the brink of extinction, despite the proneness of such populations suffering from depressed reproductive outputs [41]. It is in some such fragmented forests that we have observed the critically endangered species *Madhuca bourdillonii* and *Syzygium travancoricum*.

What is of grave concern for conservationists is the casual attitude with which the Western Ghat forests are managed, nearly oblivious of their ecological history. Bulk of the primeval forest fragments, in whose conservation the precolonial farmers appear to have played key role have perished during the period of modern forestry, whose foundations were laid by the British. Foresters and ecologists should be able to distinguish between relics of primeval forests and advanced stages of secondary successions. Lack of this perception would result in the silent extinctions of scores of endemic species. *Madhuca bourdillonii* in Uttara Kannada is on the verge of extinction on account of unsatisfactory reproduction as well as human and predatory pressures. We are hopeful that more such relic patches with their valuable biota might be in existence in between Travancore and Uttara Kannada.

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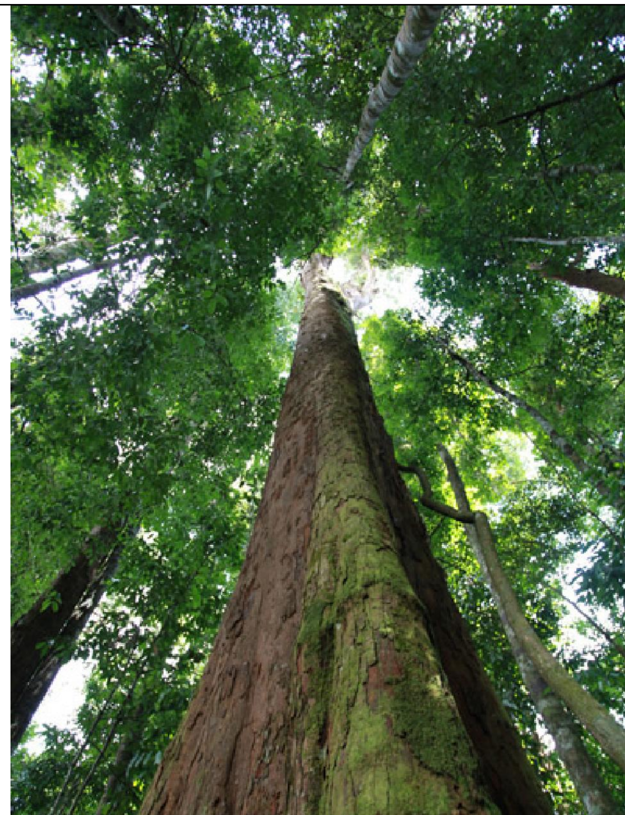

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