KFRI Research Report No. 372 ISSN 0970-8103

Mapping and Quantitative Assessment of Geographic Distribution and Population Status of Plant resources of Western Ghats

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October 2010

Abstract of project proposal

Code: KFRI 463/04

Title: Mapping and quantitative assessment of geographic distribution and population status of plant resources of Western Ghats

Objectives:

1. Quantitative assessment of population status and geographic distribution of the plant resources of Western Ghats.
2. Identifying threats on the plant resources along the Western Ghats.
3. Setting up a Western Ghats Eco-region specific database on plant resources.

Date of commencement: December 2004

Date of completion: March 2010

Funding agency: Department of Biotechnology

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Sri. C.Pramod (Feb.2005 - Jan.2007)

Sri. A.J.Robi (Feb.2007 - Jul.2008)

Sri. Anil Raj (Nov.2008 - Jan.2009)

Sri. T.J.Robi (Mar.2009 – Feb. 2010)

Acknowledgements

I am thankful to Dr.K.V.Sankaran, Director, Kerala Forest Research Institute; Dr.J.K.Sharma and Dr.R.Gnanaharan, former Directors, KFRI, for their encouragement throughout the period of the study. The unstinted co-operation from Dr.N.Ganeshaiah, Project Coordinator and Professor, University of Agricultural Sciences, Bangalore, is gratefully acknowledged. I appreciate the financial assistance and co-operation extended by the Department of Biotechnology. I am also grateful to Kerala Forest Department for permitting us to establish study plots in the forests of Kerala and for the extensive support of the KFD field staff. I appreciate the help rendered by Sri. G. Magesh, Sri. C. Pramod, Sri. A.J. Robi, Sri. Anil Raj, Sri. T.J. Robi, Research Fellows in the project. Thanks are due to Dr.N.Sasidharan, Dr.P.Vijayakumaran Nair and Dr.K.V.Bhat, Scientists, KFRI, for their valuable comments and suggestions in improving the manuscript.

Abstract

The project aims at quantitative assessment, geographic distribution, conservation status evaluation and phytogeographic studies of plant resources of Western Ghats. The data sets and the spatial maps generated under this project must be useful for the conservation, sustainable utilization and management of the plant resources of Western Ghats. The project envisages a thorough documentation of plant resources of the entire Western Ghats by adopting a uniform and novel approach of integrating fine-tuned, extensive field surveys with recent algorithms of vegetation classification. It tends to generate a spatial and upgradeable database on species/habitat/landscape elements, which would enable to derive appropriate strategies for efficient resource use. Further, it would help in drawing conservation maps for rare and endangered taxa as well as to enhance our understanding of the population status of the plant resources. The data can also be used for environmental impact assessment and to provide useful information for many biological needs.

Based on the project data it was observed that the rare, endangered and threatened (RET) plant species in the Western Ghats have gone up from 25 to 40%. It has been found that 1600 species of plants come under the RET category. Majority of these endangered species of plants have been found in Kerala and Karnataka parts of Western Ghats. The entire Western Ghats region was divided into 3000 grids of 40 km^2 each and surveyed. Under the project 4000 species of plants have been surveyed, 1500 of them were trees and the rest are shrubs and herbs. There were about 900 species with well

known medicinal use in the Western Ghats. The survey shows that diversity is abundant particularly, in central and southern parts of Western Ghats, thus making it possible to calculate the economic value of the Western Ghats and also to identify the economically rich areas.

Contents

Introduction

Retriving information about forest resources is a process for obtaining information on the quality and quantity of forest resources and forms the foundation of forest planning and forest policy. While earlier concept of sustainable forest management and forest inventory focused on timber production, modern forest inventory concepts support a holistic view of forest ecosystems addressing not only timber production, but also the multiple functions of forest as well as the need to understand the functioning mechanism of the forest ecosystems. Forest resource assessment facilitates a multifaceted analysis and study of forests is not only an important source of subsistence, employment, revenue, earnings, and raw materials to a number of industries but also critical for their vital role in ecological balance, environmental stability, biodiversity conservation, food security, and sustainable development of countries and the entire biosphere. Forests have to be managed judiciously not only for environmental protection and other services but also for various products and industrial raw material.

The natural terrestrial ecosystems like forests, grasslands, scrublands, aquatic ecosystems, agricultural systems and plantations provide immence potential in terms of *"bioresources"*. About 21% of India is under forest cover approximating to an area of 68 millian ha. Forests in India are widly distributed across different bioclimatic and topographic zones offering valuable ecosystem services as carbon sinks, soil erosion control, flood mitigation and various goods. The need for understanding and assessment of this multiplicity of biodiversity in terms of ecosystem services and goods is important in order to design appropriate conservation strategies.

Any meaningful utilization of plant resources in the country warrants a systematic inventory in resource rich areas such as the Western Ghats. The Western Ghats is considered as one of the global biodiversity hot-spots harbouring over 5000 vascular plants, of which about 30% are endemic to the region. The Western Ghats is a 1,600 km long mountain range running all along the west coast of India. It covers the states of Kerala, Tamil Nadu, Karnataka, Goa, Maharastra and Gujarat. Covering approximately 1,40,000 km^2, these mountains are home to a number of endemic plants and animal species. These hills are interrupted at Phalgat with a gap of about 30 km (Palghat gap). Western Ghats show a high altitudinal variation and the average elevation is 1,200 m. The Anaimudi is the highest peak with an elevation of 2695 m. The narrow plain between the Western Ghats and the Arabian Sea is known as the Konkan coast. A number of rivers arise from the Western Ghats and either flow westwards and drain in the Arabian Sea or flow eastwards and drain into the Bay of Bengal. Bioresource data from inventorying and monitoring are essential for identifying the key issues for policy and management goals. Diverse physical and climatic conditions of Kerala provide ample space for a spectrum of vegetation types from tropical rainforests to dry deciduous forests. Each type of vegetation has a set of life forms characteristic to the forest type. The Forests of Western Ghats have been logged from time immemorial. In many parts of the Western Ghats, the forests have been converted to agricultural lands. Besides, plantation crops such as coffee, tea, rubber and teak have replaced the original vegetation. A number of NTFP species are harvested by the forest dwelling and forest dependent communities. Extraction of medicinal plants from the Western Ghats has been recorded from the past 200 years. The Western Ghats is also threathened by a number of

developmental activities such as roads, railways, dams etc. A large number of livestock is dependent on the Western Ghats. Encroachment in many protected areas also has been reported. The Western Ghats has been declared as an ecologically sensitive area and an ecological hot-spot in 1988. A large number of plants, amphibians, birds, reptiles and mammals are endemic to this region. This area has a number of 'protected areas' including two Biosphere reserves, fourteen National parks and several Wildlife sanctuaries. Many regions are declared as reserve forests. Within the Western Ghats there are many community conservation areas like the sacred groves.

Understanding the spatial distribution of plant diversity is the prerequisite for meaningful conservation of any natural ecosystems. However, very little is known about the resource availability and quantity of extraction and its impacts on conservation of biodiversity of the forest and there is a critical need to map the plant resources at local, regional and national levels throughout the Country. Hence, mapping of these resources reflecting the spatial distribution would serve several purposes such as locating hotspots of plant diversity, assigning conservation values for different areas, information on the structure and dynamics of vegetation and eventually formulating strategies for sustainable utilization of the plant resources based on a perspective of economic value of forest resources.

The network project on quantification and mapping of plant resources of the Western Ghats was initiated in the year 2004. The present study is a part of National Project on Bioresource Quantification and Mapping of Western Ghats, sponsored by Department of Biotechnology, focusing on quantitative assessment of the geographic

distribution and population status of the plant resources of the Western Ghats. Several teams from different Institutes/Organizations like Universiyy of Agricultural Sciences (UAS), Bangalore; Ashoka Trust for Research in Ecology and the Environment (ATREE), Bangalore; College of Forestry, Sirsi; College of Forestry, Ponnampet; Kerala Forest Research Institute (KFRI), Peechi; Shivaji University, Kolhapur and RANWA, Pune were involved in the data collection and mapping of whole of the Western Ghats. Mapping of plant resources of the Southern part of the Western Ghats in Kerala i.e., from Palakkad gap to Trivandrum was assigned to Kerala Forest Reserarch Institute, with the following objectives.

1. Quantitative assessment of population status and geographic distribution of the plant resources of Western Ghats.
2. Identifying threats on the plant resources along the Western Ghats.
3. Setting up a Western Ghats Eco-region specific database on plant resources.

Background

The hill ranges of the Western Ghats, covering a length of 1,600 km from the river Tapti in the North to Kanyakumari in the South, stand as a great barrier between the West coast of India and the rest of the peninsula. This positioning influences rainfall patterns and the high precipitation of the Western slopes makes the Western Ghats biologically rich and geographically unique.

The Western Ghats are divided into 3 major regions based on geology and topography. The Northern portion of the region from river Tapti to Goa is identified as the Northwestern Ghats, the Central Western Ghats runs from Goa to the Nilgiri hill ranges and the Southwestern Ghats begin from South of Palghat gap and end at the

Southern tip of India (Fig.1). While the whole of the Western Ghats is ecologically significant, it is worthwhile to invest in regions with high conservation returns. The Southwestern Ghats provide such an opportunity with intactness of habitat and high biological wealth, of which a significant percentage is endemic.

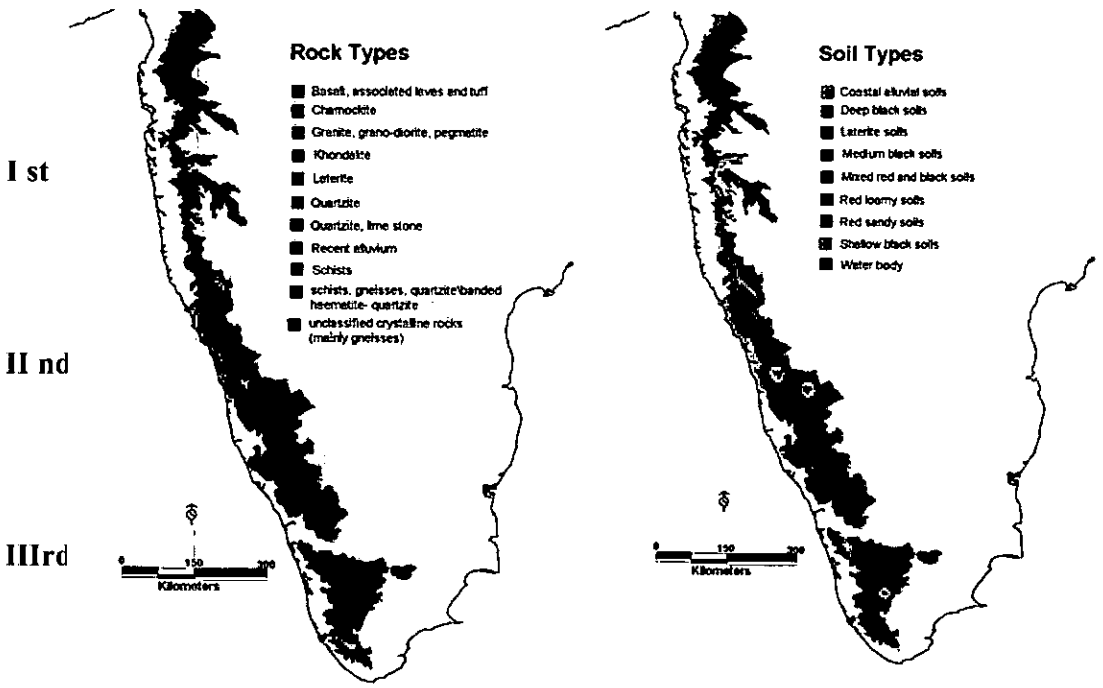


Fig.1. Three major regions of W.Ghats

The Southwestern Ghats cover an area of 12,500 km^2 in the states of Kerala and Tamil Nadu and harbour a rich floral and faunal biodiversity which include 4,000 flowering plants. Some of the important and unique habitat types found here includes wet evergreen forests and sholas in the higher elevations. This region is a veritable treasure house of biodiversity and much of it is still to be studied and understood. The Southwestern Ghats are also crucially important for the ecological goods and services they provide. Forty four rivers originate from here, providing water to the cities of Kerala and Tamil Nadu states. The important rivers providing water to different cities are the

Periyar for Ernakulam, the Chalakkudy for Trichur, the Neyyar and Karamana for Thiruvananthapuram, the Bharathapuzha for Palakkad, and Meenachil and Muvattupuzha for Kottayam. Mapping and Quantification of Plant resources of Western Ghats co-ordinated project started in the year 2004 funded by the Department of Biotechnology New Delhi.

Materials and Methods

The study area was divided into grids of 6.25 km x 6.25 km area. Grids of the Western Ghats region were generated by overlaying topo-sheets with Western Ghats boundary. Each grid was around 40 km^2 area. Three hundread grids were considered for the present study in the Southern Western Ghats of Kerala. In each of this grid, a belt transect of 1 km x 5 m was laidout. Depending on the habitat heterogeneity, each of this transect was divided into two or three units. All plant species in these sampling units were recorded and identified up to the species level by using standard floras and some species were identified by consulting taxonomists. Herbarium specimens were prepared for most of the species.

Vegetation Sampling Methodology

In the sampling unit (grid), Belt-Transect Method employed for the vegetation sampling. Belt-Transect of 1000 m x 5 m length were laid in each grid. Regenerating tree species were recorded by putting two quadrates of 5m x 5m size in 1 km transect. Two quadrates of 1m x 1m size, one at the beginning and other at the end of transect to record the herbaceous species.

Geo-coordinates of the sampling locations were recorded at the starting and end point

of transect. Starting point and the direction of transect were marked by the paint on the tree. Tree layers were enumerated in the entire 1 km belt transect. Trees having girth of 30 cm and above were measured by using tailors/metal tape. Height of the every tree was measured approximately. Regenerating tree species were recorded in numbers for each species under different height classes. Herbs were documented in percentage or in numbers for each species. After the end of the transect details of topographic factors, edaphic factors, biotic factors etc were recorded. Total Area of Western Ghat region is 1,21,900 sq km with a length of 1,500 km (straight) and 1600 km (through). The perimeter of the region is 7,753 km and the width is ranging between 12.50km (min) and 200 km (max), with an average of ~75 km. The latitude of the region (between Dhule to Kanyakumari) is $21^0\,27'\,34''$ to $8^0\,31'\,89''$ and longitude (between Thane to Thirichirapalli) is $72^0\,94'$ to $78^0\,32'$. The Western Ghats area was divided into 6.3 Km^2 grids (3231 grids of 3.75'x 3.75' size) and systematic sampling procedure was adopted using appropriate sampling strategy. Two to three transect per grid covering a length of 1 km per grid were taken. A common format for data collection was standardized and the field data collection by each collaborating team was based on the common format. The work was carried out by six groups located all along the Western Ghats and each team took the responsibility of assessing the bio-resources in their respective zones (Figs.2 and 3). In the present study 320 grids covering the Kerala part of Western Ghat regions were enumerated (Fig. 3).

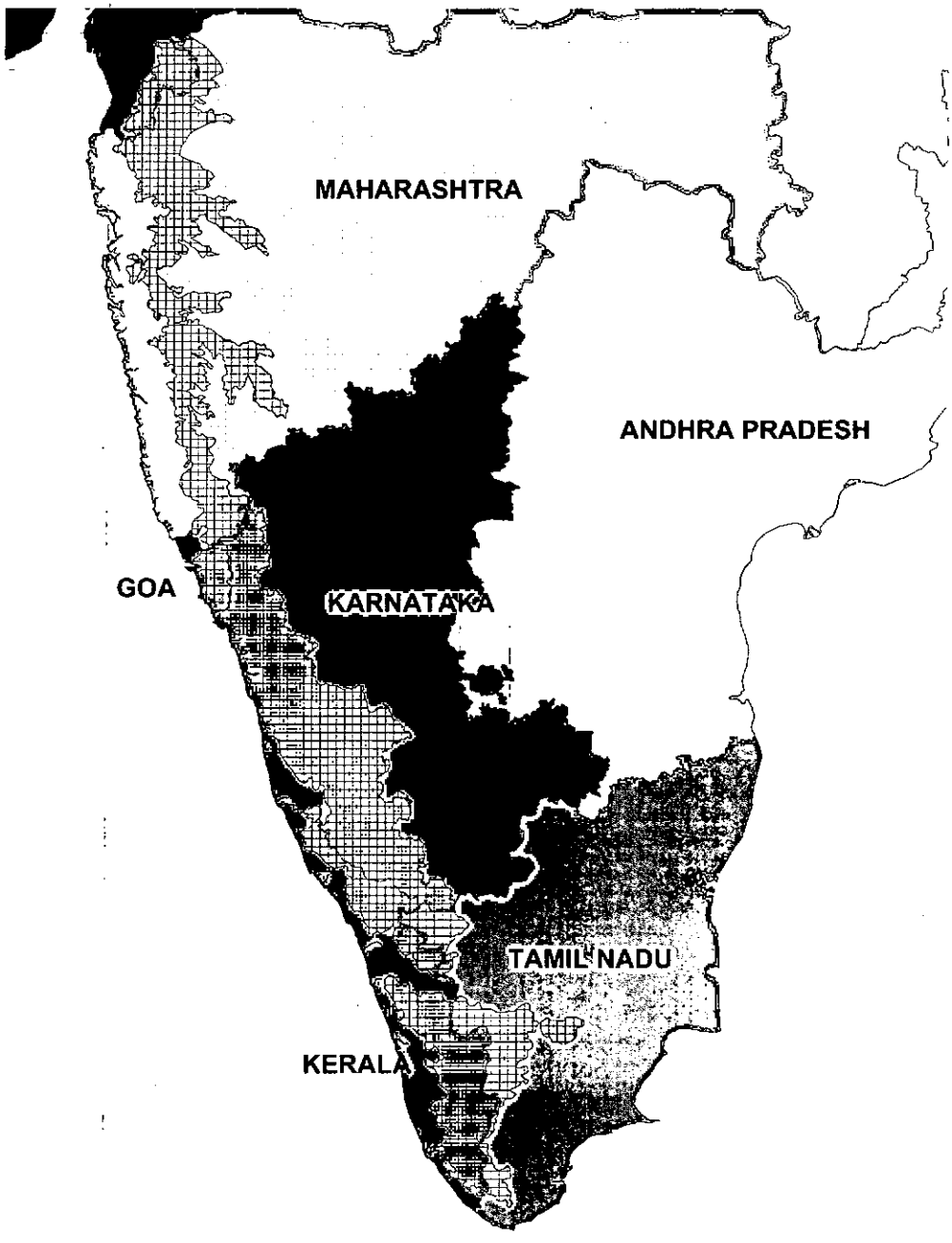


Fig.2. 10 x 10 km grid map of Western Ghats for Plants

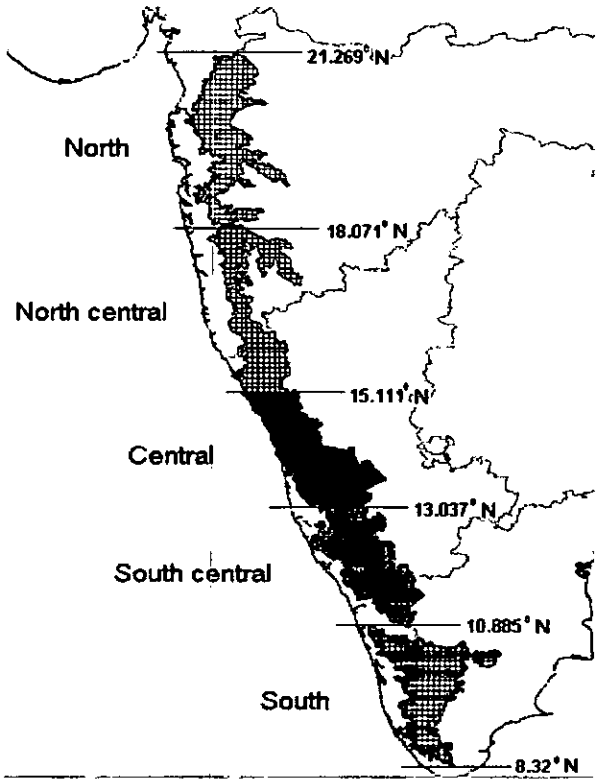


Fig.3. Grids covered in Western Ghats

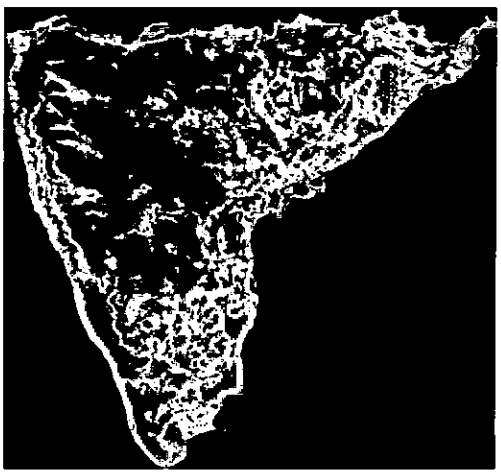


Figure 4. NDVI map of W. Ghats

Stratification of the grids based on the land-use pattern and forest types is the most crucial aspect to capture the spatial heterogeneity in plant diversity. For this purpose a special GIS based package, Decision Supporting System (DSS) for stratifying and sampling the Western Ghats, was developed at the coordinating centre, University of Agricultural Sciences, Bangalore. This userfriendly software incorporates several layers such as topographic grids, rivers, road links, monthly NDVI values (at 1 x 1 Km), FCC color maps (88 x 88 m), villages and vegetation layers. Based on NDVI image (Fig 4), the exact location of the transect, within a grid, was decided (Fig.11). Satellite imagery was also used for identifying vegetation types and its density status prior to sampling. Vegetation data from 5 x 1000 m strips of the grids were gathered for structural and species distribution analysis. One survey of India Topo-sheet at 1:50,000 scale was

equivalent to 16 sampling units of 6.25 x 6.25 km (Fig.3).The diagrammatic representation of the sampling units are given in figure 5. About 300 grids fell in Kerala region. Transects were laid to capture the maximum species richness along the altitudinal gradient or any other such gradient, and they could be of a single 5 x 1000 m or a maximum of three sub transects with measurements of two 5 x 500 m or 5 x 400 m + 5 x 300 + 5 x 300 m etc., depending upon the habitat heterogeneity and feasibility to work in a grid. The frequencies of all trees in the GBH (girth at breast height) category of 10-30 cm were recorded. All shrubs, trees that fell in the standardized classes and all climbers that had attained a girth threshold of 10 cm GBH were inventoried in 5 x5 m regeneration plots. Herbs were quantified by counting individual clumps and also culms within each clump. A common data inputting programme (WeGPR – Western Ghats Plant Resources) was developed and was used by all collaborating teams of the national project. This programme had in-built names of all the species compiled from different floras. The software helped in error free inputting of the data. The programme had been designed to retrieve the data with specific queries.

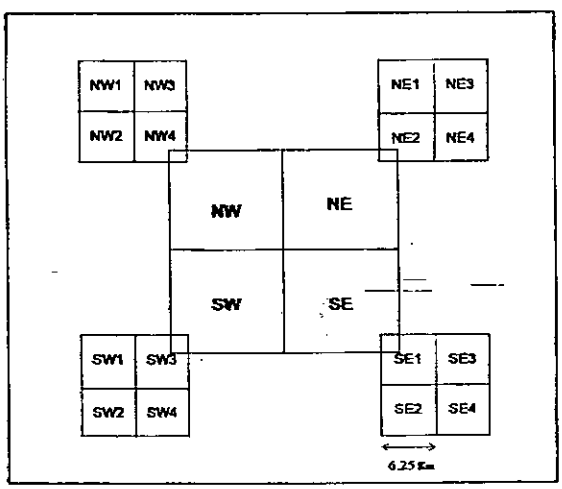


Fig.5. Diagrammatic representation of sampling units

The project objectives entail creation of reference sheets on each of the species, to be used in the field, to correctly identify the species. A common format of "Fliers" (Figs. 6, 7.) was standardized for the use of all the groups. As the part of the National project, to develop fliers about 17000 digital images were compiled and deposited in the Western Ghats image bank at the coordinating center, University of Agricultural Science –UAS, Bangalore. The sample of format of flier preparation was based on:

i. Fact fliers contained rare images and description of tree species of the Western Ghats compiled and presented to help the researchers to identify the species at the field level.

ii. The size was reduced to help the researchers to carry to the field easily (half of the A4 size).

iii. The format of the fliers was designed such that fliers could be organized in to one file based on several themes.

iv. It was open ended format, to which individual fliers could be organized for various purposes and focused as shown below:

- A taxonomist may wish to organize the fliers into families
- A tree breeder may wish to compile only timber yielding species.
- A conservation biologist may wish to choose only RET species of a region.

v. The fliers could be updated as and when information for different species was available in hand.

The effort of the study represented first ever inventories where the entire global hotspot was surveyed at very fine scale of 6.25 x 6.25 km (40 sq km). The study

enumerated all the plant resources (herbs, shrubs, trees and saplings) and their population status in each grid. This made it possible to understand resource levels and conservation status of each species across spatial dimensions.

The data generated in the process helped in assessing and mapping the plant resources in different parts of the country. From these data sets it was possible to assess the total resource available for any species.

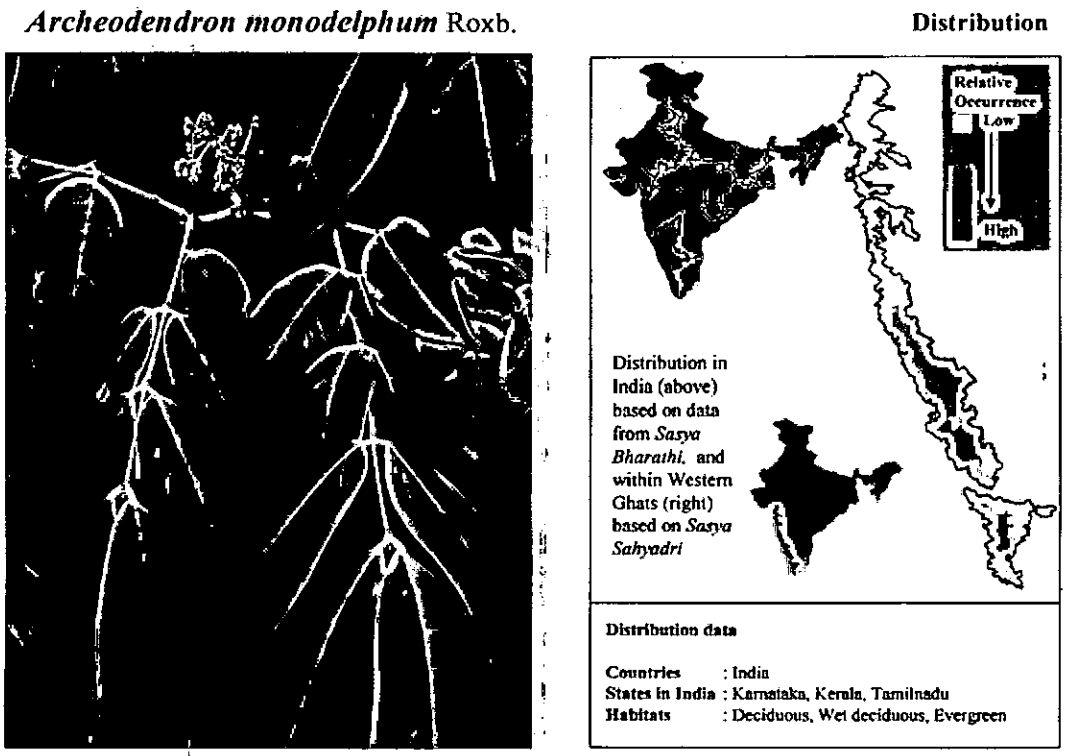


Fig.6. Sample "Fliers" front page

Archeodendron monodelphum Roxb.

Description

Synonyms :*Mimosamonadelpha, Pithecellobium bigeminum, Pithecolobium monadelphum*

Family : Fabaceae

Local names :

Key characters : Petiole 3-4 cm long, with a gland above the middle; pinnae 1-2 pairs, 10-15 cm long, usually with glands between all leaflets; leaflets 3-4 pairs, elliptic-ovate to elleptic-oblong, rounded at base, to 15x15 cm. Corolla white, 2-3 times as long as calyx. Pod circinate, acute at apex, 8x1.5 cm, brown outside, orange-red within; seeds black, exarillate.

Flowering/ Fruiting : January-July

Habitat : Frequent in Semi-evergreen to wet deciduous forests of Western Ghats.

Distribution :

Uses :

Conservation Status :

Notes:

Fig.7. Sample "Fliers" back page

Field data on occurrence, population, size class and threat status were collected from over 2000 km transects in 2300 grids spreading in all the six states. Among the total number of 2300 grids, 300 grids were covered in Kerala region by KFRI team (Fig.3). The Normalized Difference Vegetation Index (NDVI) values of the area were superimposed over grid map and transect is laid in uniform density areas (Figs. 8-10).

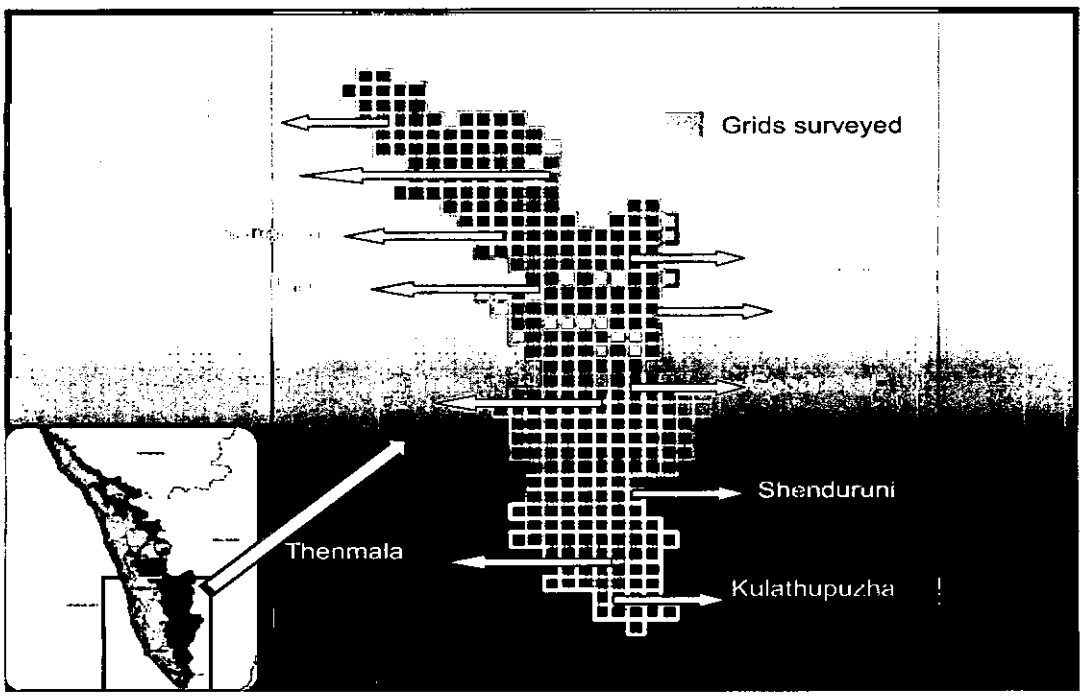


Fig.8. Grids covered in Kerala

Fig.9.NDVI value over Grids

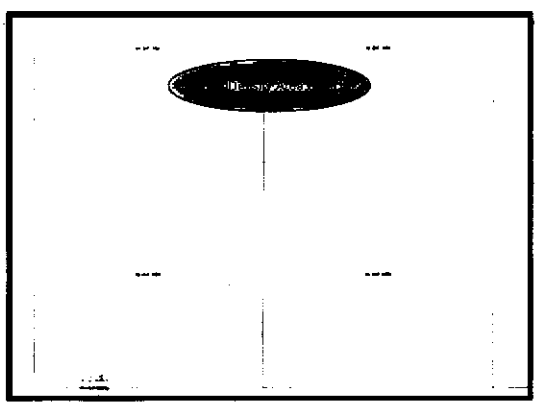


Fig.10. Uniform density area

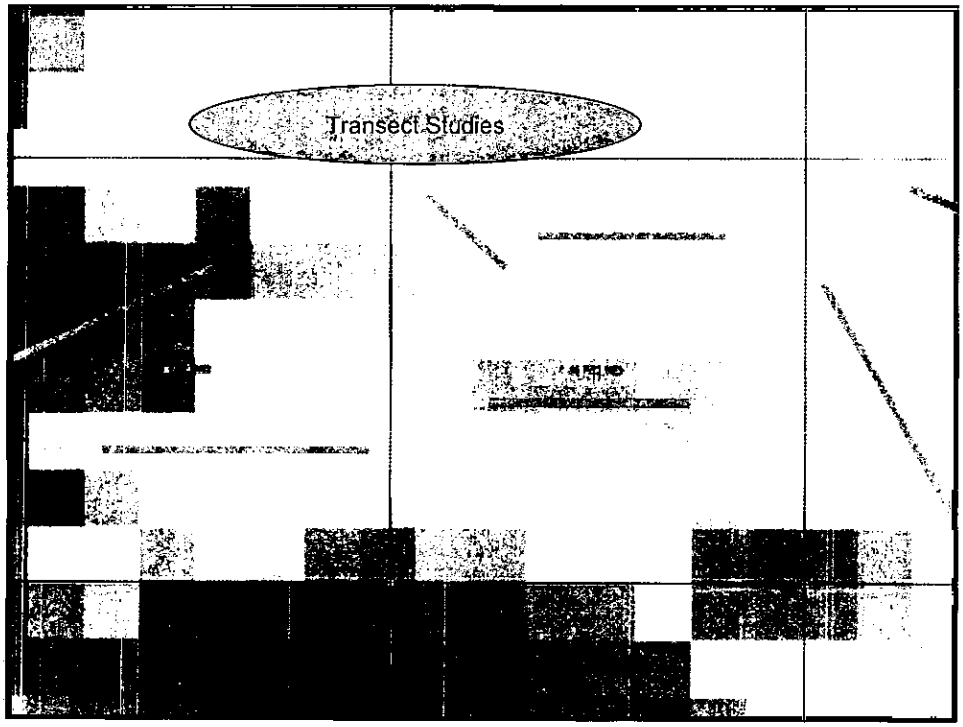


Fig.11. Transects in Uniform Density area

Results and Discussion

Forest types

Kerala is a small state in the southwestern corner of India. It represents 1.18 per cent of the total area of India but claims around 3.1 per cent of the total population of the country with a population density of 819 persons per km^2. As per official records of the Forest Department, 11,268 km^2 of the land is classed as forests, which is about 29 per cent of the total geographical area of the State.

Plant Resorces and their Population status

The effort of the study represent first ever inventories where the entire global hotspot was surveyed at very fine scale of 6.25 x 6.25 km (40km^2). The study enumerated

all the plant resources (herbs, shrubs, trees and saplings) and their population status in each grid. This made it possible to understand resource levels and conservation status of each species across spatial dimensions. The data generated in the process helped in assessing and mapping the plant resources in different parts of the country. From these data sets it would be possible to assess the total resource available for any species.

A total of 300 grids (*i.e.* 6.25 x 6.25 km each) were covered during the period of March, 2005 to March, 2010. This means 300 kilometers of transect with a 5 meters width were walked along the Central Western Ghats. With these grids, the following major forest types of Champion and Seth, (1968) were sampled (Table1).

Table 1.Major land cover types in the study area

Land cover Type	**Type as defined by Champion & Seth**	**Code (C&S)**
Evergreen Forest	Southern Hill top Tropical Evergreen Forest	IA/C3
	West Coast Tropical Evergreen Forest	IA/C4
	Myristica Swamp and Submontane Hill Valley Swamp Forest	4C/FSI & 2
	Cane Brakes	I/E1
	Nilgiri Subtropical Hill Forest	8A/C1
	Southern Montane Wet Temperate Forest	11A/C1
Semi-evergreen Forest	West-coast Semi-evergreen Forest	2A/C2
	Lateritic Semi-evergreen Forest	2/E4
	West Coast Secondary Evergreen Dipterocarp Forest	2A/2S1
	Riparian Fringing Forest	4E/RS1
	South Indian Tropical Hill Savannah Wood land	8A/C1/DS1
	Wet Bamboo Brakes	1/E2

Moist Deciduous Forest	South Moist Mixed Deciduous Forest	3B/C2
	Southern Secondary Moist Mixed Deciduous Forest	3B/2S1
	Moist Teak bearing Forest	3B/C1 (a/b/c)
	Moist Bamboo Brakes	2/E3 (2/2S1)
Dry Deciduous Forest	Southern Dry Mixed Deciduous Forest	5A/C3
	Secondary Dry Deciduous Forest	5/2S1
	Dry Savannah Forest	5/DS2
	Dry Bamboo Brakes	5/E9
Reeds	Reed Brakes (*Ochlandra*)	8A/C1/E1
Teak	Dry Teak Forest	5A/C1 (b)
Degraded Forest	Laterite Thorn Forest	5E7
Scrubs/Shrubs	Dry Deciduous Scrub	5/DS1
	Pioneer Euphorbiaceous Scrub	I/2S1
Grass lands	Southern Montane Wet Grassland	11A/C1/DS2
	Southern Montane Wet Scrub	11A/C1/DS1

In addition the following cover types are also studies: viz. Swamp forest, Riparian, Shola forests, Plantations (eucalyptus, acacia, teak, arecanut, coconut, coffee, tea) and Agriculture land (paddy, coconut, rubber).

Density and Distribution of Plant species

Geocordinates of each location or the sampling unit helped to draw the density and distribution of plant resources of the Southern Western Ghats and they also could help to understand the population status of all the species. From the "Indian Bioresource Information Network" Programme prepared to understand the density and distribution of plant resources of the whole Western Ghats could extract the thematic maps of density and distribution of all the species of Southern Western Ghats (Figs.12-14).

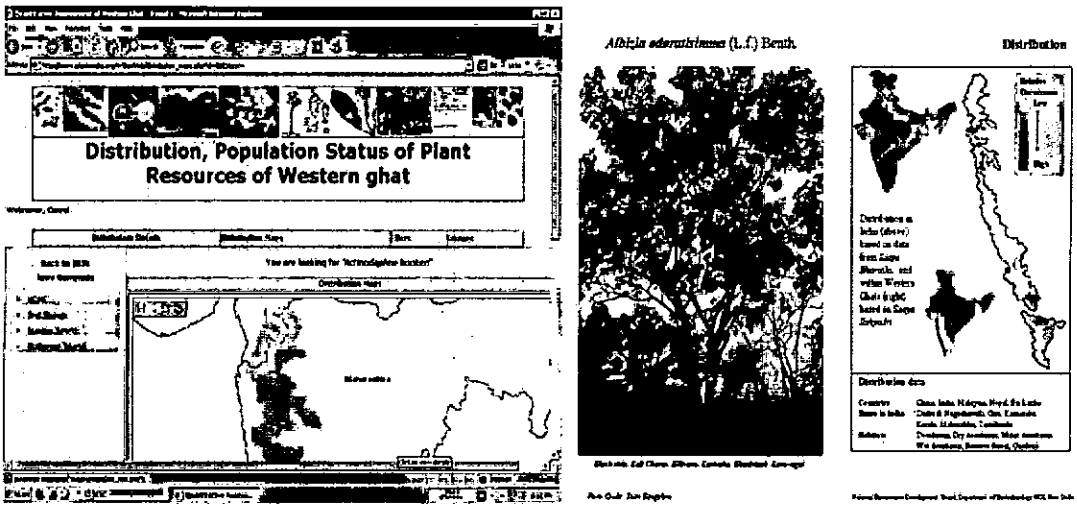
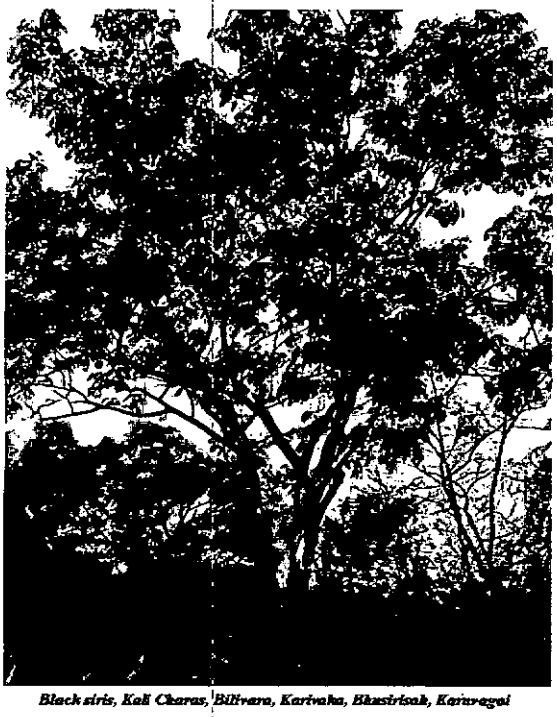


Fig.12. Maps showing Density and Distribution of Plants in Southern Western Ghats

Based on the density of the plant species from each sampling unit, it enumerates the threat status of each plant species. The study listed out some plant species categorized under Rare Endangered and Threatened category in the Southern Western Ghats. Those species which are singleton or doubleton in the grids would be facing more threats than those which occur in more number of individuals.

Pooled over all the teams, over 1, 54,997 individual plants have been considered, from Western Ghats, till date for the database creation by the major collaborator, University of Agricultural Science, Bangalore. All major forest types have been covered for enumeration. This is perhaps the biggest primary dataset on the plant resources accompanied by their spatially explicit distribution data in the country. The database developed from these studies on plant resources of the Western Ghats today holds records arising from about 2000 grids (each of 6.25 x 6.25 km geographical area). In all, 3,048 species of plant resources belonging to 1,546 genera have been identified; among them 1,389 species were of tree forms, 896 species were shrubs, and 763 species, herbs.



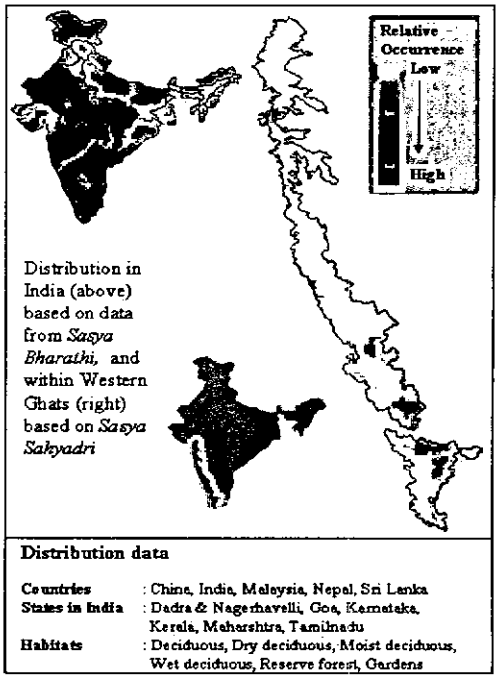


Fig.13. Sample page showing Distribution status

The overall Shannon's diversity was at 5.31. The top ten plant species with respect to abundance were *Tectona grandis, Terminalia paniculata, Memecylon umbellatum, Terminalia tomentosa, Syzigium cumini, Olea dioica, Anacardium occidentale, Acacia auriculiformis, Mangifera indica and Xylia xylocarpa.* Among these, one species was non-native to the Western Ghats; two were plantation species, suggesting the changing landscape of the plant resources of the region.

Albizia odoratisimma (L.f.) Benth.

Photo Credit: Team Bangalore

Description

Synonyms : *Mimosa odoratissima*

Family : Mimosaceae

Local names : Black siris (Eng.), Kali Charas (Hin.), Bilivara (Kan.), Karivaka (Mal), Bhusirisah (San.), Karuvagai (Tam.).

Key characters : Unarmed tree. Leaflets 8-15 pairs. Flowers fragrant, sessile in heads arranged in terminal panicles. Corolla dull white. Pods shortly stalked, oblong, thin, downy brown often with 1 cm long beak. Seeds 8-12, yellowish brown, compressed.

Flowering / Fruiting : November-May.

Habitat : Deciduous forests and also planted as avenue tree.

Distribution :Andaman Nicobar, Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Delhi, Goa, Gujarat, Himachal Pradesh, Jammu Kashmir, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Mizoram, Orissa, Rajasthan, Sikkim, Tamilnadu, Uttar Pradesh, West Bengal.

Uses : Bark is used as fish poison.

Conservation Status : Rare

Notes:

Fig.14. Fliers of Plant showing the distribution and description regarding the species

Of the 3,048 species identified, about 308 (10.10 %) plant species have been represented by only one individual (and hence identified in only grid) and 153 species (5.02 %) have been represented by two individuals in the sample grids. This suggests that the percentage of rare/endangered species could be substantial than what is popularly believed.

'WeGPR', a software tool in Visual Basic and Access has been developed to feed, assess the extent of data collected in the program and also to evaluate the distribution and availability of different species along Western Ghats. This program also maps the availability of different species and their population status in different grids,

diversity of trees, shrubs and herb layers and also links each species to the fliers and specimen collected.

Database was created for species-wise and grid-wise search at a finer scale. The database is available upto taluk level for trees, shrubs and herbs. The data so made available will help in mapping the hotspots of resource diversity and availability. The website also offers thematic maps depicting population distribution. It enables users to derive information on availability of specific resources in different areas. The datasets generated suggest that some species have already reached critical levels in certain areas and are in need of careful planning for their long term conservation.

Regeneration status

The process of natural regeneration in evergreen forest is a complex process and less known. Although it is of practical importance to foresters, scientific knowledge regarding the field factors affecting natural regeneration is practically unexplored. Much of what is written about the so-called natural regeneration refers to the reproduction of a few economic species under conditions rendered more or less unnatural by timber exploitation. Further, the various factors that control the intensity and direction of natural regeneration *viz.*, phenology, seed production, seed predation, viability, germination, establishment and survival, light and shade conditions, microclimate, etc. are unknown or imperfectly known.

Regeneration studies were conducted in selected locations by laying out sample plots of 5 m x 5 m. The regeneration plots were laid within the tree enumeration plots of 33 m x 33 m size. Two regeneration plots were selected within the sample plots diagonally.

The following classification was followed for regeneration enumeration:

i) Un-established seedlings -- less than 40 cm height,

ii) Established seedlings -- 40 to 100 cm height but below 10 cm GBH,

iii) Advanced growth -- Over 100 cm height but below 10 cm GBH,

iv) Saplings -- Young trees from 10-50 cm GBH.

Regeneration status of tree species in different grids were evaluated based on the information collected from the selected regeneration plots. The species per grid status was plotted to get a general regeneration status map of Kerala part (Fig.15).

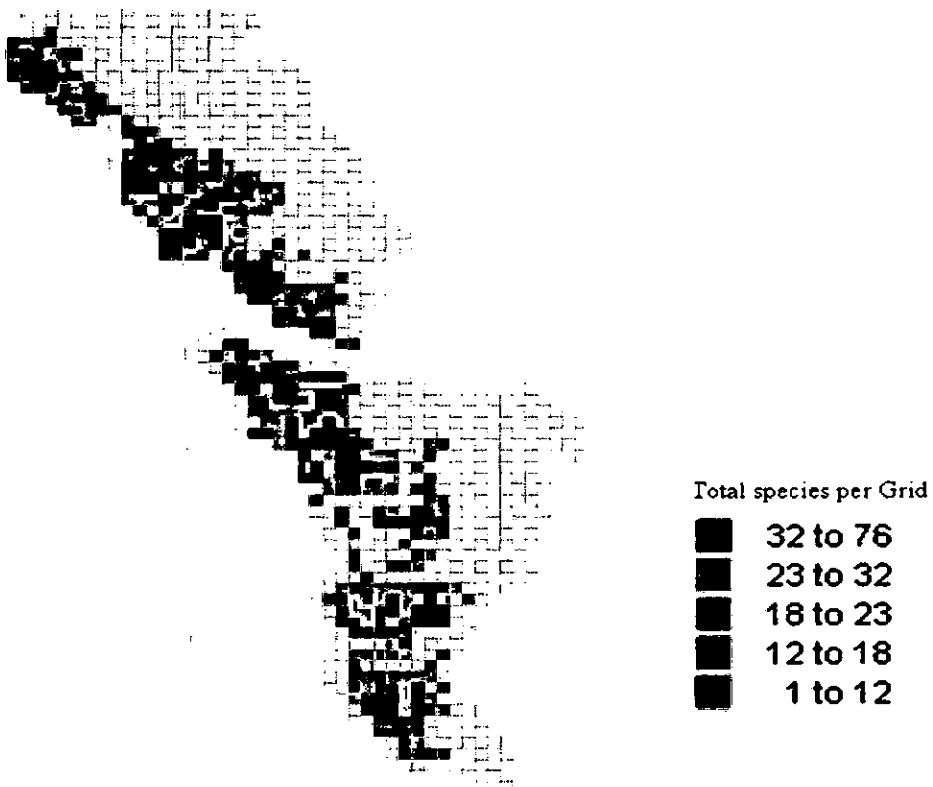


Fig.15. Distribution status of trees in Kerala region of Western Ghats

Within the primary forest the occurrence of individuals of a species in any particular spot is determined by the presence of regeneration of that species. The

occurrence of regeneration of a species is governed by the presence of the mother trees, dispersal mechanism and the flowering and fruiting behavior (Kartawinata, 1978). It is also determined by the gap formation. The lowland tropical evergreen forest is considered as the climax forest which is in a stable and steady state conditions. It is true that small scale destruction does exist, such as the gap left by old trees falling down in the forest. Within such gaps, dynamic changes occur where some seedlings grow rapidly due to light stimulation (as secondary species) while the growth of other primary species are suppressed. The forest gaps often favours growth of exotic species like Eupatorium, Mikania etc., since exotics are usually shows high range of ecological efficiency. Gap formation seems to be an important part of the life and dynamics of the climax forest (Richards, 1952).

The thick growth of the secondary forest species will undoubtedly suppress the growth of primary species. For sustainable management of forests for the better use of timber and other natural resources, special care is needed to maintain the functional aspects of the forests, by maintaining the structural composition.

Diversity indices

Diversity indices give indications of the relative importance of factors that affect the population as a whole. Diversity measures, taking into account of factors like species richness and evenness, are considered for the present study. The Richness index, Diversity indices, Evenness index and Hill-Diversity Numbers of the type were worked out (Table 2).

Table 2. Biodiversity indices of vegetation types of Kerala

Diversity indices	EG	SEG	MD	SC	NF
Richness Indices					
Mergelef's Index(R1)	17.228	23.256	27.096	8.881	5.851
Menhinick's Index(R2)	4.037	3.484	3.176	3.169	1.430
Diversity Indices					
Simpson's Index	0.021	0.022	0.039	0.056	0.160
Shannon's Index(H')	4.163	4.344	4.094	3.252	2.335
Hill Diversity Nos.					
N0:	117	186	234	50	40
N1	64.260	77.069	59.994	25.835	10.331
N2	46.741	46.053	25.969	17.765	6.235
Evenness Indices					
E1	0.874	0.831	0.751	0.831	0.633
E2	0.549	0.414	0.256	0.517	0.258
E3	0.545	0.411		0.507	0.239
E4	0.727	0.598	27.096	0.688	0.604
E5	0.723	0.592	3.176	0.675	0.561

EG – Evergreen, SEG – Semievergreen, MD – Moist deciduous, Sc – Scrubs, NF - Nonforest

Vegetation Analysis

The summary status of vegetation is given in Table 3 and the details of vegetation analysis of different types and non-forest area are given in Tables 4-8.

Table 3. Summary status of Vegetation

Cover type	Evergreen	Semi evergreen	Moist Deciduous	Scrub	Non-forest	All
Plot size (m)	1000 X 5	1000 X 5	1000 X 5	1000 X 5	1000 X 5	1000 X 5
No.of plots	9	23	59	4	12	97
Area studied (Sq m)	45000	115000	295000	20000	60000	535000
Sps observed (No)	117	186	234	50	40	333
Iindividuals (No)	840	2850	5427	249	783	10202

Type wise vegetation status of the forests

1. Evergreen Forests

The vegetation data from 9 plots of the size 1000 x 5m were analysed for the evaluation of the structural status of Evergreen forest type, covering an area of 45,000 m^2 the details of which are given in Table No. 2 and 3. Abbreviations used in the text are as follows:

D – Density, F – Frequency, Ab – Abundance, RD – Relative Density, RF – Relative Frequency, RBA – Relative Basal Area, IVI – Important Value Index.

The dominant components of the forests based on the IVI status were *Palaquium ellipticum, Pterocarpus marsupium, Chukrasia tabularis and Hydnocarpus pentandrus.*

Table 4. Type wise vegetation status (Evergreen)

Sl.No.	Species	N. Ind	D	A	F	RD	RF	RBA	IVI
1	Actinodaphne malabarica	3	0.67	3.00	0.11	0.36	0.47	0.05	0.88
2	Aglaia lawii	6	1.33	2.00	0.33	0.71	1.41	0.53	2.66
3	Alstonia scholaris	3	0.67	1.50	0.22	0.36	0.94	0.09	1.38
4	Anacolosa densiflora	8	1.78	4.00	0.22	0.95	0.94	0.59	2.49
5	Anarrhinum pedicellatum	1	0.22	1.00	0.11	0.12	0.47	0.22	0.81
6	Antidesma menasu	1	0.22	1.00	0.11	0.12	0.47	0.01	0.60
7	Aporosa acuminata	8	1.78	8.00	0.11	0.95	0.47	0.79	2.21
8	Aporosa lindleyana	5	1.11	2.50	0.22	0.60	0.94	0.36	1.89
9	Artocarpus heterophylla	2	0.44	1.00	0.22	0.24	0.94	0.49	1.67
10	Artocarpus hirsuta	6	1.33	1.50	0.44	0.71	1.88	1.59	4.18
11	Atalantia monophylla	1	0.22	1.00	0.11	0.12	0.47	0.05	0.64
12	Baccaurea courtallensis	11	2.44	5.50	0.22	1.31	0.94	0.30	2.55
13	Bischofia javanica	18	4.00	4.50	0.44	2.14	1.88	1.40	5.42
14	Bombax ceiba	1	0.22	1.00	0.11	0.12	0.47	0.22	0.81
15	Calophyllum polyanthum	4	0.89	2.00	0.22	0.48	0.94	0.33	1.74
16	Canarium strictum	3	0.67	1.00	0.33	0.36	1.41	0.42	2.18
17	Canthium dicoccum	3	0.67	3.00	0.11	0.36	0.47	0.08	0.90
18	Catunaregam torulosa	1	0.22	1.00	0.11	0.12	0.47	0.02	0.61
19	Chionanthus mala-elengi	2	0.44	2.00	0.11	0.24	0.47	0.12	0.83
20	Chukrasia tabularis	23	5.11	5.75	0.44	2.74	1.88	3.54	8.15
21	Cinnamomum macrocarpum	3	0.67	3.00	0.11	0.36	0.47	0.37	1.19
22	Cinnamomum mālābathrum	9	2.00	1.80	0.56	1.07	2.35	0.93	4.35
23	Cinnamomum sulphuratum	2	0.44	2.00	0.11	0.24	0.47	0.21	0.92
24	Clerodendrum viscosum	2	0.44	1.00	0.22	0.24	0.94	0.03	1.20
25	Cullenia exarillata	32	7.11	32.00	0.11	3.81	0.47	3.22	7.50
26	Dillenia pentagyna	1	0.22	1.00	0.11	0.12	0.47	0.02	0.61
27	Dimocarpus longan	16	3.56	4.00	0.44	1.90	1.88	1.52	5.30
28	Diospyros buxifolia	4	0.89	4.00	0.11	0.48	0.47	0.44	1.39
29	Diospyros ebenum	3	0.67	3.00	0.11	0.36	0.47	0.31	1.13
30	Diospyros malabarica	1	0.22	1.00	0.11	0.12	0.47	0.02	0.61
31	Diospyros paniculata	9	2.00	9.00	0.11	1.07	0.47	1.15	2.69
32	Dipterocarpus bourdilloni	16	3.56	16.00	0.11	1.90	0.47	2.62	4.99

33	Drypetes wightii	30	6.67	15.00	0.22	3.57	0.94	2.54	7.05
34	Dysoxylum malabaricum	7	1.56	2.33	0.33	0.83	1.41	0.95	3.20
35	Elaeocarpus munroni	1	0.22	1.00	0.11	0.12	0.47	0.02	0.61
36	Elaeocarpus sp.	2	0.44	2.00	0.11	0.24	0.47	0.06	0.77
37	Elaeocarpus serratus	6	1.33	1.50	0.44	0.71	1.88	1.12	3.71
38	Elaeocarpus tuberculatus	22	4.89	4.40	0.56	2.62	2.35	2.92	7.88
39	Erythrina indica	1	0.22	1.00	0.11	0.12	0.47	0.06	0.65
40	Eucalyptus grandis	14	3.11	7.00	0.22	1.67	0.94	0.50	3.11
41	Fagraea ceilanica	3	0.67	3.00	0.11	0.36	0.47	0.13	0.96
42	Ficus drupacea	1	0.22	1.00	0.11	0.12	0.47	0.02	0.60
43	Ficus exasperata	1	0.22	1.00	0.11	0.12	0.47	0.02	0.61
44	Ficus hispida	1	0.22	1.00	0.11	0.12	0.47	0.17	0.76
45	Ficus racemosa	2	0.44	2.00	0.11	0.24	0.47	0.25	0.95
46	Ficus Species	16	3.56	8.00	0.22	1.90	0.94	2.20	5.04
47	Ficus tsjakela	1	0.22	1.00	0.11	0.12	0.47	0.04	0.63
48	Flacourtia montana	4	0.89	2.00	0.22	0.48	0.94	0.10	1.51
49	Fragaria chiloensis	1	0.22	1.00	0.11	0.12	0.47	0.40	0.99
50	Garcinia indica	2	0.44	2.00	0.11	0.24	0.47	0.04	0.75
51	Garcinia morella	3	0.67	3.00	0.11	0.36	0.47	0.07	0.90
52	Garcinia wightii	24	5.33	24.00	0.11	2.86	0.47	0.93	4.26
53	Gluta travancorica	11	2.44	11.00	0.11	1.31	0.47	0.74	2.52
54	Gmelina arborea	9	2.00	2.25	0.44	1.07	1.88	0.36	3.31
55	Holarrhena antidysenterica	1	0.22	1.00	0.11	0.12	0.47	0.00	0.59
56	Holarrhena sp.	2	0.44	2.00	0.11	0.24	0.47	0.03	0.74
57	Holigarna arnottiana	26	5.78	4.33	0.67	3.10	2.82	2.02	7.94
58	Holigarna grahamii	2	0.44	2.00	0.11	0.24	0.47	0.04	0.74
59	Holigarna nigra	22	4.89	22.00	0.11	2.62	0.47	0.79	3.87
60	Hopea racophloea	1	0.22	1.00	0.11	0.12	0.47	0.01	0.60
61	Humboldtia bourdillonii	15	3.33	15.00	0.11	1.79	0.47	0.39	2.64
62	Hydnocarpus alpina	6	1.33	1.50	0.44	0.71	1.88	0.22	2.81
63	Hydnocarpus pentandra	26	5.78	5.20	0.56	3.10	2.35	2.67	8.11
64	Hydnocarpus sp.	1	0.22	1.00	0.11	0.12	0.47	0.01	0.60
65	Ixora brachiata	2	0.44	1.00	0.22	0.24	0.94	0.08	1.26
66	Knema attenuata	11	2.44	2.75	0.44	1.31	1.88	2.25	5.44
67	Lagerstroemia microcarpa	2	0.44	1.00	0.22	0.24	0.94	0.27	1.45
68	Lannea coromandelica	5	1.11	2.50	0.22	0.60	0.94	0.51	2.05
69	Laportea crenulata	1	0.22	1.00	0.11	0.12	0.47	0.01	0.60
70	Ligustrum gamblei	4	0.89	4.00	0.11	0.48	0.47	0.20	1.15
71	Litsea Species	20	4.44	6.67	0.33	2.38	1.41	0.43	4.22
72	Lophopetalum wightianum	1	0.22	1.00	0.11	0.12	0.47	1.00	1.59
73	Macaranga peltata	20	4.44	3.33	0.67	2.38	2.82	1.10	6.29
74	Mallotus philippensis	5	1.11	1.67	0.33	0.60	1.41	0.25	2.26
75	Mangifera indica	1	0.22	1.00	0.11	0.12	0.47	0.15	0.74
76	Melicope indica	4	0.89	4.00	0.11	0.48	0.47	0.11	1.06
77	Memecylon umbellatum	2	0.44	2.00	0.11	0.24	0.47	0.06	0.76
78	Mesua ferrea	18	4.00	9.00	0.22	2.14	0.94	2.01	5.09
79	Myristica beddomei	24	5.33	24.00	0.11	2.86	0.47	1.41	4.74
80	Myristica malabarica	6	1.33	3.00	0.22	0.71	0.94	0.48	2.14
81	Neolitsea scrobiculata	1	0.22	1.00	0.11	0.12	0.47	0.01	0.60
82	Olea-dioica	3	0.67	1.50	0.22	0.36	0.94	0.27	1.56
83	Otonephelium stipulaceum	10	2.22	10.00	0.11	1.19	0.47	1.29	2.95
84	Palaquium ellipticum	63	14.00	21.00	0.33	7.50	1.41	19.31	28.22
85	Persea macrantha	10	2.22	2.00	0.56	1.19	2.35	1.36	4.90
86	Phyllanthus emblica	3	0.67	3.00	0.11	0.36	0.47	0.10	0.93
87	Polyalthia coffeoides	2	0.44	1.00	0.22	0.24	0.94	0.15	1.32
88	Polyalthia shendurunii	1	0.22	1.00	0.11	0.12	0.47	0.03	0.62
89	Polyalthia suberosa	1	0.22	1.00	0.11	0.12	0.47	0.19	0.78
90	Prunus ceylanica	2	0.44	2.00	0.11	0.24	0.47	0.35	1.06
91	Pterocarpus marsupium	8	1.78	4.00	0.22	0.95	0.94	13.14	15.04

92	Pterospermum reticulatum	1	0.22	1.00	0.11	0.12	0.47	0.02	0.61
93	Pterygota alata	1	0.22	1.00	0.11	0.12	0.47	0.02	0.61
94	Rapanea wightiana	5	1.11	5.00	0.11	0.60	0.47	0.15	1.22
95	Rhodomyrtus tomentosa	1	0.22	1.00	0.11	0.12	0.47	0.01	0.60
96	Schefflera stellata	2	0.44	2.00	0.11	0.24	0.47	0.02	0.73
97	Schleichera oleosa	9	2.00	4.50	0.22	1.07	0.94	0.62	2.63
98	Semecarpus travancorica	1	0.22	1.00	0.11	0.12	0.47	0.17	0.76
99	Stereospermum colais	1	0.22	1.00	0.11	0.12	0.47	0.70	1.29
100	Symplocos cochinchinensis	3	0.67	1.50	0.22	0.36	0.94	0.04	1.33
101	Symplocos lancifolia	1	0.22	1.00	0.11	0.12	0.47	0.08	0.66
102	Syzygium cumini	14	3.11	7.00	0.22	1.67	0.94	1.74	4.35
103	Syzygium gardneri	1	0.22	1.00	0.11	0.12	0.47	0.12	0.71
104	Terminalia arjuna	1	0.22	1.00	0.11	0.12	0.47	0.11	0.70
105	Terminalia bellirica	1	0.22	1.00	0.11	0.12	0.47	0.70	1.29
106	Terminalia sp.	1	0.22	1.00	0.11	0.12	0.47	0.42	1.01
107	Toona ciliata	21	4.67	5.25	0.44	2.50	1.88	1.86	6.23
108	Trema orientalis	23	5.11	7.67	0.33	2.74	1.41	1.21	5.35
109	Trichilia connaroides	1	0.22	1.00	0.11	0.12	0.47	0.02	0.61
110	Turpinia malabarica	1	0.22	1.00	0.11	0.12	0.47	0.04	0.62
111	Vateria indica	7	1.56	3.50	0.22	0.83	0.94	0.88	2.65
112	Vateria macrocarpa	4	0.89	4.00	0.11	0.48	0.47	1.24	2.19
113	Vepris bilocularis	2	0.44	2.00	0.11	0.24	0.47	0.02	0.73
114	Vernonia arborea	18	4.00	3.60	0.56	2.14	2.35	1.03	5.52
115	Xanthophyllum arnottianum	8	1.78	4.00	0.22	0.95	0.94	0.19	2.08
116	Xanthophyllum sp.	9	2.00	4.50	0.22	1.07	0.94	0.14	2.15
117	Xanthoxylum rhetsa	1	0.22	1.00	0.11	0.12	0.47	0.06	0.65

2. Semi Evergreen Forests

The vegetation data from 23 plots covering an area of 1,15000 m^2 were analysed for structural details of Semi Evergreen forests Table 5). The dominant tree species of the type were *Aporosa lindleyana, Xylia xylocarpa, Xanthophyllum arnotianum and Macaranga peltata.*

Table 5. Typewise vegetation status (Semi evergreen)

Sl.No	Species	N. Ind	D	A	F	RD	RF	RBA	IVI
1	Acrocarpus fraxinifolius	1	0.09	1.00	0.04	0.04	0.16	0.01	0.21
2	Actinodaphne bourdillonii	1	0.09	1.00	0.04	0.04	0.16	0.03	0.23
3	Actinodaphne madraspatana	2	0.17	2.00	0.04	0.07	0.16	0.01	0.25
4	Actinodaphne malabarica	14	1.22	4.67	0.13	0.49	0.48	0.40	1.38
5	Aglaia barberi	6	0.52	2.00	0.13	0.21	0.48	0.11	0.81
6	Aglaia lawii	8	0.70	2.67	0.13	0.28	0.48	0.28	1.04
7	Aglaia sp.	14	1.22	14.00	0.04	0.49	0.16	0.54	1.19
8	Albizia odoratissima	2	0.17	1.00	0.09	0.07	0.32	0.03	0.43
9	Allophylus serratus	1	0.09	1.00	0.04	0.04	0.16	0.00	0.20
10	Alseodaphne semicarpifolia	1	0.09	1.00	0.04	0.04	0.16	0.04	0.23
11	Alstonia scholaris	31	2.70	2.58	0.52	1.09	1.93	1.06	4.07
12	Antidesma alexiteria	6	0.52	6.00	0.04	0.21	0.16	0.04	0.41
13	Aphanamixis polystachya	8	0.70	4.00	0.09	0.28	0.32	0.35	0.96
14	Aporosa lindleyana	82	7.13	4.82	0.74	2.88	2.73	1.52	7.13

15	Archidendron monadelphum	2	0.17	2.00	0.04	0.07	0.16	0.32	0.55
16	Artocarpus gomezianus	1	0.09	1.00	0.04	0.04	0.16	0.02	0.22
17	Artocarpus hirsuta	58	5.04	4.14	0.61	2.04	2.25	3.14	7.42
18	Artocarpus integrifolia	4	0.35	4.00	0.04	0.14	0.16	0.41	0.71
19	Baccaurea courtallensis	80	6.96	8.89	0.39	2.81	1.45	0.59	4.84
20	Bambusa bambos	5	0.43	2.50	0.09	0.18	0.32	0.01	0.50
21	Bauhinia malabarica	2	0.17	1.00	0.09	0.07	0.32	0.06	0.45
22	Beilschmiedia wightii	6	0.52	2.00	0.13	0.21	0.48	0.28	0.97
23	Bischofia javanica	22	1.91	3.67	0.26	0.77	0.96	0.64	2.38
24	Bombax ceiba	19	1.65	2.71	0.30	0.67	1.13	0.99	2.78
25	Bridelia retusa	2	0.17	2.00	0.04	0.07	0.16	0.07	0.30
26	Callicarpa tomentosa	6	0.52	3.00	0.09	0.21	0.32	0.05	0.58
27	Calophyllum polyanthum	1	0.09	1.00	0.04	0.04	0.16	0.21	0.40
28	Calycopteris floribunda	2	0.17	2.00	0.04	0.07	0.16	0.02	0.25
29	Canarium strictum	7	0.61	7.00	0.04	0.25	0.16	0.03	0.44
30	Carallia brachiata	2	0.17	2.00	0.04	0.07	0.16	0.01	0.24
31	Careya arborea	24	2.09	8.00	0.13	0.84	0.48	0.44	1.77
32	Casearia ovata	1	0.09	1.00	0.04	0.04	0.16	0.00	0.20
33	Cassia fistula	8	0.70	2.00	0.17	0.28	0.64	0.31	1.23
34	Chionanthus mala-elengi	5	0.43	1.67	0.13	0.18	0.48	0.06	0.71
35	Chukrasia tabularis	5	0.43	2.50	0.09	0.18	0.32	0.47	0.96
36	Cinnamomum malabathrum	23	2.00	5.75	0.17	0.81	0.64	0.39	1.84
37	Cinnamomum zeylanicum	1	0.09	1.00	0.04	0.04	0.16	0.01	0.21
38	Cleidion javanicum	6	0.52	6.00	0.04	0.21	0.16	0.12	0.50
39	Clerodendron sp.	1	0.09	1.00	0.04	0.04	0.16	0.01	0.21
40	Cordia wallichii	1	0.09	1.00	0.04	0.04	0.16	0.06	0.25
41	Croton malabaricus	8	0.70	1.33	0.26	0.28	0.96	0.07	1.31
42	Cullenia exarillata	2	0.17	2.00	0.04	0.07	0.16	0.29	0.53
43	Cycas circinalis	1	0.09	1.00	0.04	0.04	0.16	0.01	0.20
44	Dalbergia latifolia	5	0.43	1.25	0.17	0.18	0.64	0.27	1.09
45	Dalbergia sissoides	1	0.09	1.00	0.04	0.04	0.16	0.05	0.25
46	Dillenia pentagyna	51	4.43	3.64	0.61	1.79	2.25	2.01	6.05
47	Dimocarpus sp.	1	0.09	1.00	0.04	0.04	0.16	0.00	0.20
48	Dimocarpus longan	7	0.61	1.40	0.22	0.25	0.80	0.15	1.20
49	Diospyros buxifolia	6	0.52	1.50	0.17	0.21	0.64	0.26	1.11
50	Diospyros cordifolia	1	0.09	1.00	0.04	0.04	0.16	0.08	0.28
51	Diospyros ebenum	30	2.61	15.00	0.09	1.05	0.32	0.51	1.88
52	Diospyros malabarica	1	0.09	1.00	0.04	0.04	0.16	0.02	0.21
53	Dipterocarpus bourdilloni	54	4.70	27.00	0.09	1.89	0.32	5.07	7.29
54	Dipterocarpus indicus	4	0.35	2.00	0.09	0.14	0.32	1.03	1.49
55	Drypetes wightii	2	0.17	2.00	0.04	0.07	0.16	0.03	0.26
56	Dysoxylum beddomei	1	0.09	1.00	0.04	0.04	0.16	0.04	0.24
57	Dysoxylum binectariferum	2	0.17	2.00	0.04	0.07	0.16	0.53	0.76
58	Dysoxylum malabaricum	25	2.17	3.57	0.30	0.88	1.13	1.03	3.03
59	Elaeocarpus sp.	3	0.26	3.00	0.04	0.11	0.16	0.16	0.43
60	Elaeocarpus serratus	3	0.26	1.50	0.09	0.11	0.32	0.13	0.56
61	Elaeocarpus tuberculatus	22	1.91	3.67	0.26	0.77	0.96	2.64	4.38
62	Erythrina indica	8	0.70	1.60	0.22	0.28	0.80	0.28	1.37
63	Erythrina stricta	5	0.43	5.00	0.04	0.18	0.16	0.22	0.56
64	Euodia sp.	1	0.09	1.00	0.04	0.04	0.16	0.01	0.21
65	Euodia lunu-ankenda	5	0.43	5.00	0.04	0.18	0.16	0.06	0.40
66	Ficus arnottiana	1	0.09	1.00	0.04	0.04	0.16	0.02	0.22
67	Ficus heterophylla	7	0.61	2.33	0.13	0.25	0.48	0.06	0.79
68	Ficus hispida	8	0.70	2.00	0.17	0.28	0.64	0.23	1.15
69	Ficus Species	3	0.26	1.00	0.13	0.11	0.48	0.77	1.35
70	Ficus tsjakela	1	0.09	1.00	0.04	0.04	0.16	0.09	0.29
71	Flacourtia jangomas	6	0.52	6.00	0.04	0.21	0.16	0.40	0.78
72	Flacourtia montana	4	0.35	2.00	0.09	0.14	0.32	0.07	0.53
73	Garcinia gummigutta	1	0.09	1.00	0.04	0.04	0.16	0.07	0.27

74	Garcinia spicata	10	0.87	10.00	0.04	0.35	0.16	0.18	0.69
75	Glochidion zeylanicum	5	0.43	5.00	0.04	0.18	0.16	0.08	0.41
76	Gmelina arborea	11	0.96	3.67	0.13	0.39	0.48	0.25	1.12
77	Grevillea robusta	1	0.09	1.00	0.04	0.04	0.16	0.01	0.21
78	Grewia tiliifolia	25	2.17	3.57	0.30	0.88	1.13	1.24	3.24
79	Gymnacranthera canarica	35	3.04	11.67	0.13	1.23	0.48	1.49	3.20
80	Harpullia arborea	7	0.61	3.50	0.09	0.25	0.32	0.11	0.67
81	Helicteres isora	2	0.17	1.00	0.09	0.07	0.32	0.01	0.40
82	Heritiera papilio	12	1.04	6.00	0.09	0.42	0.32	0.25	0.99
83	Holarrhena pubescens	9	0.78	4.50	0.09	0.32	0.32	0.05	0.69
84	Holigarna arnottiana	34	2.96	4.86	0.30	1.19	1.13	1.60	3.92
85	Holigarna grahamii	2	0.17	2.00	0.04	0.07	0.16	0.04	0.27
86	Holoptelea integrifolia	2	0.17	2.00	0.04	0.07	0.16	0.04	0.27
87	Hopea parviflora	37	3.22	3.36	0.48	1.30	1.77	3.90	6.97
88	Hopea ponga	26	2.26	13.00	0.09	0.91	0.32	1.46	2.69
89	Hopea racophloea	3	0.26	3.00	0.04	0.11	0.16	0.08	0.35
90	Hydnocarpus alpina	1	0.09	1.00	0.04	0.04	0.16	0.00	0.20
91	Hydnocarpus pentandra	68	5.91	4.00	0.74	2.39	2.73	2.18	7.30
92	Ixora brachiata	67	5.83	6.70	0.43	2.35	1.61	1.07	5.03
93	Ixora sp	1	0.09	1.00	0.04	0.04	0.16	0.03	0.22
94	Kingiodendron pinnatum	20	1.74	6.67	0.13	0.70	0.48	1.12	2.31
95	Knema attenuata	89	7.74	9.89	0.39	3.12	1.45	1.88	6.45
96	Kydia calycina	1	0.09	1.00	0.04	0.04	0.16	0.02	0.21
97	Lagerstroemia microcarpa	36	3.13	2.57	0.61	1.26	2.25	1.77	5.28
98	Lagerstroemia reginae	8	0.70	8.00	0.04	0.28	0.16	0.16	0.60
99	Lannea coromandelica	3	0.26	1.50	0.09	0.11	0.32	0.17	0.59
100	Leea indica	7	0.61	1.40	0.22	0.25	0.80	0.05	1.10
101	Litsea Species	1	0.09	1.00	0.04	0.04	0.16	0.01	0.21
102	Lophopetalum wightianum	14	1.22	4.67	0.13	0.49	0.48	0.73	1.71
103	Macaranga peltata	97	8.43	5.39	0.78	3.40	2.89	2.44	8.74
104	Mallotus philippensis	22	1.91	2.00	0.48	0.77	1.77	0.78	3.32
105	Mallotus tetracoccus	2	0.17	2.00	0.04	0.07	0.16	0.05	0.28
106	Mangifera indica	11	0.96	2.75	0.17	0.39	0.64	0.60	1.63
107	Margaritaria indica	1	0.09	1.00	0.04	0.04	0.16	0.02	0.22
108	Mastixia arborea	4	0.35	4.00	0.04	0.14	0.16	0.26	0.56
109	Meiogyne pannosa	1	0.09	1.00	0.04	0.04	0.16	0.03	0.22
110	Melaleuca sp.	3	0.26	3.00	0.04	0.11	0.16	0.12	0.39
111	Melia dubia	2	0.17	2.00	0.04	0.07	0.16	0.05	0.28
112	Melilotus leucantha	3	0.26	3.00	0.04	0.11	0.16	0.17	0.43
113	Mesua ferrea	32	2.78	6.40	0.22	1.12	0.80	0.70	2.63
114	Miliusa tomentosa	3	0.26	1.50	0.09	0.11	0.32	0.23	0.66
115	Mitragyna parvifolia	3	0.26	1.50	0.09	0.11	0.32	0.04	0.47
116	Mitragyna tubulosa	16	1.39	8.00	0.09	0.56	0.32	0.20	1.09
117	Myristica beddomei	9	0.78	9.00	0.04	0.32	0.16	0.22	0.70
118	Myristica dactyloides	11	0.96	5.50	0.09	0.39	0.32	0.23	0.94
119	Myristica sp.	2	0.17	2.00	0.04	0.07	0.16	0.01	0.24
120	Myristica fragrans	2	0.17	1.00	0.09	0.07	0.32	0.15	0.54
121	Myristica magnifica	32	2.78	16.00	0.09	1.12	0.32	0.98	2.42
122	Myristica malabarica	56	4.87	9.33	0.26	1.96	0.96	1.70	4.63
123	Naringi crenulata	5	0.43	1.67	0.13	0.18	0.48	0.04	0.69
124	Neolamarckia cadamba	1	0.09	1.00	0.04	0.04	0.16	0.00	0.20
125	Neonauclea purpurascens	2	0.17	1.00	0.09	0.07	0.32	0.08	0.47
126	Nothopegia colebrookiana	2	0.17	2.00	0.04	0.07	0.16	0.13	0.36
127	Olea dioica	26	2.26	2.36	0.48	0.91	1.77	0.32	3.00
128	Orophea erythrocarpa	1	0.09	1.00	0.04	0.04	0.16	0.01	0.20
129	Oroxylum indicum	1	0.09	1.00	0.04	0.04	0.16	0.01	0.20
130	Otonephelium stipulaceum	9	0.78	4.50	0.09	0.32	0.32	0.08	0.72
131	Palaquium ellipticum	5	0.43	1.67	0.13	0.18	0.48	0.74	1.39
132	Persea macrantha	24	2.09	2.18	0.48	0.84	1.77	1.58	4.19

133	Phyllanthus emblica	4	0.35	4.00	0.04	0.14	0.16	0.04	0.34
134	Poeciloneuron indicum	20	1.74	10.00	0.09	0.70	0.32	0.27	1.29
135	Polyalthia coffeoides	19	1.65	6.33	0.13	0.67	0.48	0.45	1.60
136	Polyalthia fragrans	27	2.35	3.86	0.30	0.95	1.13	1.30	3.37
137	Pongamia pinnata	3	0.26	1.50	0.09	0.11	0.32	0.05	0.47
138	Prunus ceylanica	5	0.43	1.25	0.17	0.18	0.64	0.03	0.85
139	Pterocarpus marsupium	47	4.09	9.40	0.22	1.65	0.80	1.46	3.91
140	Pterospermum reticulatum	8	0.70	1.60	0.22	0.28	0.80	0.09	1.18
141	Sapindus trifoliatus	2	0.17	1.00	0.09	0.07	0.32	0.06	0.45
142	Schleichera oleosa	31	2.70	3.44	0.39	1.09	1.45	2.75	5.29
143	Spondias indica	1	0.09	1.00	0.04	0.04	0.16	0.00	0.20
144	Spondias pinnata	3	0.26	1.50	0.09	0.11	0.32	0.29	0.72
145	Sterculia coccinea	1	0.09	1.00	0.04	0.04	0.16	0.15	0.35
146	Sterculia guttata	11	0.96	1.57	0.30	0.39	1.13	0.45	1.96
147	Sterculia urens	1	0.09	1.00	0.04	0.04	0.16	0.01	0.21
148	Stereospermum chelonoides	4	0.35	1.33	0.13	0.14	0.48	0.15	0.77
149	Stereospermum colais	11	0.96	1.83	0.26	0.39	0.96	0.39	1.75
150	Strombosia ceylanica	16	1.39	4.00	0.17	0.56	0.64	0.36	1.56
151	Strychnos nux-vomica	7	0.61	1.75	0.17	0.25	0.64	0.28	1.17
152	Swietenia mahagoni	2	0.17	2.00	0.04	0.07	0.16	0.13	0.36
153	Symplocos cochinchinensis	2	0.17	1.00	0.09	0.07	0.32	0.01	0.40
154	Syzygium cumini	4	0.35	2.00	0.09	0.14	0.32	0.10	0.56
155	Syzygium gardneri	9	0.78	2.25	0.17	0.32	0.64	0.31	1.27
156	Syzygium hemisphericum	11	0.96	3.67	0.13	0.39	0.48	0.93	1.80
157	Syzygium laetum	14	1.22	4.67	0.13	0.49	0.48	0.32	1.29
158	Syzygium mundagam	19	1.65	4.75	0.17	0.67	0.64	0.26	1.57
159	Syzygium species	1	0.09	1.00	0.04	0.04	0.16	0.05	0.25
160	Syzygium travancoricum	1	0.09	1.00	0.04	0.04	0.16	0.34	0.53
161	Syzygium zeylanicum	10	0.87	10.00	0.04	0.35	0.16	0.16	0.68
162	Tabernaemontana alternifolia	1	0.09	1.00	0.04	0.04	0.16	0.01	0.21
163	Tabernaemontana sp.	18	1.57	3.00	0.26	0.63	0.96	0.14	1.74
164	Tectona grandis	131	11.39	21.83	0.26	4.60	0.96	2.16	7.72
165	Terminalia bellirica	21	1.83	4.20	0.22	0.74	0.80	2.01	3.55
166	Terminalia tomentosa	7	0.61	2.33	0.13	0.25	0.48	0.32	1.05
167	Terminalia travancorensis	5	0.43	2.50	0.09	0.18	0.32	0.15	0.65
168	Tetrameles nudiflora	16	1.39	2.67	0.26	0.56	0.96	2.69	4.22
169	Toona ciliata	5	0.43	2.50	0.09	0.18	0.32	0.23	0.72
170	Trema orientalis	1	0.09	1.00	0.04	0.04	0.16	0.01	0.21
171	Trewia nudiflora	1	0.09	1.00	0.04	0.04	0.16	0.05	0.24
172	Trichilia connaroides	3	0.26	1.50	0.09	0.11	0.32	0.10	0.53
173	Turpinia malabarica	33	2.87	16.50	0.09	1.16	0.32	1.22	2.70
174	Vateria indica	33	2.87	5.50	0.26	1.16	0.96	0.82	2.95
175	Vepris bilocularis	4	0.35	4.00	0.04	0.14	0.16	0.24	0.54
176	Vernonia arborea	21	1.83	5.25	0.17	0.74	0.64	0.48	1.86
177	Vitex altissima	29	2.52	4.83	0.26	1.02	0.96	2.41	4.39
178	Vitex leucoxylon	1	0.09	1.00	0.04	0.04	0.16	0.03	0.23
179	Wrightia tinctoria	22	1.91	3.14	0.30	0.77	1.13	0.40	2.30
180	Xanthophyllum arnottianum	194	16.87	27.71	0.30	6.81	1.13	1.83	9.76
181	Xanthophyllum sp.	41	3.57	6.83	0.26	1.44	0.96	0.48	2.88
182	Xanthoxylum rhetsa	1	0.09	1.00	0.04	0.04	0.16	0.03	0.23
184	Xylopia parvifolia	4	0.35	4.00	0.04	0.14	0.16	0.02	0.32
185	Unidentified sp.	1	0.09	1.00	0.04	0.04	0.16	0.05	0.24

3. Moist Deciduous Forests

The dominant trees of this type based on the IVI were *Tectona grandis, Terminalia paniculata, Xylia xylocarpa and Lagerstroemia microcarpa* (Table 6). The stray occurance of few Evergreen/Semievergreen components like, *Palaquium ellipticum, Leea indica, Litsea coriacea* and *L. floribunda* were also notable. This was mainly due to micro habitat changes in selected grids, due to geomorphological variations, thus forming more moist islands inside the moist deciduous forests. The fragmented nature of this cover type due to various anthropogenic, edaphic and climatic factors and its impact in species composition was evident.

Table 6. Typewise vegetation status (Moist Deciduous)

Sl.No.	Species	N. Ind	D	A	F	RD	RF	RBA	IVI
1	Abarema bigemina	1	0.03	1.00	0.02	0.02	0.07	0.02	0.11
2	Acacia auriculiformis	11	0.37	2.20	0.08	0.20	0.37	0.09	0.67
3	Acacia catechu	4	0.14	4.00	0.02	0.07	0.07	0.04	0.19
4	Acacia intsia	3	0.10	1.00	0.05	0.06	0.22	0.01	0.28
5	Acacia mangium	4	0.14	2.00	0.03	0.07	0.15	0.06	0.29
6	Acronychia pedunculata	4	0.14	2.00	0.03	0.07	0.15	0.06	0.28
7	Actinodaphne angustifolia	1	0.03	1.00	0.02	0.02	0.07	0.03	0.12
8	Actinodaphne bourdillonii	1	0.03	1.00	0.02	0.02	0.07	0.02	0.11
9	Actinodaphne malabarica	31	1.05	4.43	0.12	0.57	0.52	0.31	1.40
10	Aglaia barberi	1	0.03	1.00	0.02	0.02	0.07	0.02	0.11
11	Ailanthus excelsa	1	0.03	1.00	0.02	0.02	0.07	0.00	0.09
12	Ailanthus malabarica	5	0.17	1.67	0.05	0.09	0.22	0.02	0.34
13	Ailanthus triphysa	2	0.07	1.00	0.03	0.04	0.15	0.01	0.19
14	Albizia amara	1	0.03	1.00	0.02	0.02	0.07	0.03	0.12
15	Albizia lebbeck	2	0.07	1.00	0.03	0.04	0.15	0.05	0.24
16	Albizia odoratissima	61	2.07	2.90	0.36	1.12	1.55	1.60	4.28
17	Albizia species	2	0.07	2.00	0.02	0.04	0.07	0.05	0.16
18	Allophylus cobbe	1	0.03	1.00	0.02	0.02	0.07	0.00	0.09
19	Allophylus serratus	2	0.07	1.00	0.03	0.04	0.15	0.00	0.19
20	Alseodaphne semicarpifolia	1	0.03	1.00	0.02	0.02	0.07	0.00	0.10
21	Alstonia scholaris	60	2.03	2.73	0.37	1.11	1.63	1.37	4.10
22	Anacardium occidentale	14	0.47	3.50	0.07	0.26	0.30	0.27	0.82
23	Anemone wightiana	1	0.03	1.00	0.02	0.02	0.07	0.01	0.10
24	Anogeissus latifolia	7	0.24	7.00	0.02	0.13	0.07	0.08	0.29
25	Antidesma alexiteria	1	0.03	1.00	0.02	0.02	0.07	0.01	0.10
26	Aphanamixis polystachya	2	0.07	2.00	0.02	0.04	0.07	0.01	0.12
27	Aporosa acuminata	7	0.24	7.00	0.02	0.13	0.07	0.15	0.35
28	Aporosa lindleyana	145	4.92	6.04	0.41	2.67	1.77	1.67	6.11
29	Areca catechu	3	0.10	1.00	0.05	0.06	0.22	0.01	0.28

30	Artocarpus heterophylla	10	0.34	1.67	0.10	0.18	0.44	0.45	1.08
31	Artocarpus hirsuta	26	0.88	1.73	0.25	0.48	1.11	0.46	2.05
32	Azadirachta indica	3	0.10	3.00	0.02	0.06	0.07	0.01	0.14
33	Baccaurea courtallensis	4	0.14	1.00	0.07	0.07	0.30	0.04	0.41
34	Bambusa arundinacea	5	0.17	1.00	0.08	0.09	0.37	0.00	0.47
35	Bambusa sp.	40	1.36	3.33	0.20	0.74	0.89	0.06	1.69
36	Bauhinia benthami	2	0.07	2.00	0.02	0.04	0.07	0.01	0.13
37	Bauhinia malabarica	8	0.27	1.60	0.08	0.15	0.37	0.06	0.57
38	Bauhinia racemosa	5	0.17	1.67	0.05	0.09	0.22	0.03	0.34
39	Beilschmiedia dalzellii	1	0.03	1.00	0.02	0.02	0.07	0.01	0.10
40	Beilschmiedia wightii	4	0.14	4.00	0.02	0.07	0.07	0.06	0.20
41	Bischofia javanica	13	0.44	1.63	0.14	0.24	0.59	0.31	1.14
42	Bombax ceiba	124	4.20	4.43	0.47	2.28	2.07	2.40	6.75
43	Bombax insigne	8	0.27	2.67	0.05	0.15	0.22	0.11	0.48
44	Bridelia airy-shawii	1	0.03	1.00	0.02	0.02	0.07	0.01	0.10
45	Bridelia retusa	39	1.32	2.60	0.25	0.72	1.11	0.43	2.26
46	Callicarpa tomentosa	9	0.31	3.00	0.05	0.17	0.22	0.02	0.41
47	Calophyllum polyanthum	1	0.03	1.00	0.02	0.02	0.07	0.08	0.17
48	Calycopteris floribunda	6	0.20	2.00	0.05	0.11	0.22	0.02	0.35
49	Canarium strictum	1	0.03	1.00	0.02	0.02	0.07	0.04	0.14
50	Canthium dicoccum	3	0.10	3.00	0.02	0.06	0.07	0.02	0.15
51	Carallia brachiata	2	0.07	1.00	0.03	0.04	0.15	0.07	0.25
52	Careya arborea	35	1.19	2.50	0.24	0.64	1.03	0.22	1.90
53	Caryota urens	14	0.47	1.75	0.14	0.26	0.59	0.16	1.01
54	Casearia ovata	2	0.07	1.00	0.03	0.04	0.15	0.00	0.19
55	Cassia fistula	53	1.80	2.30	0.39	0.98	1.70	0.37	3.05
56	Cassia siamea	3	0.10	3.00	0.02	0.06	0.07	0.01	0.14
57	Casuarina equisetifolia	1	0.03	1.00	0.02	0.02	0.07	0.00	0.10
58	Ceiba pentandra	1	0.03	1.00	0.02	0.02	0.07	0.00	0.10
59	Cinnamomum sp.	2	0.07	2.00	0.02	0.04	0.07	0.01	0.12
60	Chionanthus mala-elengi	19	0.64	1.73	0.19	0.35	0.81	0.13	1.29
61	Chukrasia tabularis	10	0.34	3.33	0.05	0.18	0.22	0.38	0.79
62	Cinnamomum malabathrum	16	0.54	2.00	0.14	0.29	0.59	0.17	1.05
63	Cleistanthus collinus	32	1.08	6.40	0.08	0.59	0.37	0.22	1.17
64	Clerodendrum viscosum	1	0.03	1.00	0.02	0.02	0.07	0.00	0.09
65	Cordia wallichii	10	0.34	2.50	0.07	0.18	0.30	0.13	0.61
66	Croton malabaricus	2	0.07	2.00	0.02	0.04	0.07	0.01	0.12
67	Cyananthus cordifolius	1	0.03	1.00	0.02	0.02	0.07	0.02	0.11
68	Cycas circinalis	3	0.10	3.00	0.02	0.06	0.07	0.01	0.14
69	Dalbergia lanceolaria	24	0.81	4.00	0.10	0.44	0.44	0.33	1.22
70	Dalbergia latifolia	62	2.10	2.48	0.42	1.14	1.85	1.13	4.12
71	Dalbergia sissoides	43	1.46	3.91	0.19	0.79	0.81	0.52	2.12
72	Dalbergia sissoo	2	0.07	2.00	0.02	0.04	0.07	0.01	0.12
73	Dalbergia sp	3	0.10	1.00	0.05	0.06	0.22	0.02	0.30
74	Debregeasia longifolia	4	0.14	4.00	0.02	0.07	0.07	0.01	0.16
75	Delonix regia	3	0.10	1.00	0.05	0.06	0.22	0.01	0.29
76	Dillenia parviflora	2	0.07	2.00	0.02	0.04	0.07	0.06	0.17
77	Dillenia pentagyna	153	5.19	4.94	0.53	2.82	2.29	4.40	9.51
78	Dimocarpus longan	5	0.17	1.67	0.05	0.09	0.22	0.07	0.38
79	Diospyros buxifolia	3	0.10	1.50	0.03	0.06	0.15	0.01	0.22
80	Diospyros ebenum	5	0.17	2.50	0.03	0.09	0.15	0.07	0.31
81	Diospyros montana	1	0.03	1.00	0.02	0.02	0.07	0.00	0.09
82	Diospyros sylvatica	2	0.07	2.00	0.02	0.04	0.07	0.02	0.13
83	Dipterocarpus indicus	2	0.07	2.00	0.02	0.04	0.07	0.30	0.41
84	Drypetes elata	2	0.07	2.00	0.02	0.04	0.07	0.01	0.12
85	Drypetes oblongifolia	1	0.03	1.00	0.02	0.02	0.07	0.02	0.11
86	Drypetes venusta	2	0.07	2.00	0.02	0.04	0.07	0.02	0.13
87	Dysoxylum binectariferum	1	0.03	1.00	0.02	0.02	0.07	0.02	0.11
88	Dysoxylum malabaricum	1	0.03	1.00	0.02	0.02	0.07	0.01	0.10

88	Erythrina glauca	1	0.03	1.00	0.02	0.02	0.07	0.02	0.11
90	Erythrina indica	44	1.49	2.20	0.34	0.81	1.48	0.68	2.97
91	Erythrina stricta	7	0.24	3.50	0.03	0.13	0.15	0.10	0.38
92	Erythrina sp.	5	0.17	5.00	0.02	0.09	0.07	0.05	0.22
93	Eucalyptus globulus	38	1.29	9.50	0.07	0.70	0.30	0.14	1.14
94	Eucalyptus grandis	2	0.07	2.00	0.02	0.04	0.07	0.00	0.12
95	Euodia lunu-ankenda	4	0.14	2.00	0.03	0.07	0.15	0.04	0.26
96	Ficus callosa	3	0.10	1.00	0.05	0.06	0.22	0.29	0.56
97	Ficus exasperata	2	0.07	1.00	0.03	0.04	0.15	0.01	0.19
98	Ficus heterophylla	37	1.25	3.36	0.19	0.68	0.81	0.17	1.66
99	Ficus hispida	25	0.85	2.78	0.15	0.46	0.67	0.34	1.46
100	Ficus nervosa	1	0.03	1.00	0.02	0.02	0.07	0.02	0.11
101	Ficus racemosa	10	0.34	1.67	0.10	0.18	0.44	0.08	0.71
102	Ficus religiosa	2	0.07	1.00	0.03	0.04	0.15	0.02	0.20
103	Ficus Species	7	0.24	1.40	0.08	0.13	0.37	0.08	0.57
104	Ficus tjaela	2	0.07	1.00	0.03	0.04	0.15	0.01	0.19
105	Ficus sp.	3	0.10	1.00	0.05	0.06	0.22	0.15	0.42
106	Flacourtia montana	3	0.10	1.50	0.03	0.06	0.15	0.03	0.23
107	Garcinia gummigutta	5	0.17	1.00	0.08	0.09	0.37	0.04	0.50
108	Garuga pinnata	5	0.17	1.67	0.05	0.09	0.22	0.05	0.36
109	Givotia moluccana	18	0.61	9.00	0.03	0.33	0.15	0.31	0.79
110	Gliricidia maculata	3	0.10	3.00	0.02	0.06	0.07	0.02	0.15
111	Gliricidia sp.	6	0.20	6.00	0.02	0.11	0.07	0.02	0.20
112	Glochidion zeylanicum	1	0.03	1.00	0.02	0.02	0.07	0.00	0.09
113	Gmelina arborea	39	1.32	3.55	0.19	0.72	0.81	0.83	2.36
114	Grevillea robusta	12	0.41	4.00	0.05	0.22	0.22	0.04	0.49
115	Grewia tiliifolia	219	7.42	6.26	0.59	4.04	2.59	3.17	9.79
116	Gymnacranthera canarica	21	0.71	21.00	0.02	0.39	0.07	0.26	0.72
117	Haldina cordifolia	15	0.51	3.75	0.07	0.28	0.30	0.36	0.93
118	Harpullia arborea	2	0.07	2.00	0.02	0.04	0.07	0.02	0.13
119	Helicteres isora	1	0.03	1.00	0.02	0.02	0.07	0.01	0.10
120	Hevea brasiliensis	44	1.49	14.67	0.05	0.81	0.22	0.24	1.27
121	Holarrhena antidysenterica	4	0.14	1.33	0.05	0.07	0.22	0.13	0.43
122	Holarrhena sp.	23	0.78	1.92	0.20	0.42	0.89	0.05	1.36
123	Holigarna arnottiana	10	0.34	2.50	0.07	0.18	0.30	0.32	0.80
124	Holoptelea integrifolia	22	0.75	1.69	0.22	0.41	0.96	0.80	2.16
125	Homalium zeylanicum	1	0.03	1.00	0.02	0.02	0.07	0.00	0.09
126	Hopea parviflora	8	0.27	1.60	0.08	0.15	0.37	0.62	1.13
127	Hopea racophloea	6	0.20	6.00	0.02	0.11	0.07	0.02	0.20
128	Hydnocarpus alpina	1	0.03	1.00	0.02	0.02	0.07	0.01	0.10
129	Hydnocarpus pentandrus	48	1.63	3.43	0.24	0.88	1.03	1.30	3.22
130	Hymenodictyon humikson	6	0.20	2.00	0.05	0.11	0.22	0.06	0.39
131	Ixora brachiata	18	0.61	2.00	0.15	0.33	0.67	0.11	1.11
132	Julostylis angustifolia	2	0.07	2.00	0.02	0.04	0.07	0.02	0.13
133	Knema attenuata	12	0.41	6.00	0.03	0.22	0.15	0.27	0.64
134	Kydia calycina	9	0.31	1.80	0.08	0.17	0.37	0.10	0.64
135	Lagerstroemia hirsuta	3	0.10	1.50	0.03	0.06	0.15	0.02	0.22
136	Lagerstroemia microcarpa	151	5.12	4.31	0.59	2.78	2.59	4.89	10.25
137	Lagerstroemia reginae	3	0.10	3.00	0.02	0.06	0.07	0.05	0.18
138	Lagerstroemia sp.	2	0.07	1.00	0.03	0.04	0.15	0.09	0.28
139	Lannea coromandelica	30	1.02	3.00	0.17	0.55	0.74	0.75	2.04
140	Leea indica	6	0.20	1.50	0.07	0.11	0.30	0.01	0.42
141	Litsea coriacea	1	0.03	1.00	0.02	0.02	0.07	0.00	0.10
142	Litsea floribunda	1	0.03	1.00	0.02	0.02	0.07	0.00	0.09
143	Litsea Species	8	0.27	1.60	0.08	0.15	0.37	0.07	0.59
144	Lophopetalum wightianum	7	0.24	7.00	0.02	0.13	0.07	0.14	0.34
145	Macaranga peltata	238	8.07	6.10	0.66	4.39	2.88	2.70	9.97
146	Madhuca longifolia	13	0.44	13.00	0.02	0.24	0.07	0.38	0.69
147	Mallotus philippensis	53	1.80	2.79	0.32	0.98	1.40	0.33	2.72

148	Mallotus tetracoccus	5	0.17	2.50	0.03	0.09	0.15	0.02	0.26
149	Mangifera indica	10	0.34	1.67	0.10	0.18	0.44	0.36	0.99
150	Mastixia arborea	9	0.31	9.00	0.02	0.17	0.07	0.02	0.26
151	Melia dubia	1	0.03	1.00	0.02	0.02	0.07	0.01	0.10
152	Memecylon umbellatum	1	0.03	1.00	0.02	0.02	0.07	0.00	0.10
153	Mesua ferrea	3	0.10	1.50	0.03	0.06	0.15	0.06	0.26
154	Miliusa tomentosa	35	1.19	2.19	0.27	0.64	1.18	0.25	2.08
155	Mitragyna parvifolia	22	0.75	1.83	0.20	0.41	0.89	0.23	1.52
156	Mitragyna tubulosa	2	0.07	1.00	0.03	0.04	0.15	0.01	0.20
157	Morinda sp.	3	0.10	3.00	0.02	0.06	0.07	0.02	0.15
158	Morinda tinctoria	7	0.24	7.00	0.02	0.13	0.07	0.02	0.22
159	Myristica beddomei	19	0.64	9.50	0.03	0.35	0.15	0.34	0.83
160	Myristica magnifica	12	0.41	12.00	0.02	0.22	0.07	0.18	0.47
161	Myristica malabarica	4	0.14	2.00	0.03	0.07	0.15	0.12	0.34
162	Naringi crenulata	6	0.20	2.00	0.05	0.11	0.22	0.02	0.35
163	Neolamarckia cadamba	1	0.03	1.00	0.02	0.02	0.07	0.01	0.10
164	Neonauclea purpurascens	8	0.27	1.60	0.08	0.15	0.37	0.05	0.57
165	Olea dioica	61	2.07	3.81	0.27	1.12	1.18	0.51	2.81
166	Otonephelium stipulaceum	3	0.10	3.00	0.02	0.06	0.07	0.02	0.15
167	Palaquium ellipticum	5	0.17	5.00	0.02	0.09	0.07	0.15	0.31
168	Persea macrantha	29	0.98	1.93	0.25	0.53	1.11	0.86	2.50
169	Phyllanthus emblica	34	1.15	2.43	0.24	0.63	1.03	0.22	1.88
170	Pithecellobium saman	2	0.07	1.00	0.03	0.04	0.15	0.15	0.33
171	Poeciloneuron indicum	5	0.17	5.00	0.02	0.09	0.07	0.10	0.26
172	Polyalthia cerasoides	1	0.03	1.00	0.02	0.02	0.07	0.00	0.09
173	Polyalthia coffeoides	4	0.14	2.00	0.03	0.07	0.15	0.08	0.30
174	Polyalthia fragrans	22	0.75	2.44	0.15	0.41	0.67	0.34	1.41
175	Pongamia pinnata	1	0.03	1.00	0.02	0.02	0.07	0.02	0.11
176	Pterocarpus marsupium	61	2.07	3.39	0.31	1.12	1.33	1.60	4.06
177	Pterospermum diversifolium	8	0.27	8.00	0.02	0.15	0.07	0.16	0.38
178	Pterospermum reticulatum	10	0.34	1.67	0.10	0.18	0.44	0.04	0.67
179	Pterospermum rubiginosum	11	0.37	2.75	0.07	0.20	0.30	0.38	0.88
180	Radermachera xylocarpa	3	0.10	1.50	0.03	0.06	0.15	0.01	0.21
181	Sapindus laurifolius	1	0.03	1.00	0.02	0.02	0.07	0.02	0.11
182	Sapindus sp.	19	0.64	3.17	0.10	0.35	0.44	0.20	0.99
183	Sapindus trifoliatus	5	0.17	1.25	0.07	0.09	0.30	0.02	0.41
184	Schleichera oleosa	58	1.97	2.52	0.39	1.07	1.70	0.50	3.27
185	Spathodea campanulata	2	0.07	1.00	0.03	0.04	0.15	0.05	0.23
186	Spondias indica	4	0.14	2.00	0.03	0.07	0.15	0.05	0.27
187	Spondias pinnata	10	0.34	1.11	0.15	0.18	0.67	0.27	1.12
188	Sterculia balanghas	1	0.03	1.00	0.02	0.02	0.07	0.01	0.10
189	Sterculia guttata	39	1.32	1.95	0.34	0.72	1.48	0.49	2.68
190	Sterculia urens	18	0.61	2.00	0.15	0.33	0.67	0.24	1.24
191	Sterculia villosa	1	0.03	1.00	0.02	0.02	0.07	0.01	0.11
192	Stereospermum chelonoides	1	0.03	1.00	0.02	0.02	0.07	0.01	0.10
193	Stereospermum colais	93	3.15	3.44	0.46	1.71	2.00	1.54	5.25
194	Streblus asper	1	0.03	1.00	0.02	0.02	0.07	0.01	0.11
195	Strombosia ceylanica	1	0.03	1.00	0.02	0.02	0.07	0.01	0.10
196	Strychnos nux-vomica	1	0.03	1.00	0.02	0.02	0.07	0.02	0.11
297	Strychnos sp.	54	1.83	2.25	0.41	1.00	1.77	0.60	3.37
298	Swietenia mahagoni	96	3.25	32.00	0.05	1.77	0.22	1.55	3.54
299	Syzygium chavaran	1	0.03	1.00	0.02	0.02	0.07	0.04	0.13
200	Syzygium cumini	11	0.37	2.20	0.03	0.20	0.37	0.11	0.69
201	Syzygium travancoricum	1	0.03	1.00	0.02	0.02	0.07	0.18	0.27
202	Tabernaemontana alternifolia	8	0.27	1.60	0.08	0.15	0.37	0.03	0.55
203	Tabernaemontana sp.	67	2.27	3.35	0.34	1.23	1.48	0.29	3.00
204	Tectaria coadunata	9	0.31	4.50	0.03	0.17	0.15	0.07	0.39
205	Tectona grandis	698	23.66	21.81	0.54	12.86	2.37	10.32	25.54
206	Terminalia sp.	2	0.07	2.00	0.02	0.04	0.07	0.00	0.11

207	Terminalia angustifolia	2	0.07	2.00	0.02	0.04	0.07	0.07	0.18
208	Terminalia bellirica	49	1.66	2.45	0.34	0.90	1.48	1.73	4.11
209	Terminalia catappa	2	0.07	1.00	0.03	0.04	0.15	0.01	0.19
210	Terminalia chebula	1	0.03	1.00	0.02	0.02	0.07	0.18	0.28
211	Terminalia crenulata	138	4.68	4.93	0.47	2.54	2.07	2.68	7.30
212	Terminalia paniculata	399	13.53	8.14	0.83	7.35	3.62	8.85	19.82
213	Terminalia procera	2	0.07	2.00	0.02	0.04	0.07	0.01	0.12
214	Trema sp.	6	0.20	1.50	0.07	0.11	0.30	0.03	0.44
215	Tetrameles nudiflora	19	0.64	1.90	0.17	0.35	0.74	2.18	3.27
216	Toona ciliata	10	0.34	2.00	0.08	0.18	0.37	2.15	2.70
217	Trema orientalis	8	0.27	2.00	0.07	0.15	0.30	0.02	0.46
218	Trichilia connaroides	1	0.03	1.00	0.02	0.02	0.07	0.00	0.10
219	Turpinia malabarica	7	0.24	7.00	0.02	0.13	0.07	0.08	0.29
220	Vateria indica	21	0.71	10.50	0.03	0.39	0.15	0.27	0.80
221	Vepris bilocularis	12	0.41	2.40	0.08	0.22	0.37	0.14	0.73
222	Vernonia arborea	20	0.68	2.86	0.12	0.37	0.52	0.14	1.02
223	Vitex altissima	14	0.47	1.56	0.15	0.26	0.67	0.66	1.58
224	Wrightia tinctoria	118	4.00	4.72	0.42	2.17	1.85	0.49	4.51
225	Wrightia tomentosa	1	0.03	1.00	0.02	0.02	0.07	0.00	0.10
226	Xanthophyllum arnottianum	24	0.81	4.80	0.08	0.44	0.37	0.11	0.92
227	Xanthophyllum sp.	19	0.64	3.17	0.10	0.35	0.44	0.10	0.89
228	Xanthoxylum rhetsa	1	0.03	1.00	0.02	0.02	0.07	0.00	0.09
229	Xylia xylocarpa	423	14.34	12.09	0.59	7.79	2.59	8.59	18.97
230	Zaleya decandra	2	0.07	2.00	0.02	0.04	0.07	0.12	0.23
231	Unidentified sp.	1	0.03	1.00	0.02	0.02	0.07	0.00	0.10

4. Scrub Forests

The Scrub forest grids were dominated by *Anacardium occidentale, Tectona grandis, Hevea brasiliensis,* and *Syzygium lanceolatum* (Table7). The dominance of *Anacardium occidentale* can be attributed to the lateritic edaphic conditions of the scrub lands. The presence odf species like *Tectona grandis* and *Hevea brasiliensis* in the grids were mainly due to the plantation enhancement activities of different organizations.

Table 7. Typewise vegetation status of Scrub forests

Sl.No.	Species	N. Ind	D	A	F	RD	RF	RBA	IVI
1	Albizia odoratissima	5	2.50	5.00	0.25	2.01	1.61	6.55	10.17
2	Alstonia scholaris	1	0.50	1.00	0.25	0.40	1.61	1.11	3.12
3	Anacardium occidentale	33	16.50	16.50	0.50	13.25	3.23	7.94	24.42
4	Antidesma menasu	1	0.50	1.00	0.25	0.40	1.61	0.24	2.25
5	Artocarpus heterophylla	3	1.50	3.00	0.25	1.20	1.61	1.94	4.76
6	Artocarpus hirsuta	3	1.50	1.00	0.75	1.20	4.84	1.33	7.38
7	Bambusa bambos	8	4.00	8.00	0.25	3.21	1.61	0.66	5.49
8	Bischofia javanica	1	0.50	1.00	0.25	0.40	1.61	1.48	3.49
9	Bombax ceiba	16	8.00	16.00	0.25	6.43	1.61	3.79	11.82
10	Caryota urens	2	1.00	2.00	0.25	0.80	1.61	0.63	3.05
11	Casearia sp.	2	1.00	2.00	0.25	0.80	1.61	0.20	2.62

12	Chionanthus mala-elengi	9	4.50	3.00	0.75	3.61	4.84	2.89	11.34
13	Cinnamomum macrocarpum	1	0.50	1.00	0.25	0.40	1.61	0.08	2.09
14	Cinnamomum malabathrum	2	1.00	2.00	0.25	0.80	1.61	0.62	3.03
15	Cocos nucifera	1	0.50	1.00	0.25	0.40	1.61	0.32	2.34
16	Dalbergia latifolia	3	1.50	1.50	0.50	1.20	3.23	2.39	6.82
17	Dillenia pentagyna	1	0.50	1.00	0.25	0.40	1.61	0.15	2.17
18	Drypetes venusta	1	0.50	1.00	0.25	0.40	1.61	0.21	2.22
19	Elaeocarpus serratus	2	1.00	2.00	0.25	0.80	1.61	4.16	6.58
20	Erythrina indica	2	1.00	1.00	0.50	0.80	3.23	2.97	7.00
21	Ficus hispida	6	3.00	6.00	0.25	2.41	1.61	0.62	4.65
22	Flacourtia montana	5	2.50	5.00	0.25	2.01	1.61	3.52	7.14
23	Gliricidia maculata	15	7.50	15.00	0.25	6.02	1.61	2.19	9.83
24	Glochidion zeylanicum	2	1.00	2.00	0.25	0.80	1.61	0.77	3.19
25	Grewia tiliifolia	4	2.00	2.00	0.50	1.61	3.23	0.91	5.74
26	Hevea brasiliensis	30	15.00	30.00	0.25	12.05	1.61	8.33	21.99
27	Ixora notoniana	1	0.50	1.00	0.25	0.40	1.61	0.06	2.08
28	Litsea wightiana	4	2.00	4.00	0.25	1.61	1.61	1.78	5.00
29	Macaranga indica	1	0.50	1.00	0.25	0.40	1.61	0.16	2.18
30	Macaranga peltata	6	3.00	3.00	0.50	2.41	3.23	1.08	6.72
31	Mallotus tetracoccus	1	0.50	1.00	0.25	0.40	1.61	0.12	2.13
32	Mangifera indica	6	3.00	6.00	0.25	2.41	1.61	4.29	8.31
33	Nothapodytes nimmoniana	1	0.50	1.00	0.25	0.40	1.61	0.91	2.93
34	Olea dioica	15	7.50	15.00	0.25	6.02	1.61	7.99	15.62
35	Pavetta breviflora	1	0.50	1.00	0.25	0.40	1.61	0.60	2.62
36	Schefflera rostrata	2	1.00	2.00	0.25	0.80	1.61	0.27	2.69
37	Schleichera oleosa	1	0.50	1.00	0.25	0.40	1.61	0.24	2.26
38	Stereospermum colais	1	0.50	1.00	0.25	0.40	1.61	0.09	2.10
39	Stereospermum sp	1	0.50	1.00	0.25	0.40	1.61	0.72	2.74
40	Strychnos nux-vomica	2	1.00	2.00	0.25	0.80	1.61	1.11	3.53
41	Symplocos oligandra	2	1.00	2.00	0.25	0.80	1.61	0.20	2.62
42	Syzygium caryophyllatum	2	1.00	2.00	0.25	0.80	1.61	0.46	2.88
43	Syzygium lanceolatum	14	7.00	14.00	0.25	5.62	1.61	9.87	17.11
44	Tabernaemontana heyneana	2	1.00	1.00	0.50	0.80	3.23	0.13	4.16
45	Tamarindus indica	1	0.50	1.00	0.25	0.40	1.61	0.26	2.28
46	Tectona grandis	20	10.00	10.00	0.50	8.03	3.23	11.15	22.40
47	Terminalia paniculata	1	0.50	1.00	0.25	0.40	1.61	0.12	2.13
48	Vernonia arborea	1	0.50	1.00	0.25	0.40	1.61	0.24	2.26
49	Xanthophyllum arnottianum	1	0.50	1.00	0.25	0.40	1.61	0.72	2.74
50	Xylia xylocarpa	3	1.50	1.50	0.50	1.20	3.23	1.43	5.86

5. Non-forested Area

The non-forested areas (area outside the Reserve forests and Protected area) were dominated by *Hevea brasiliensis*, *Tectona grandis* and *Ailanthes triphysa* (Table8). The various afforestation programmes of Forest department and the activities of Rubber Board to promote rubber plantations were the major reasons for the large occurance of these species.

Table 8. Vegetation status (Non Forested Area)

Sl.No.	Species	N. Ind	D	A	F	RD	RF	RBA	IVI
1	Acacia auriculiformis	1	0.17	1.00	0.08	0.13	1.35	0.07	1.55
2	Ailanthus malabarica	70	11.67	70.00	0.08	8.94	1.35	7.78	18.07
3	Ailanthus sp.	82	13.67	82.00	0.08	10.47	1.35	8.49	20.32
4	Anacardium occidentale	26	4.33	26.00	0.08	3.32	1.35	3.31	7.99
5	Areca catechu	36	6.00	36.00	0.08	4.60	1.35	2.16	8.11
6	Artocarpus heterophylla	3	0.50	1.50	0.17	0.38	2.70	0.38	3.46
7	Artocarpus hirsuta	19	3.17	3.80	0.42	2.43	6.76	5.21	14.40
8	Bambusa arundinacea	1	0.17	1.00	0.08	0.13	1.35	0.00	1.48
9	Bambusa sp.	2	0.33	1.00	0.17	0.26	2.70	0.02	2.98
10	Bombax ceiba	11	1.83	5.50	0.17	1.40	2.70	1.94	6.05
11	Callicarpa tomentosa	1	0.17	1.00	0.08	0.13	1.35	0.05	1.53
12	Casuarina equisetifolia	1	0.17	1.00	0.08	0.13	1.35	0.06	1.54
13	Ceiba pentandra	1	0.17	1.00	0.08	0.13	1.35	0.23	1.70
14	Cinnamomum verum	2	0.33	2.00	0.08	0.26	1.35	0.10	1.70
15	Cocos nucifera	34	5.67	8.50	0.33	4.34	5.41	4.76	14.51
16	Dalbergia latifolia	1	0.17	1.00	0.08	0.13	1.35	0.07	1.55
17	Erythrina indica	1	0.17	1.00	0.08	0.13	1.35	0.58	2.06
18	Eucalyptus globulus	5	0.83	5.00	0.08	0.64	1.35	0.98	2.97
19	Ficus heterophylla	1	0.17	1.00	0.08	0.13	1.35	0.07	1.55
20	Gliricidia maculata	3	0.50	3.00	0.08	0.38	1.35	0.28	2.02
21	Gliricidia sp.	2	0.33	2.00	0.08	0.26	1.35	0.11	1.72
22	Grewia tiliifolia	5	0.83	2.50	0.17	0.64	2.70	0.98	4.32
23	Hevea brasiliensis	180	30.00	20.00	0.75	22.99	12.16	24.88	60.03
24	Holoptelea integrifolia	1	0.17	1.00	0.08	0.13	1.35	0.06	1.54
25	Lagerstroemia speciosa	1	0.17	1.00	0.08	0.13	1.35	0.04	1.52
26	Litsea Species	1	0.17	1.00	0.08	0.13	1.35	0.13	1.61
27	Macaranga peltata	16	2.67	4.00	0.33	2.04	5.41	0.96	8.41
28	Mangifera indica	5	0.83	1.67	0.25	0.64	4.05	1.41	6.10
29	Myristica fragrans	12	2.00	12.00	0.08	1.53	1.35	0.87	3.76
30	Naringi crenulata	2	0.33	2.00	0.08	0.26	1.35	0.06	1.66
31	Pithecellobium saman	1	0.17	1.00	0.08	0.13	1.35	0.24	1.71
32	Schleichera oleosa	4	0.67	2.00	0.17	0.51	2.70	0.22	3.43
33	Strychnos nux-vomica	2	0.33	1.00	0.17	0.26	2.70	0.08	3.04
34	Swietenia mahagoni	1	0.17	1.00	0.08	0.13	1.35	0.03	1.51
35	Tectona grandis	225	37.50	37.50	0.50	28.74	8.11	30.72	67.56
36	Terminalia crenulata	2	0.33	2.00	0.08	0.26	1.35	0.26	1.86
37	Terminalia paniculata	4	0.67	1.33	0.25	0.51	4.05	0.44	5.01
38	Theobroma cacao	3	0.50	3.00	0.08	0.38	1.35	0.16	1.89
39	Vepris bilocularis	3	0.50	1.50	0.17	0.38	2.70	0.97	4.06
40	Xylia xylocarpa	12	2.00	12.00	0.08	1.53	1.35	0.85	3.74

Tree and Shrub counts in Grids

The status of permenant vegetation of the region can be evaluated by the trend in tree and shrub counts in the 320 grids of Kerala region of Western Ghats. The top 20 tree species showing maximum number of presence (counts) and their respective percentage

values are given in Table 9. Accordingly, in Western Ghats, among tree species, *Mangifera indica* is had1293 counts (9.33% of the total of 20 top level species counts) and *Dalbergia latifolia* had the least (20th position with 3.31% of the total counts). The increase in the percentage occurrence of *Macaranga peltata* (5.24% of the total, which was more than 50% of the top ranked species value) is alarming. Being a light demanding species, and also as an indicator species of forest openings, the considerably larger counts of this species in Kerala part of Western Ghats, is a clear indication of the deforestation trend prevailing in the area.This trend should be considered seriously, and approptriate action should be taken for minimizing the forest openings and thus to slow down the retrogression.

Similarly, the top 20 shrub species in Western Ghats region and their respective counts and percentage values are given in Table 10. It was observed that *Lantana camara*, which had an occurrence of 16.41% out of top 20 shrub species, was the most virulent invasive shrub in the area; whereas, species like *Chromolaena odorata, Cyclea peltata* and *Smilax zeylanica* are the co-dominans in Kerala region. As an invasive weed, the spreading of this species needs special attention in forest management.

Table 9. Top 20 Trees of Kerala forests and Western Ghats

Whole Western Ghats			*Kerala region*		
Species	**%**	**Grid Count**	**Species**	**%**	**Grid Count**
Mangifera indica	9.33	1293	Macaranga peltata	9.13	231
Tectona grandis	7.43	1029	Terminalia paniculata	8.65	220
Syzygium cumini	7.07	980	Tectona grandis	8.30	210
Terminalia paniculata	6.98	967	Mangifera indica	6.77	171
Careya arborea	5.70	789	Bombax ceiba	6.01	153
Bombax ceiba	5.46	757	Artocarpus hirsuta	5.89	149
Terminalia tomentosa	5.27	730	Mallotus philippensis	5.33	135
Macaranga peltata	5.24	726	Schleichera oleosa	5.14	130
Terminalia bellerica	5.14	712	Alstonia scholaris	4.74	120
Butea monosperma	4.30	595	Aporosa lindleyana	4.31	109
Olea dioica	4.24	587	Dillenia pentagyna	4.03	102
Lannea coromandelica	4.23	586	Olea dioica	4.03	102
Ficus racemosa	4.22	585	Cassia fistula	3.75	95
Lagerstroemia lanceolata	4.16	576	Xylia xylocarpa	3.55	90
Azadirachta indica	4.05	561	Artocarpus heterophylla	3.55	90
Aporosa lindleyana	3.59	497	Hydnocarpus pentandrus	3.44	87
Cassia fistula	3.53	489	Terminalia bellerica	3.40	86
Mallotus philippensis	3.42	474	Careya arborea	3.32	84
Acacia nilotica	3.33	461	Lagerstroemia lanceolata	3.28	83
Dalbergia latifolia	3.31	459	Dalbergia latifolia	3.24	82
	100	**13853**		**99.99**	**2529**

Table10. Top 20 Shrubs of Kerala forests and Western Ghats

Whole Western Ghats			*Kerala region*		
Species	**%**	**Grid Count**	**Species**	**%**	**Grid Count**
Lantana camara	16.41	619	Lantana camara	11.78	116
Smilax zeylanica	6.79	256	Chromolaena odorata	9.73	96
Hemidesmus indicus	6.23	235	Cyclea peltata	8.82	87
Solanum mauritianum	5.38	203	Smilax zeylanica	7.51	78
Chromolaena odorata	5.30	200	Calycopteris floribunda	6.86	61
Calycopteris floribunda	5.17	195	Glycosmis pentaphylla	5.58	59
Cyclea peltata	4.99	188	Hemidesmus indicus	5.47	54
Jasminum malabaricum	4.51	170	Pothos scandens	4.46	44
Cryptolepis buchanani	4.43	167	Leea indica	3.86	39
Calotropis gigantea	4.35	164	Helicteres isora	3.85	38
Cocculus hirsutus	4.08	154	Asparagus racemosus	3.85	38
Vitex negundo	4.06	153	Naravelia zeylanica	3.55	35
Leea indica	3.98	150	Zizyphus oenoplia	3.44	34
Asparagus racemosus	3.95	149	Mikania micrantha	3.34	33
Dioscorea bulbifera	3.87	146	Jasminum malabaricum	3.26	32
Securinega virosa	3.74	141	Pelargonium sp.	3.26	32
Zizyphus oenoplia	3.47	131	Chasalia curviflora	3.14	31
Carissa congesta	3.37	127	Carissa carandas	3.04	30
Agave americana	3.02	114	Ziziphus mauritiana	2.54	25
Carissa carandas	2.89	109	Vitex negundo u	2.43	24
	99.99	**3771**		**99.99**	**986**

Products of the Project

1. A website focusing on Western Ghats

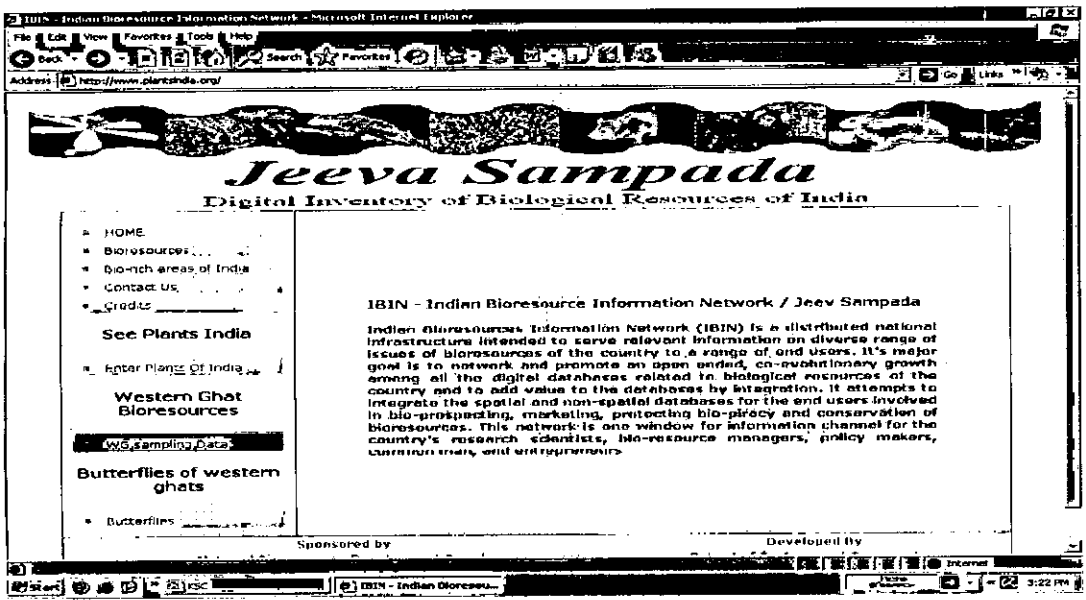


Fig.16. Indian Bioresource Network Information (IBIN) website window.

"Indian Bioresource Network Information" (IBIN) programme has already been initiated the one focusing on Western Ghats is now made available (Fig.16) online (www.ibin.co.in). The data, so made available, is already helping in mapping the hotspots resource diversity and availability. A Database was created for specieswise and gridwise search at finer scale. The data is made available online through the website (www.plantsindia.org). The database is available upto taluk level for trees, shrubs and herbs.

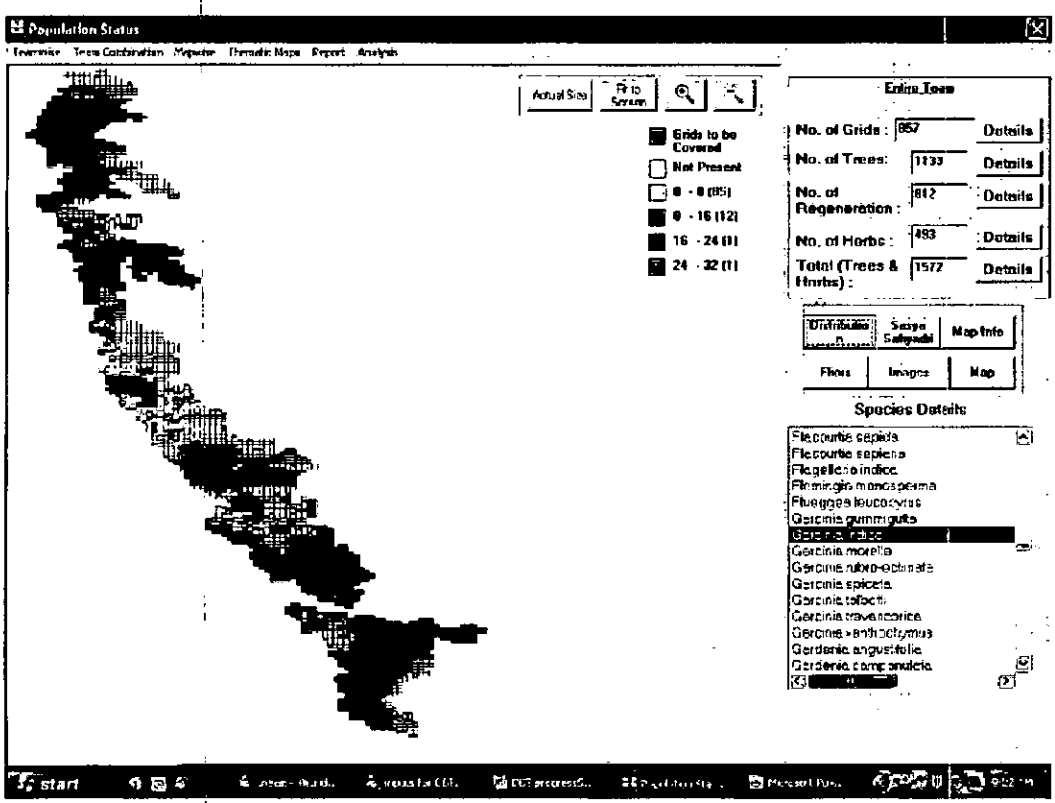
The data so made available will help in mapping the hotspots of resource diversity and availability. The website also offers thematic maps depicting population distribution. It enables users to derive information on availability of specific resources in different areas. The datasets generated suggest that some species have already reached critical levels in certain areas and are in need of careful planning for their long term conservation.

2. 'WeGPR' - Software to feed, manage data and to analyze spatial and temporal patterns of species

A comprehensive, access based program termed 'WeGPR', (Western Ghats Plant Resources) a software tool in VisualBasic and Access has been developed to feed, manage, and access the extent of data collected in the program and also to evaluate the distribution and availability of different species along Western Ghats. This program also maps the availability of different species and their population status in different grids, diversity of trees, shrubs and herb layers and also links each species to the fliers and specimen collected.

The progress of the data compiled can also be monitored through the program for

different regions of the Western Ghats. The module can be used to pick the combination of the data collected by teams along Western Ghats that one wishes to view (Fig.17).



A Screen window of WeGPR showing the population distribution of *Garcinia indica*

Fig.17. WeGPr window of *Garcinia indica* distribution

3. Decision Support System (DSS)

Stratification of the grids based on land use pattern and forest types is the most crucial aspect to capture the spatial heterogeneity in plant diversity. For this purpose a special GIS based package, Decision Supporting System (DSS) for stratifying and sampling the Western Ghats, was developed at the Coordinating center. This user friendly software incorporates several layers such as Topographic grids, rivers, road links, monthly NDVI values (at 1 X 1 km), FCC color maps (88 X 88 m), villages and vegetation layers. Based on all these, the investigators can objectively decide on

the exact locations of the transect, within a grid (Fig.18-20) and number of individuals per grid (Fig.21).

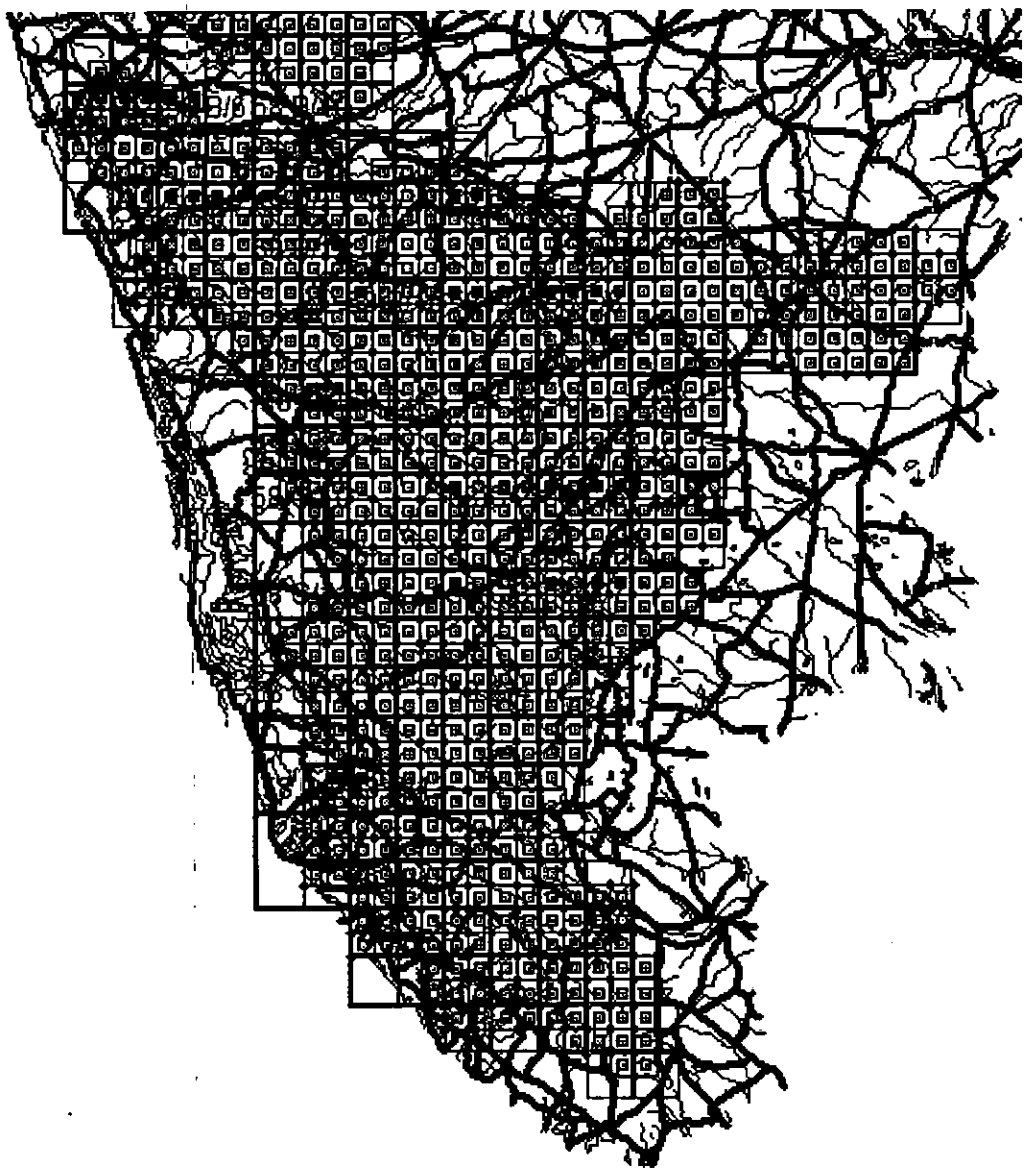


Fig.18.Study grids in southern Kerala

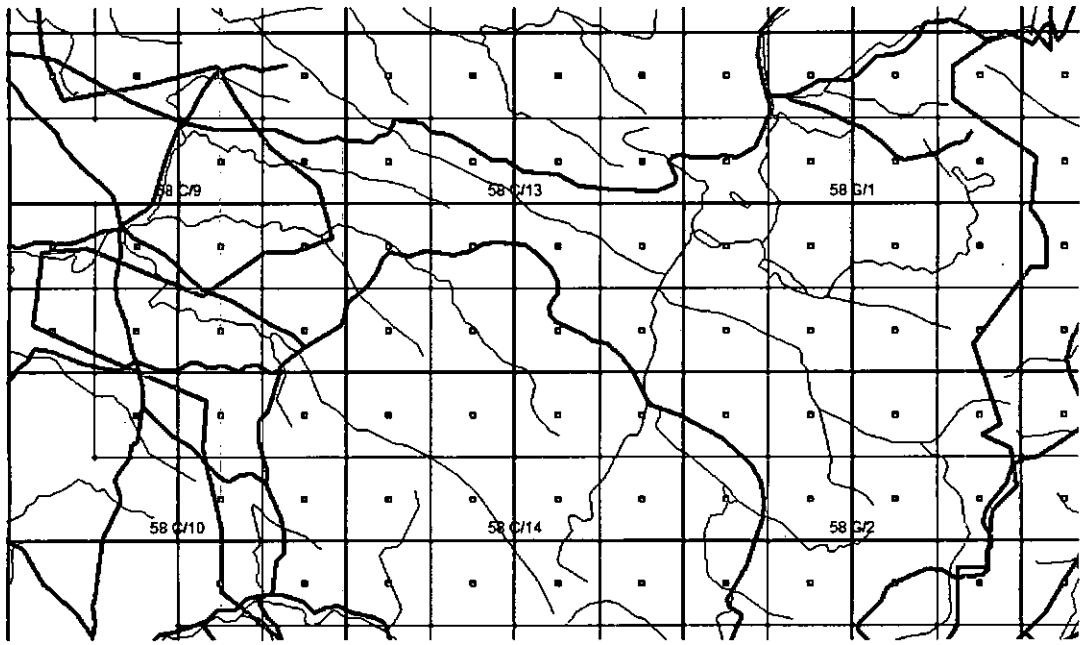


Fig.19. First level enlargement of grids

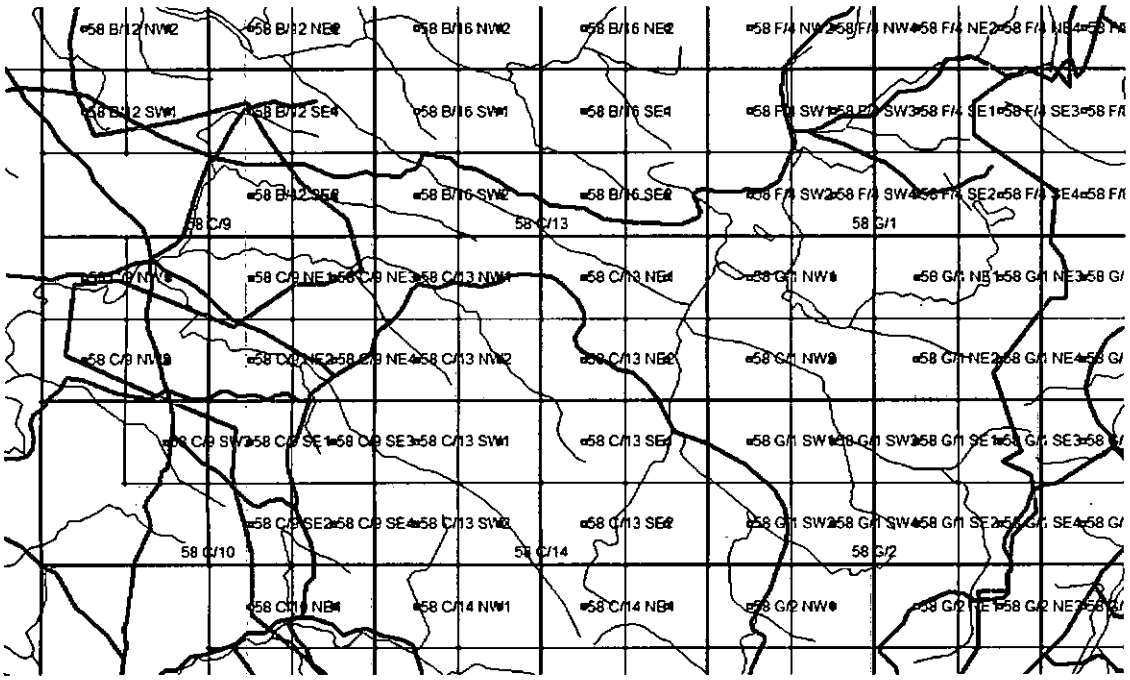


Fig.20. First level enlargement of grids

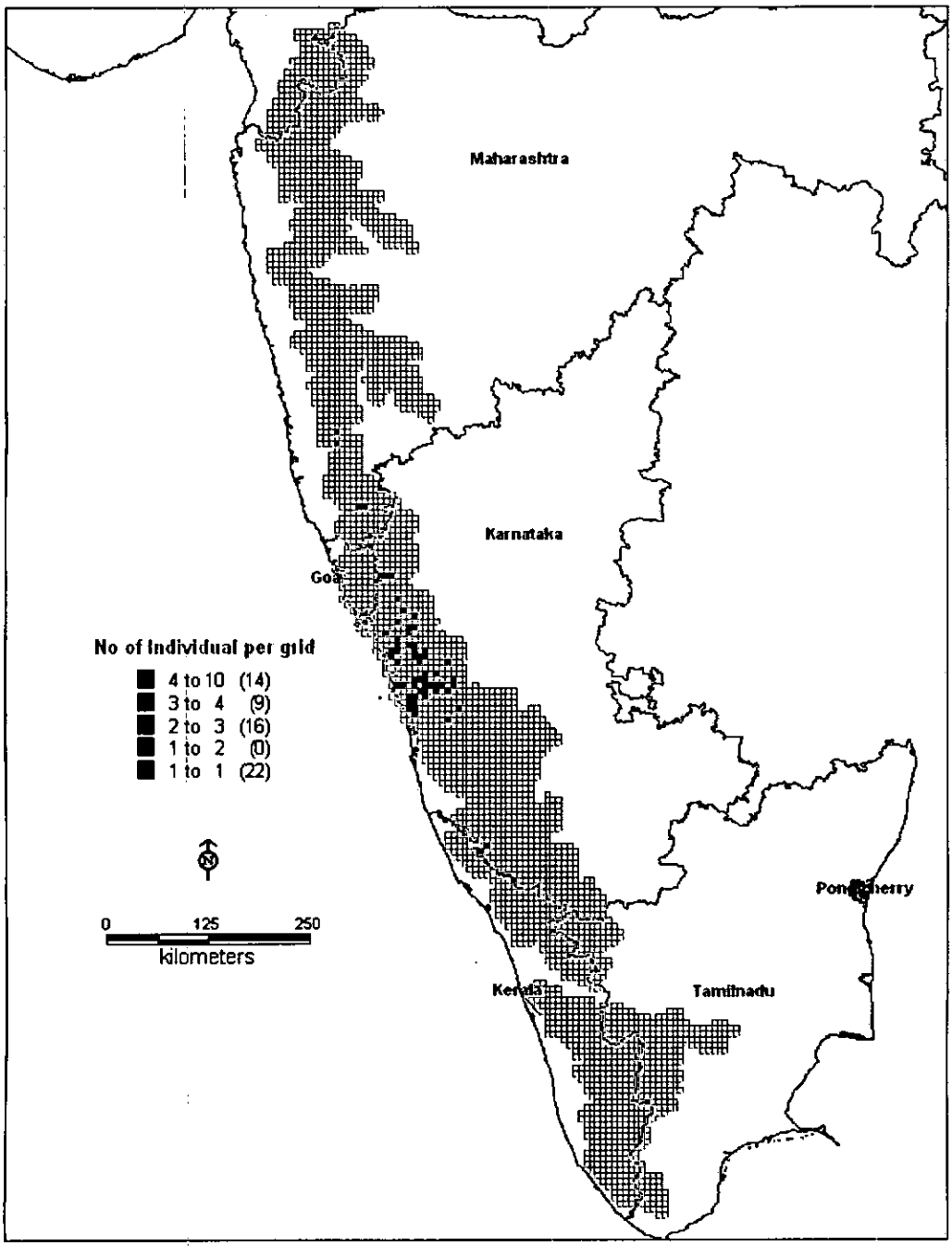


Fig.21. Grids showing species density distribution status

Forests are characterized by the variety of vegetation types due to climatic, edaphic and bio-geographic factors. According to (Richards, 1952) the Moist Forests in Western and Southeast Asia are among the oldest types in the World, being at least 30 million years old.

The tropical regions are endowed with a remarkably high level of biological diversity and habitat heterogeneity; so there are roughly twice as many species in tropical regions as compared to temperate ones. In India tropical rainforests occur in the Western Ghats, foot hills of the Himalayas, Khasi-Jaintia hills, Patkoi-Lushai hills of North- East India and the Andaman-Nicobar Islands. They harbor the largest number of species in the smallest area (Nayar, 1997).

The Ecosystem approach

The ecosystem approach is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. Application of the ecosystem approach will help to reach a balance of the three objectives of the convention. It is based on the application of appropriate scientific methodologies focused on levels of biological organization which encompass the essential processes, functions and interactions among organisms and their environment. The ecosystem approach for forest biological diversity could be described as a strategy for integrated management of forests that promotes their conservation and sustainable use in an equitable way. The ecosystem approach requires adaptive management to deal with the complex and dynamic nature of forest ecosystems and the absence of complete knowledge or understanding of their functioning. The ecosystem approach stresses that forest ecosystems should be managed within the limits of their functioning. Therefore,

the conservation of their structure and functioning should be a priority target. This is a prerequisite for keeping their full values, including the goods and services that forests deliver to human beings.

Diversity

The plant component determines the structure and functioning of tropical forest ecosystems more than any others (Richards,1952) which is rich in diversity has a high biomass and productivity. From the biodiversity point of view in the forest ecosystem, Tropical forests contain maximum diversity. Ecosystem diversity is generally assessed by the diversity of the component species relative dominance of various species as well as types of species. Ecosystem diversity denotes the diversity of habitats, communities and ecological processes within the biosphere. Ecosystem diversity is generally measured at two levels, that is, communities and ecosystems. Communities being kernel parts of ecosystem, measurements of community diversity are often used as of ecosystem diversity. Though some ecosystem diversity indexes have been put forward, none of them have got widely accepted. Ecosystem is also a dynamic function unit; those changes mainly include the long-term changes of physical environment and the genetic changes as a result of natural selection. Monitoring of ecosystems is based right on those changes. Two ways of monitoring are recommended; using sampling quadrate to monitor the changes of composition, structure and major ecological processes of ecosystem; and by using remote sensing and geographical information system (GIS) to monitor the change of area and distribution pattern of different ecosystem. Forest ecosystem studies have expanded spatially in recent years to address large scale environmental issues. We are using a geographic information system (GIS) to understand and integrate forest processes

at landscape to regional spatial scales. McNulty and Swank, (1996) used GIS and remote sensing techniques to analyze forest ecosystem. The rich and diverse vegetation wealth of India is undoubtedly due to its immensely varying climatic and geographical conditions with varied ecological habitats. It is therefore essential to have reasonably fair assessment of floral and faunal components of the biodiversity for the optimum utilization of resources.

Today is the outcome of evolutionary process which is continuing for over 3- 5 million years involving speciation, selection, migration, etc. Management plans must preserve the habitats and landscape structure needed by the target species rather than simply preserving the species in isolation. For effective forest management and bioresearch assessment authentic and scientific studies are essential which include vegetation analysis, habitat identification, restoration of rare and endangered plants etc. Kerala, on the lap of the Western Ghats draws more attention in conservational aspects because it harbors 1637 endemic plants out of 4679 species recorded from Kerala (Sasidharan 2004).

Physiognomic and structural status

The word structure has been used in many ways to describe assemblages of trees or species which seem to be follow particular mathematical laws; e.g. distribution of diameters at breast height (1.3m), total heights, spatial distribution of trees, floristic diversity and associations.

Physiognomic structural analysis of forests is often little more than qualitative descriptions. They are supported by tables or illustrations based on transect, profiles, quadrates or sample plots. Analysis is normally confined to small areas. On larger areas

the analysis tends to be partial, restricted to trees and shrubs exceeding certain minimum dimensions. Detailed physiognomic inventories are frequently based on unsystematic sampling within a forest ecosystem; hence it may not be wise to generalize the ecosystem based on such studies. Special ecological conditions may locally modify structure. The effect of gregarious structures, both global and by species is a decrease of local complexity in floristic mixtures. The fact that certain species are living preferentially together accentuates this tendency and contributes to structurize the forests. Although, the association concept can not be questioned, "a priori" it is obvious in certain niches or in special biotopes; it seems far obvious in lowland tropical rain forests where no noticeable variations of the environment occur to create marked floristic differences. Analyses demarcate new structures, linked to the behavior of each species and are reflected in specific spatial distributions. The assemblage of these behaviors is translated by several characteristics such as floristic richness and diversity. It is worthwhile to fit observed spatial distributions with theoretical models and deduct the properties of the tropical forests.

The distinguishing principal biological types like trees, shrubs, herbs, climbers, epiphytes etc. in an ecosystem; their relative importance and the position in the ecosystem and the variation in the structural and functional aspects are of importance in forestry studies. Trees are obviously the most important biological type. Study methods will be different for each biological type, because of dimensional differences and varying degrees of difficulty in gathering and identifying specimens and in drawing individuals "in situ". The structural information and land cover maps are essential for management of Wildlife Sanctuaries, National Parks, and Reserved Forests, etc. With regard to the

mapping and vegetation analysis of the Western Ghats, particularly Kerala part, very little information is available to that of different forest types and plant diversity assessment.

Changes

The pattern of change is extremely complex. Different processes operate at different magnitude and scale affecting individual species, population status, regional changes etc. The multidirectional success ional changes due to edaphic, climatic and biotic influences make the system more complex. Different time scale changes are noted; one of the smallest time-scale change is the phonological changes, i.e. The seasonal periodic change observed in the case of flushing, flowering, fruiting etc. of different species and is distinctive. This will affect the species composition of influencing the regeneration pattern of species and thus controlling the future of forests. In past this will also be determined by the inherited competitive characteristics of the species (ecological efficiency)including their intrinsic pattern of change in phenology during ontogenesis and by establishing communities by getting advantage of the site-specific vegetation dynamics. In the long term these process will interact through natural selection to determine future associations and cover types. The distribution of species and forest types will also vary in space and time according to limits imposed by environmental factors. These changes can be accelerated by anthropogenic effects and the resultant formations are normally unpredictable but definitely towards the degraded succession stages.

Broad patterns across zones of Western Ghats

Since Western Ghats are highlt heterogenous with respect to geo-climatological parameters, the entire Western Ghats were devided in to 5 zones based on the geographical continuity (Fig.2) and major patterns of diversity and distribution are

evaluated. The study reveals that, based on the overall estimation, Zone 3 (Northern Karnataka and Goa) was the richest in terms of the recovery of species and genera (963 species and 469 genera), while Zone 1 representing the Southern Kerala and Tamil Nadu was the least speciose. However, when species diversity was considered (as computed through Shannon's index), a clear gradient was identified. Zone 1 was the most diverse with Shannon's index value of 5.33, while northern most Zone 5 (Upper Maharashtra and Gujarat) was the least diverse (3.70). The trend was similar when data on genera was also considered. In the Zone 1 (Southern Kerala and Tamil Nadu), the average number of grids occupied by a species is the least, suggesting that the species are more densly packed.

An analysis of the similarity of the plant resources was assessed by computing the number of species shared by different zones and by computing Jaccard's similarity index. Zone 3 and Zone 4 shared maximum number of species (307) and least number of species was shared by Zone 1 and Zone5 (99).

New tools

Remote sensing forms a valuable tool in mapping and monitoring of biodiversity and provides valuable information to quantify spatial patterns, biophysical patterns, ecological process that determine species richness and anthropogenic factors causing loss of species richness and for predicating response of species to global changes. Information on existing land use / land cover pattern, its spatial distribution and changes etc. are essential requisite for planning (Dinwa *et.al.* 1993). The conventional methods of detecting land use/ land cover changes are costly, low in accuracy and pretend a picture only of a small area. Remote sensing, because of its capabilities of synoptic viewing and

repetitive coverage, provides useful information on land use / land cover dynamics (Sharama *et. al.*1989). The techniques of remote sensing have ushered in studying, surveying and monitoring forest features. With the development of remote sensing techniques, a new era has started in the field of resource survey, management and change detection studies. One of the greatest advantages in using remote sensing data is its ability to generate information in spatial and temporal domain, which is very crucial for successful model analysis, prediction and validation. The use of remote sensing technology involves large amount of spatial data management. The GIS technology provides suitable alternate for efficient management of computer database. The key to all GIS is the fundamental map base, to which all data eventually relates. Remote sensing is now being widely regarded as a layer in GIS. Remote sensing, although a specialized technique, is now accepted as a basic survey methodology, means of providing data for a resource scientist, whereas the GIS is the method by which data layers can be interrelated in order to arrive more logic conclusion.

Sampling

Quantitative sampling methods in small areas or quadrates were introduced in a few earlier studies of American vegetation (Pound and Clements, 1898). Quadrate sizes for different vegetation types vary accordingly. The minimal area of quadrate was standardized by species/area curve method (Cain, 1938). The increase in number of species with increase in area was first scientifically treated by Jaccard (1912) followed by Braun-Blanquet (1932), Cain (1938), Misra and Puri (1954), Oosting (1956), Misra (1968), Singh *etal.*, (1984), Basha (1988), Subhash Nautiyal *et al.* (1987), Pascal (1988), and Roy (1993).

Distribution

Distribution of species is one of the most important aspects of vegetation that has attracted many ecologists (Whitford, 1948; Ashby, 1948; Cole, 1949). Whitford (1948) used the ratio of abundance and percentage frequency as a measure of contagiousness among the plants. In most of the cases, abundance/frequency value of less than 0.025 indicates regular distribution, 0.025 to 0.05 random and more than 0.05 contagious (Curtis and Cottom, 1956). Gleason (1936, 1939) proposed the Continuum Concept. Curtis and McIntosh (1951) modified this concept. Continuum index value helps in evaluating the environmental influences over the vegetation. Phytosociological works in Kerala are summarized as follows. Some of the important publications are Singh *et al.* (1984) for Silent Valley, Basha (1987) for the evergreen forests of Silent Valley and Attappadi; Pascal (1988) for evergreen forests of Western Ghats and Menon and Balasubramanyan (1985) for Trichur Forest Division and Pascal and Pelissier (1996) for tropical evergreen forests of southwest India.

Western Ghats

Western Ghats form a discrete bio-geographic zone within which are recognized two biotic provinces, a narrow wet coastal plain, to the west of an almost continuous line of steeply rising hills and mountains. Western Ghats are a treasurehouse of plant and animal life, next only to the Himalayan tracts in the diversity of plant and animal species. The zone extends from 22 degrees N in south Gujarat to 8^0 N in extreme south of Tamil Nadu. The whole area is estimated at 1, 60, 000 km^2, of which forest cover is about one third. The Western Ghats is more than just a rich biological storehouse. Evergreen forests are fragile and cannot withstand disturbances as compared to moist deciduous forests.

Some 4000 of India's 50,000 plant species are recorded from Western Ghats; of these one thousand eight hundred or almost half are endemics. The richest formation is the Tropical Evergreen Forest with an estimated three thousand species, compared to an estimated 1800 in the moist deciduous forests. Biogeographic theory shows that the large natural areas have more species than smaller areas and, as a consequence, if you reduce a large area to a smaller area, you will suffer species loss. It is not only clear felling which causes loss of adequate habitat, the low population densities of most species and the high degree of endemisity, dictates that conserved Tropical Evergreen forest must be large and undisturbed to be fully effective. Logging reduces cover, humidity and subsequent canopy height and diversity and thereby reducing niche availability and species diversity. Vegetation mapping 1960s showed a total of 15000 km^2 of fairly intact forest canopy. Field surveys suggest that much of this is logged or otherwise exploited and true primary forest will be 10,000 km^2. It would appear that Western Ghats are on the way to the loss of another 50% of the habitat and another 10% of the species.

The rich and diverse vegetation wealth of India, undoubtedly due to it's immensely varying climatic and geographical conditions with varied ecological habitats is unique. It is therefore essential to have reasonably fair assessment of floral and faunal components of the biodiversity for optimum utilization of resources. Management plans must preserve the habitats and landscape structure needed by the target species rather than simply preserving the species in isolation. Thus habitat conservation has got importance and we are witnessing areas set aside as National Parks, Wild Life Sanctuaries etc. For effective forest management and bioresearch assessment authentic and scientific studies are

essential which include vegetation analysis, habitat identification, restoration of rare and endangered taxa, etc.

Forest status of Kerala

The status of forest vegetation of Kerala is well studied in the past (Chandrasekharan, 1962). Accordingly, the most widely distributed genera in the top canopy of Evergreen forests of Kerala are, *Palaquium* and *Hopea*. Other typical genera in this type are *Vateria, Calophyllum, Kingiodendron, Mesua, Cullenia, Poeciloneuron, Artocarpus* and *Tetrameles*. *Dipterocarpus* species are characteristics, but not as an essential component and are often locally absent. Leguminosae are relatively uncommon. Anacardiaceae, Meliaceae, Lauraceae, Euphorbiaceae and Myrtaceae are well represented. The families represented in the middle canopy are, Myrtaceae, Lauraceae, Meliaceae and Euphorbiaceae. Undergrowths of palms like *Pinanga dicksonii, Arenga wightii, Caryota urens*, are also met with.

The semi-evergeeen forests is an intermediate form between Tropical evergreen and Tropical moist deciduous types and is considered to represent as a transition stage influenced by man and environment. The "seral" (secondary) forms are under various stages of retrogression from the Evergreen climax type. In some cases the secondary stages are of 'Bio-edaphic' in nature, changing soil condition, subsequently the species association. The following forest types are considered as the major secondary edaphic types in Kerala.

C1- Lowland evergreen forest	S5- (b) Moist bamboo brakes
C2- Highland evergreen forest	S6- Low level grassland
C3- "Low" tropical Ghat evergreen forest	E1- Myristica swamps
S1- Semi-evergreen (secondary) forest	E2- Tropical valley freshwater swamps
S2- Secondary evergreen forest	E3- Tropical riverian forest
S3- Moist deciduous (secondary) forest	E4- Cane brakes
S4- Open deciduous forest	E5- Xylia mixed forest
S5- (a) Wet bamboo brakes	E6- Laterite scrubs

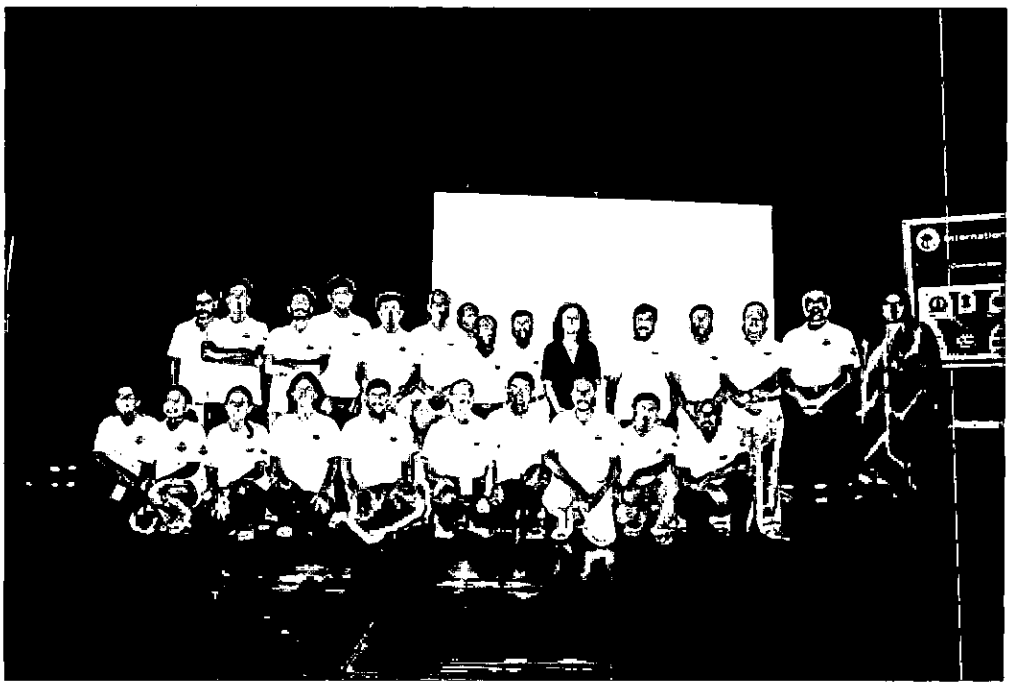
Summary of the National Mapping Project

The project aims at quantitatively assessing the geographic distribution, conservation status and phytogeographic aspects of plant resources of Western Ghats. The data sets and the spatial maps generated in this project would have important implications for the conservation, sustainable utilization and management of our plant resources. The project envisages a thorough documentation of plant resources of the entire Western Ghats by adopting a uniform and novel approach of integrating fine-tuned extensive field surveys with recent algorithms of vegetation classification. It tends to generate a spatial and upgradable database on species/habitat/landscape elements, which would enable to derive appropriate strategies for efficient resource use. Further it would help in drawing conservation maps for rare and endangered taxa as well as enhance our understanding population levels of the valuable plant resources. The data can also be used

for environmental impact assessment and to provide useful information for many biological sciences.

Based on the project data it was observed that the rare, endangered and threatened (RET) plant species in the Western Ghats have gone up from 25 to 40%. It has been found that 1600 species of plants come under the RET category. Majority of these endangered species of plants have been found in Kerala and Karnataka parts of Western Ghats. The entire Western Ghats region was divided into 3000 grids of 40 km^2 each and surveyed. Under the project 4000 species of plants have been surveyed, 1500 of them were tree and the rest were shrubs and herbs. There are about 900 species with well known medicinal use in the Western Ghats. The survey shows that diversity is abundant, particularly in central and southern parts of Western Ghats, thus making it possible to calculate the economic value of the Western Ghats and also identify the economically rich areas.

The five year project has been taken up by School of Ecology and Conservation, University of Agricultural Sciences, Bangalore, financially supported by Department of Biotechnology, New Delhi and seven teams are involved as collaborators in the project for collection of field information from various parts of Western Ghats. KFRI team is one among them for the collection of field data from Kerala part of Western Ghats (*KFRI 463/04 project: Mapping and quantitative assessment of geographic distribution and population status of plant resources of Western Ghats*).



The Research team

According to the study, the major cause of RET category to go up is due to anthropic activities like lopping, cutting stumps, collection of litter, soil removel, grazing, diversion of water and fuel collection. The other activities such as minning, river valley projects, forest fire, and timber extraction have contributed further. The scientific data from the survey will help to take policy decisions, for conservationists, identify the exact location and availability of the plant species, develop strategies for recovering plants of declining population and to identify suitable areas for conservation. Moreover it paves the way for developing suitable regions for harvesting and marketing the plants used for drugs and other commercial purposes. Under the project 4000 plant species have been surveyed, 1555 of them are trees and the rests are shrubs and herbs. It has been found that 1600 species of plants comes under the RET categories. It was found that about 30% of the plants come under rare category and 10% are endangered and threatened plant species. There are about 900 species with well known medicinal use in the Western Ghats.

References

Ashby, M. 1961. *Introduction to Plant Ecology.* Mac Million & Co Ltd, London, 456 pp

Basha, S. Chand, 1988. Studies on the ecology of evergreen forests of Kerala with special reference to Silent valley and Attapady. *Ph.D.Thesis, University of Kerala, Trivandrum.*232 pp.

Braun-Blanquet, J. 1932. *Plant Ecology.*Mc-Graw Hill Book Co.NewYork, 312 pp.

Chandrasekharan, C. 1962(a). Forest types of Kerala State (1). *Indian For. 88:* 660-674.

Chandrasekharan, C. 1962(b). Forest types of Kerala State (2).*Indian For.88:* 731-742.

Chandrasekharan, C. 1962(c). Forest types of Kerala State (3).*Indian For. 88*:837-847.

Cain, S.A.1938 .The species area-curve. *Arnes.mid.nat., 19:* 578-581.

Curtis, J.T. and R.P. McIntosh, 1950. The interrelations of certain analytic and synthetic phytosociological characters. *Ecology, 32:* 434-455.

Cole La, M.C.1949. The measurement of interspecific association. *Ecology.30:* 411-424.

Curtis, J. T. and Cottom. 1956. *Plant Ecology Workbook. Laboratory Field Reference manual.* Burgess Publication Co., Minnosota, 193 pp.

Dhinwa, P.S., S.K. Pathak, S.V.C. Sastry, M. Rao, K.L.Majundar, M.L.Chotani, and J.P. Singh, 1993. Landuse change analysis of Bharathpur district using GIS. *Photonirvachak. J. Ind. Soc.Remote Sensing, 20(4):* 237-250.

Gleason, H. A. 1936. The individualistic concept of the plant association. *Bull. Torrey. Bot. Club. 53:* 1-20.

Gleason, H.A. 1939. The individualistic concept of plant association. *Am. Midland Naturalist.21:* 92- 110.

Jaccard, P. 1912. The distribution of the flora of Alpine zone. *New Phytol., 11:* 37-50.

Magurran, A.E. 1988. *Ecological Diversity and its Measurement.* Croom Helm Limited, London. 179 pp.

McNulty, S. G.and W.T.Swank, 1996. *Eco-Informa '96*, Lake Buena Vista, Florida, 4-7 November 1996.

Menon, A.R.R. and K. Balasubramanian. 1985. Species relation studies in Moist Deciduous Forests of Trichur Forest Division (Kerala). *Kerala Forest Research Institute, Research Report No. 32.* 194 p

Misra, R. and G. S. Puri. 1954. *Indian Mannual of Plant Ecology.* The English Book Depot.Poona and Dehra Dun. 256 p.

Misra, R. 1968. *Ecology Workbook.* Oxford and IBH Publications.Co.,NewDelhi. 244 p.

Mueller-Dombois, D. and H. Ellenberg, 1974. *Aims and Methods of Vegetation Ecology.* John Wiley and Sons, New York 547p.

Nayar, M. P. 1997. Biodiversity challenges in Kerala and science of conservation biology. *Biodiversity of Tropical Forests the Kerala Scenario, 7-80:* P.Pushpangadan and K.S.S.Nair, (eds.) STEC, Kerala, Trivandrum.

Oosting, H. J. 1956 . *The study of plant communities.* 2nd edition, Freeman and Co.. San Fransico.

Pascal, J. P. 1988. Wet evergreen forests of Western Ghats of India: Ecology, structure, floristic composition and succession. *Institute Francais*, Pondichery. *Fraw. Sect. Sci. Tech. Tome.* XX: 345.

Pascal, J. P. and Raphael Pelissier 1996. Structure and floristic composition of a tropical evergreen forest in south west India. *J. Trop. Ecol., 12:* 191- 214.

Pound, R. and F. E.Clements, 1898. A method of determining the abundance of secondary species. *Minn.Bot.Stud., 2:* 19-24

Richards, D. W. 1952. *Tropical Rainforest – An ecological study.* University Press, Cambridge.

Roy, P. N. 1993. A study of the optimum size of sample plot for forest inventory. *Ind. For., 119(1):* 1-10.

Singh, R. K. and S. Khan, 1984. The Forest vegetation of Silent Valley, India. *Tropical Rainforest, the Leeds.Symposium,* 25-52.

Sharma, K. D., S. Singh, N. Singh, and D.N. Bohra, 1989. Satellite Remote Sensing for detecting temporal changes in grazing lands. *(Photonirvachak) J. Ind. Soc.Remote Sensing, 17(4):* 55-59.

Subhash Nautiyal, N. G., Totey, A.K. Singh and A.K. Bhomik, 1987. Forest vegetation survey of South Raipur division, M.P:A quadrat analysis. *Indian J. For.10 (1):*16-18.

Whitmore, T. C. 1984. *Tropical rainforest of the Far East.* (2nd ed.) Clarendon Press, Oxford.