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Biodiversity Characterization at Landscape Level Using Satellite Remote Sensing (DBT-DOS project) Phase – II study

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Abstract of project proposal

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Title: Biodiversity characterization at landscape level using satellite remote Sensing (DBT-DOS project) Phase-II study.

Objectives: 1.Gathering structural and compositional data of vegetation of selected localities in Goodrikal reserves.

2. Analysis of vegetation for structural parameters

3. Preparation of ecological maps using satellite remote sensing data

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Investigator: Dr. A.R.R.Menon

Research Fellow: Sri.E.S.Abhilash

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Abstract

Biodiversity characterization at landscape level has been carried out using Indian Remote Sensing Satellite data in Kerala. The study has been undertaken jointly by the Department of Space and is part of a major initiative taken up by the Department of Biotechnology under its Network programme for Bioprospecting, commenced in 1997. The programme is a true implementation of “gene to ecosystem” concept in biodiversity conservation and prospecting. This project is a pioneering effort to create geospatial database on vegetation cover types, disturbance regimes and biological richness. The spatial data have also been linked with the species database and field sample data laid down in different strata of vegetation to the phase II part of the project, detailed sampling was performed in comparatively undisturbed forests of Goodrikal reserves in Ranni forest division, with an ecological insight, to understand the forest dynamics. The information system evolved in the present study through multicriteria analysis in GIS, facilitates the rapid assessment of biodiversity and its monitoring (loss and/or gain), assessment of nature of habitats and disturbance regime therein; evolving species-habitat relationship, mapping biological richness and gap analysis; and prioritizing conservation and bioprospecting. A very detailed land cover map of the area was prepared using Aerial photographs and Satellite imageries. The density sliced version of the cover map was also generated using digital mapping techniques and is the basis of the sampling site selection. The vegetation data were gathered and analyzed for 25 selected localities, representing the different forest types and density levels. The slope class map, contour map etc. are also generated from the available terrain information The structure of the forest vegetation and the distribution of different forest types are described in detail.

Contents

INTRODUCTION

The Department of Space (DOS) at the behest of Department of Biotechnology (DBT), Ministry of Science and Technology, Government of India, New Delhi has taken up a project on "Characterising the biological richness at landscape level using satellite remote sensing data". Under this programme three test site areas, *viz.* North-Eastern Himalayas, Western Ghats and Western Himalayas, have been chosen, based on existing knowledge about the biodiversity 'hot spots'. As part of this programme, a collaborative project was undertaken by Kerala Forest Research Institute (KFRI) with National Remote Sensing Agency (NRSA) for the 'Biodiversity Characterization study of Kerala part of Western Ghats'. The outcome of the three year project was brought out as KFRI Research Report No. 274 (2005). As Phase II of the project, a very detailed study was undertaken by NRSA with the collaboration of KFRI in tropical evergreen forests of the Western Ghats in Moozhiyar Reserve Forests of Ranni Forest Division.

Phytosociological inventory and analysis of vegetation to derive the special patterns of plant diversity are essential for landscape level biodiversity analysis. In the present study an attempt was made on these lines. Emphasis on the study of spatial patterns of plant diversity is highly necessary for landscape level study. This can be achieved using remote sensing techniques. The tropical forests are rich in phytodiversity (Padalia *et al.,* 2004). The importance of spatial heterogeneity to species diversity has been well documented (Whittaker, 1972). Landscape parameter is emphasized by patch size, type, number, shape, heterogeneity and edge features indicate spatial organization of vegetation types, biotic disturbance and habitat stability (Turner, 1989; Li and Reynolds, 1993; Ritters *et al..,* 1995). Goodrikal Reserve Forest of the Western Ghats was selected, mainly due to its virgin nature, for a detailed ecological investigation. The present report is the outcome of the phase II study of the biodiversity characterization project mentioned above.

MATERIALS AND METHODS

STUDY AREA

For the detailed evaluation of the vegetation under the phase II study of biodiversity characterization program, Goodrikal Reserve Forest of Southern Kerala, mainly consisting of West Coast Tropical Evergreen forest type, was selected. The area lies between 76° 45' and77° 30' E longitude and between 14° 45' and15° 15' N latitude, at an altitudinal range of 100 to 1400 m (Figs.1 and 2). The boundary and some important places in the study area are given in Figure.3.

Fig.1 Location map of study area

The climate in the area is moderately hot and humid. Diurnal variation in temperature is not more than 10°C. The maximum mean daily temperature in the plains during the hottest month of March is about 32°C and that in the coldest month of January is 20°C. The plains are generally hot and humid and the hills, cooler and drier.

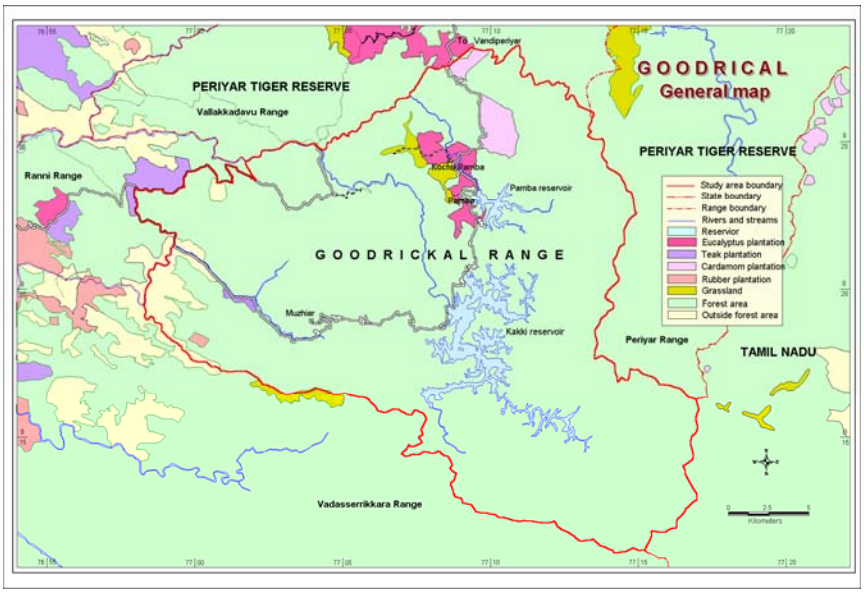

Fig.2. Study site (Goodrical R.F.)

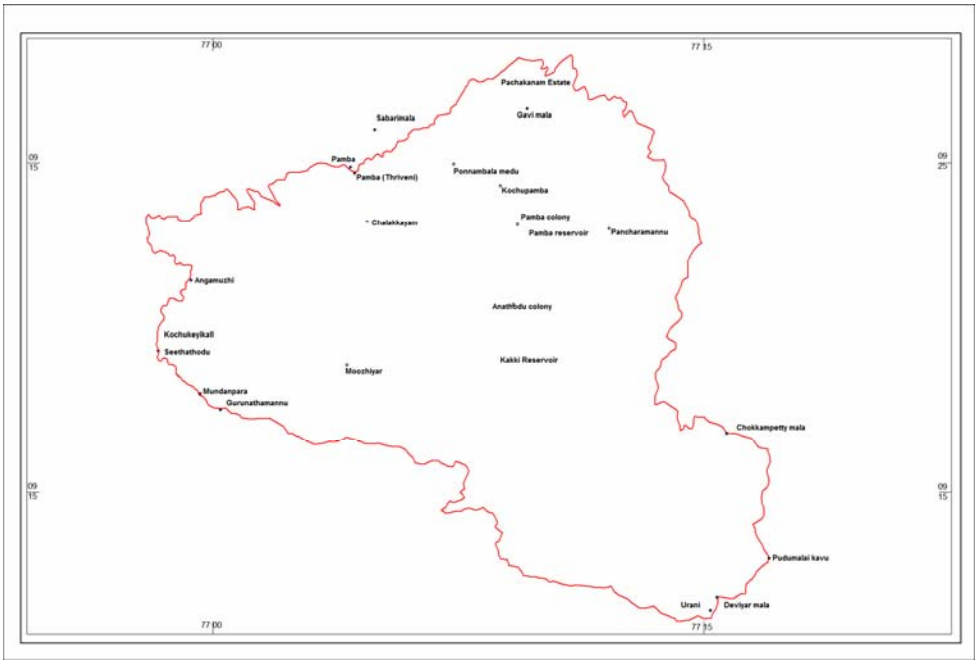

Fig 3. Boundary map of Goodrical RF and place

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Vegetation Classification Scheme

Since the study was part of a National level project on *'Biodiversity assessment'* for North-eastern India, Western Himalayas and Western Ghats; covering three different climatic zones, a broad vegetation classification scheme was adopted for mutual uniformity. In the present study, Level II Vegetation classification is attempted. Following classification scheme was adopted for "Stratification"**,** using Remote Sensing Digital data.

Forest Vegetation

I. Forests

1. *Dominant phenological types*

1.1. Evergreen

1.2. Semi-evergreen

1.3. Moist deciduous

1.4. Dry deciduous

2. *Gregarious types (single species dominated*)

2.1. Bamboo

3. *Local specific classes*

3.1. Mangroves

3.2. Sholas

3.3. Riperian

3.4. Sacred groves

4. *Degradation types*

4.1. Degraded forest stages (eg. 10-40 per cent tree density, signs of erosion and of composition not confirming with any of the above types).

II. Scrubs

III. Grasslands

Non forest vegetation

IV. Major Wetlands

V. Orchards (Tea/Coffee/Coconut gardens etc.)

VI. Agriculture

VII. Fallow/Barren

VIII. Water body

IX. Settlements

Digital Classification of Satellite Data

Pre-processing

The raw digital data were enhanced using contrast stretching and/or ratio based techniques to facilitate better discrimination during ground data collection or locating sample points.

Reconnaissance Survey

The reconnaissance survey was undertaken for getting better acquaintance with the general nature of vegetation of the area. Major vegetation types and few prime localities of characteristic types were noted during reconnaissance survey. The variations and tonal patterns were also observed on existing images/maps (Fig. 5). Traversing along major drainage, roads, paths, etc. for ground truthing, existing literature survey, and interaction with forest officials were also made during field survey.

The vegetation classification was performed as per the scheme mentioned earlier. The different scenes were classified using *Maximum likelihood* algorithm. After completing the classification, misclassified areas were checked and reclassified considering small *Area of Interest* (AOI) or through Interactive Editing for improved accuracy. Finally all classified scenes were mosaiced and the edges were smoothened.

The approach for land cover mapping is as follows:

(Schematic approach for land cover mapping)

Raw Satellite Data

Pre-processing Geometric and Radiometric correction

Sun angle effect Ratioing Haze removal

NDVI etc. (Removal of Discrepancies, Histogram equalization
Dark object subtraction etc.)

Knowledge base Hybrid classification Ground-truthing

Digitally classified vegetation/cover map

PHYTOSOCIOLOGICAL STUDIES

The phytosociological parameters of the vegetation were worked out for the computation of structural status of cover types. The sampling principles were based on inventorying the homogeneity status, identified by remote sensing data analysis. As per the spectral signature variability in consonance with the vegetation/cover type and orientation of terrain, 25 plots of 0.1 ha size (33 m x 33 m) were marked on 1: 50, 000 scaled topo-sheets (Fig. 12), and plots were relocated using GPS and species data were gathered.

Sampling Strategy

Stratified random sampling with probability proportion to the size (PPS) was adopted for analyzing vegetation composition of all the types encountered. The percentage sampling procedure, to sample an area of nearly 0.01 percent of total area of each type was adopted. In view of the availability of time, money and other resources, optimum number of sample points were taken up, covering all vegetation types, in different density/disturbance regimes. For each vegetation type, the size of the quadrat was determined through *'Species-Area curve method'* (Muller– Dombois and Ellenberg, 1978). The plot size was restricted to 0.1 ha. (33 m x 33 m). A minimum of 8-10 quadrats were analysed for each type. Each sample site was located on Survey of India Toposheets. Exact longitude and latitude and location height (msl) were noted down using Global Position System (Garmin III plus and Magellan Nav. Pro. 5000).

Plot Method and Enumeration

At each sample plot, complete enumerations of species were done. The circumferences at breast height (cbh) or 1.3 m above ground level, of all tree species were recorded. The individuals with cbh >30 cm were considered as trees and with >17 cm and <30 cm cbh as saplings. The number of seedlings of different species were counted and the average girth of each species were recorded. For shrubs, plots of 10 m x 10 m were laid within the main plot. For herbaceous layer or ground flora, the *nested quadrat method*s with 1 m x 1 m plot size were taken in two opposite corners and wherever required number of samples were increased up to five, ie. at four corners and one in centre (Fig. 13).

Census quadrat techniques were adopted and the plots were laid down across the contour, so that land morphological variations can be accounted in enumeration. Two subplots of 10 m x 10 m size were laid diagonally at each main plot and status of shrubs and herbs along with regeneration status of tree species were enumerated.

Phytosociological Analysis

The analysis was done as per Muller-Dombois and Ellenburg (1978).

$$\textit{Frequency} = \frac{\text{Total number of quadrats in which species occurred}}{\text{Total number of quadrats studied}} \times 100$$

$$\textit{Density} \text{ (Per quadrats)} = \frac{\text{Total number of individuals of the species}}{\text{Total number of quadrats studied}} \times 100$$

$$\textit{Abundance} = \frac{\text{Total number of individuals of species occurring}}{\text{Total number of quadrats in which species occurred}} \times 100$$

$$\textit{Relative frequency} = \frac{\text{Frequency of a species}}{\text{Sum of frequency of all species}} \times 100$$

$$\textit{Relative Density} = \frac{\text{Density of a species}}{\text{Sum of density of all species}} \times 100$$

$$\textit{Relative dominance} = \frac{\text{Total stand basal cover of species}}{\text{Total stand basal cover of all the species}} \times 100$$

$$\textit{Basal cover} = \frac{(\text{cbh})\ 2}{4\ \Pi}$$

Sum of basal cover of individual plants of a species will yield *total stand basal cover* of that species.

$$\textit{Mean basal cover} = \frac{\text{Stand basal cover}}{\text{Density}}$$

Importance Value Index (IVI) = Relative Frequency + Relative Density + Relative Dominance

The standard vegetation analysis procedures were adopted (Muller-Dombois and Ellenberg, 1978) for structural status evaluation.

The phytodiversity has been quantified in terms of Shannon-Weiner index as:

$$\text{Shanon-Weiner index (SW)} = \sum_{i=1}^{M} (Pi)(\log 2\ Pi)$$

where Pi = proportion of total sample belonging to ith species. The data are tabulated (Table 26).

OBSERVATION HIGHLIGHTS

VEGETATION MAPPING

A general vegetation type map of Kerala was generated as the part of DBT/DOS sponsored project on 'Landscape level Biodiversity Characterization using Remote Sensing and GIS-Kerala, Western Ghats' (Fig. 4). The land cover statistics are given in Table 1.

Table 1. Land cover statistics of Kerala using IRS satellite data (in sq. km)

District	EG	SEG	MD	DD	GR	DEG	GRSP	PLN (NF)	SC	AGR	FAL/BAR	REEDS	WAT
Trivandrum	57.0	67	274.4		22.2	33.4	16.1		0.4	1492.1	155.4	3.1	30.5
Quilon	110.4	115.1	399.5	1.8	92.6	112	18.9	0.0	25.9	1311.5	169.1	15	101.2
Pathanamthitta	386.8	270.5	617.2	7.8	78.4	50.8	36.8	1.0	21.3	1029.8	74.5	29.8	21.5
Kottayam	22.9	13.3	145.4	3.1	24.7	15.8	25.6	61.9	8.8	1577.6	253.3	5	46.2
Aleppy			4.6					142.4		740.1	419.6	114.3	113.6
Idukki	799.8	564.3	1641.9	5	612.4	328	167	0.3	182.2	319.6	19	11.8	113.1
Ernakulam	19.2	4.2	115.3	0.8	56.6	51.2	17.1	122.2	21.8	1443.2	437.5	3.4	93
Thrissur	176.3	43.8	346.6		101.6	16.9	77.8	219.2	9.6	1333	635.2		56.8
Malappuram	209	95.4	320.5	1.6	8.1		95.4	421.9		1691.7	690.6		29
Palakkad	335.3	160.6	670.3		130.7	165	98.2	210.2		1332.4	1285.8		44.2
Wayanad	100.6	93.8	318.5	259			177.5	769.8		127.3	276.2		5.1
Kozhikode	90.3	82.5	114.2	0.2	0		87.4	491.4		985.8	436.4		44.7
Kannur	62.6	77	61.8	1.5		55.5	33.3	707.5		989.2	912.1		46.4
Kasaragod	10.4	16.5	0			62.1	5.6	409.3		568.3	870.4		19.7
Percent of total geographic area	6.13	4.13	12.94	0.72	2.9	2.29	2.2	9.15	0.7	38.45	17.07	0.47	1.97

EG - Evergreen forest, SEG - Semievergreen forest, MD - Moist deciduous forest, DD - Dry deciduous forest
GR - Grassland, DEG - Degraded forest, FAL/BAR - Fallow Barren, WAT - Water, AGRL - Agricultural, GRSP - Gregarious species, PLN (NF) - Plantation Non forest, SC - Scrubs

Geocoded sub scenes of satellite images of Kerala of 1999 was mosaiced to get state level picture. A detailed vegetation map of the study area was prepared in 1: 50,000 scale using IRS 1C LISS III imagery of 1999, by adopting standard digital

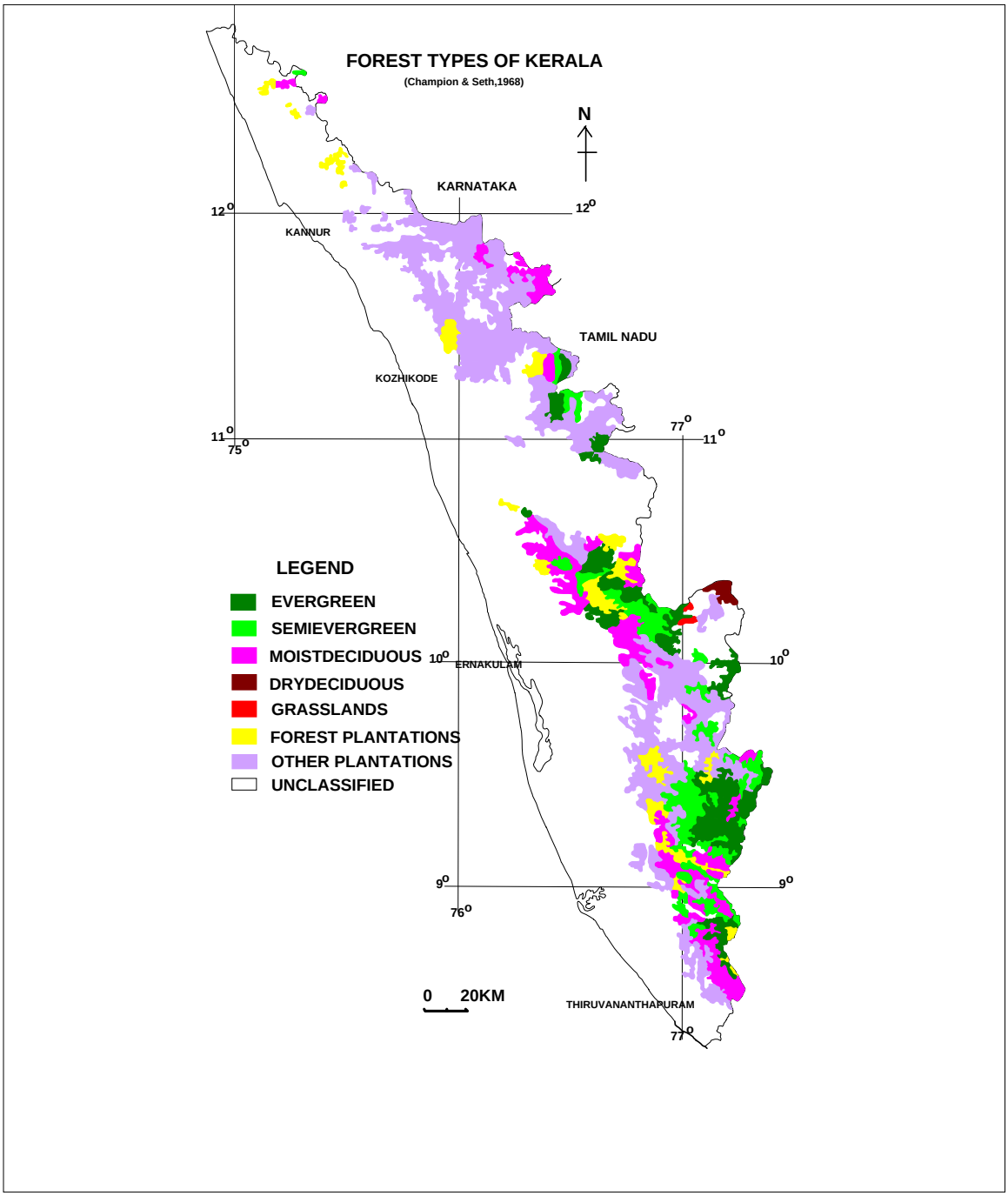


Fig.4. Map of Kerala showing major forest types

classification procedure. The vegetation classification was performed using maximum likelihood algorithm and the sub scenes of satellite images were mosaiced to generate the state level picture (Fig. 6), accordingly West Coast Tropical Evergreen Forest Type (Champion and Seth, 1968) occupies the major portion of the study area.

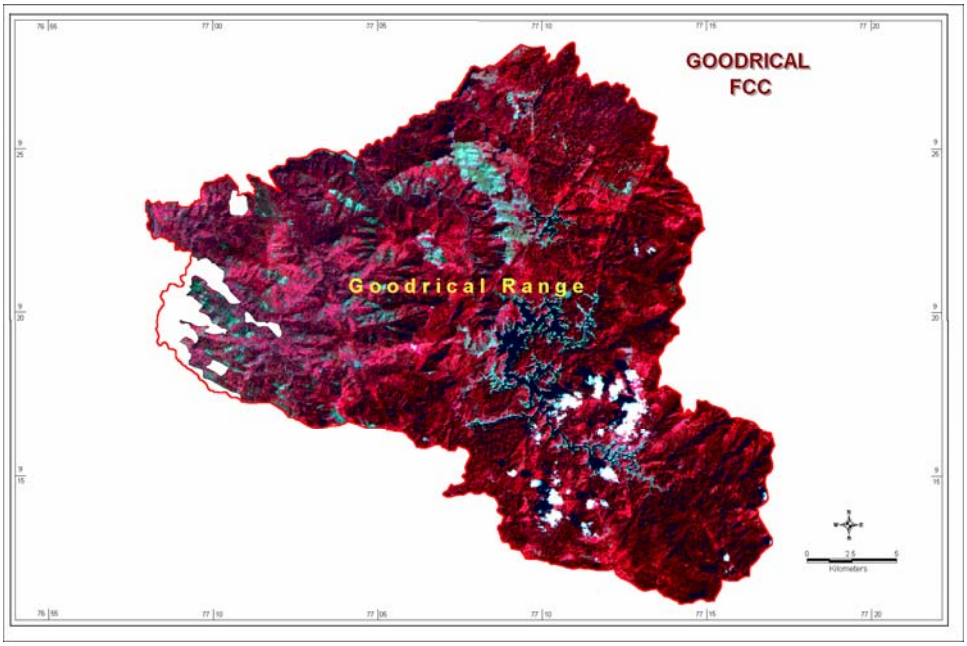


Fig. 5. False Color Composite of Goodrical RF

A density sliced cover map of the area was also prepared (Fig. 7) and the field sampling sites were identified and selected, according to the cover density status of different types.

A very detailed forest type map was prepared from 1: 15, 000 scaled aerial photographs of 1990 (Fig. 8) using various photo elements and subsequent visual interpretation techniques. Three density level vegetation classification for the major forest types viz. Evergreen, Semi-evergreen and Moist deciduous forest types were also performed based on canopy density classification system, as Spare, Medium and Dense (less than 30% canopy density, 30-60% canopy density and more than 60% canopy density, respectively) cover classes.

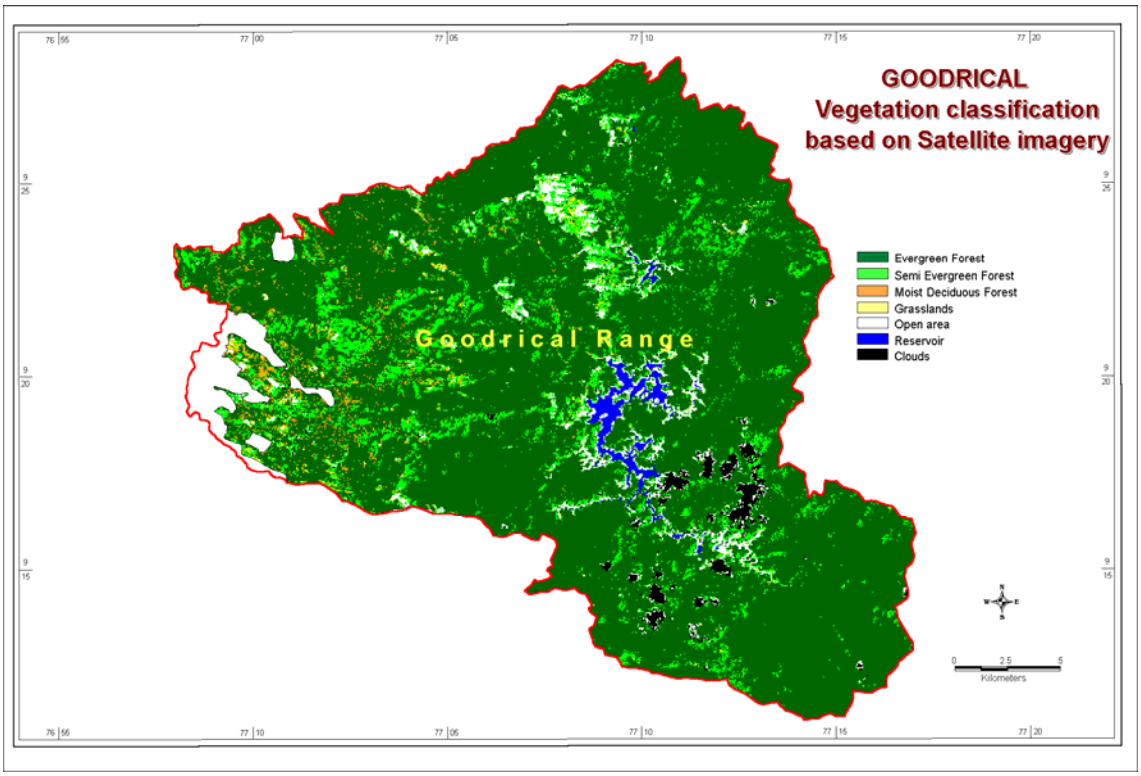
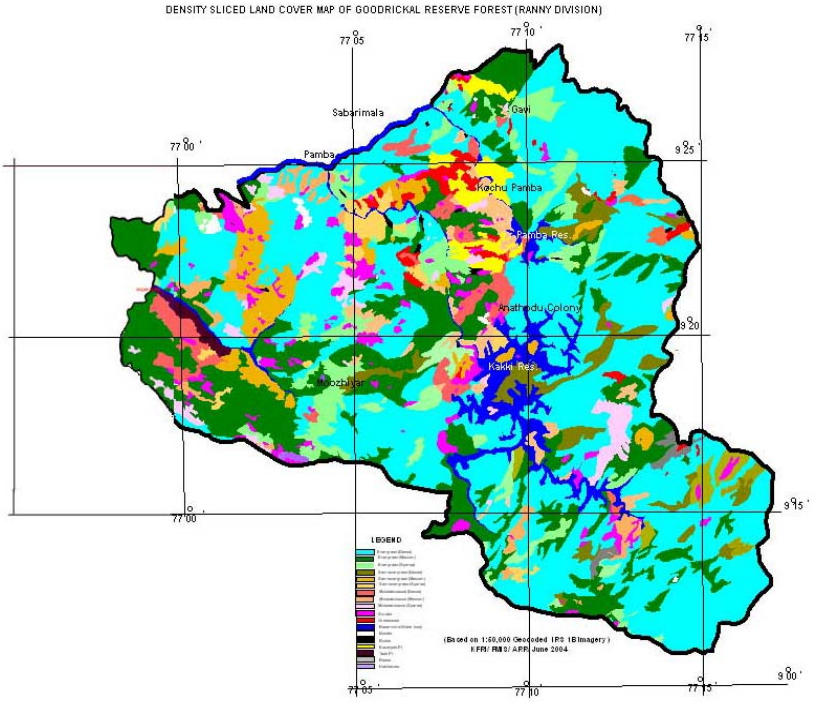


Fig. 6. Digital map of the study area based on 1:50,000 IRS 1C Liss 3 imagery of 1999.

The digitally classified map is having six major units such as evergreen, semi-evergreen, moist deciduous forest plantations, open scrubs and reservoirs. Most of the area is having high dense evergreen cover type with very less forest fragmentation. Since the area is less disturbed when compared to other parts of the Western Ghats, except to that of selection felled region, structural and regeneration status of vegetation is comparatively good to that of other parts of Western Ghats.

Fig. 7. Density sliced vegetation map of Goodrical Reserve Forest



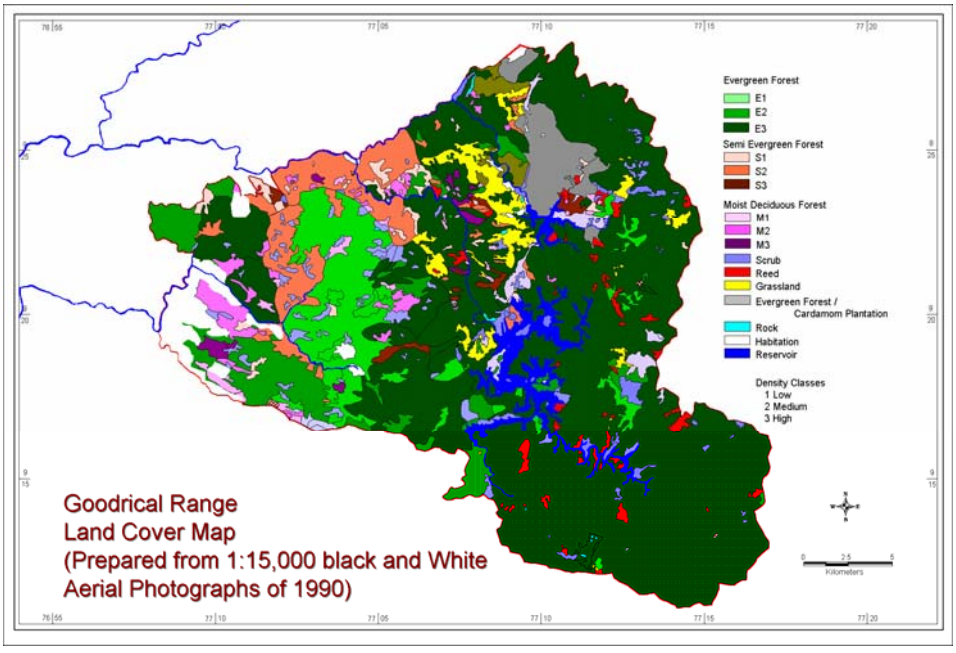


Fig. 8 Vegetation map of Goodrical RF based on 1:15,000 Black and White Aerial Photographs of 1982.

To supplement the data on cover types, drainage map, contour map and the slope map of the reserve were generated using Survey of India toposheets as the base layer (Figs. 9 , 10 and 11).

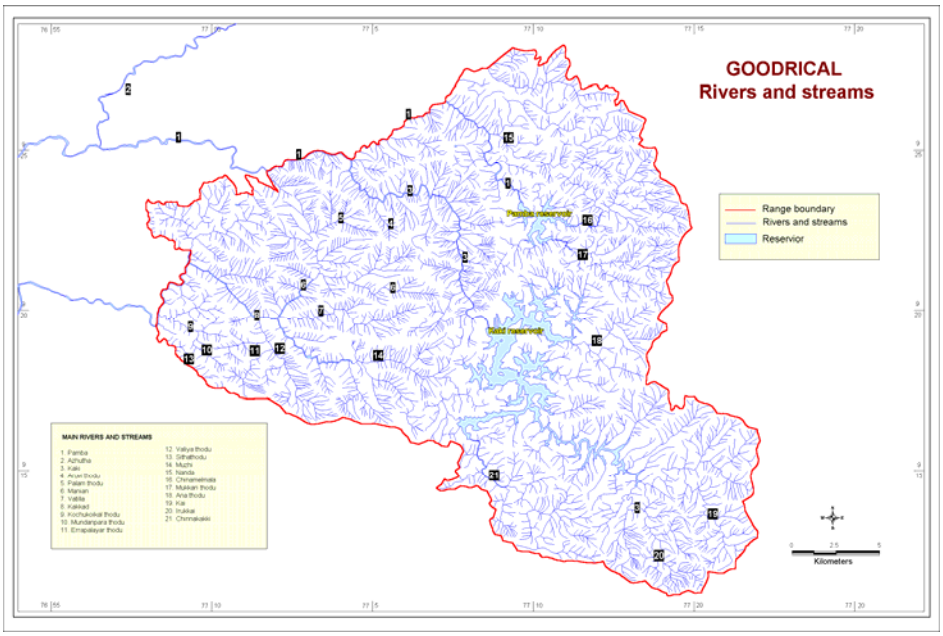


Fig. 9. Drainage map of the study area

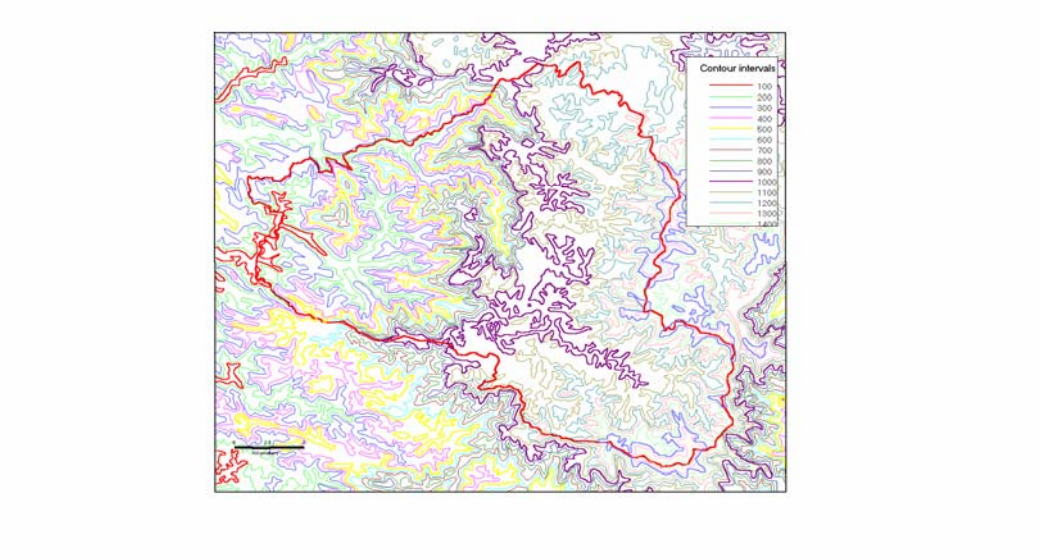


Fig.10 Contour map of the area

With respect to altitudinal zonation the study area can be broadly divided into two regions viz; western part towards Angamoozhy side with 100-500 m elevation zone and eastern part towards Kakki-Pamba side with 1100-1400 m elevation. The tribal hamlets and habitations are restricted towards the western part of the study site.

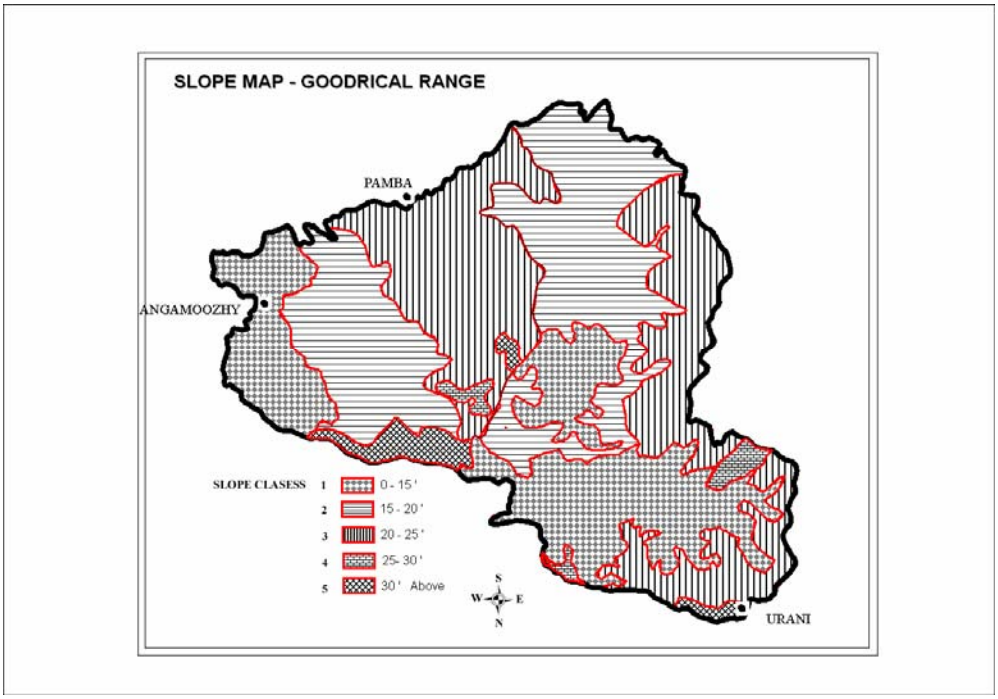


Fig. 11. Slope map of the area

The slope map generated from the Survey of India toposheets is having five different slope classes viz: Class 1 having 0-15º slopes, Class 2 with 15-20º slopes, Class 3 having 20-25º slopes, Class 4 with 25-30º slopes and Class 5 with more than 30º slopes. The southern most part of the study area is having high gradient (Urani side) and is not easly approachable, whereas, the western part near Angamoozhy area is of Class1 area and habitated. The major area of the study site is between 15 and 25^0 slopey and supports tropical wet evergreen forest types.

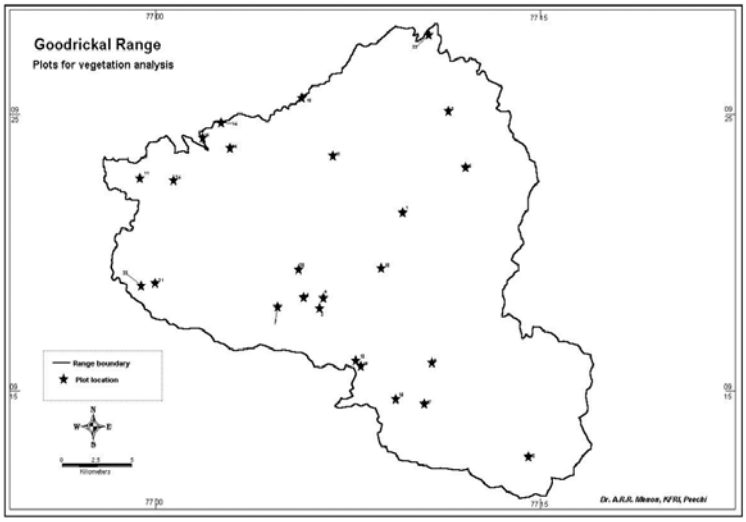


Fig. 12. Study plots of the area

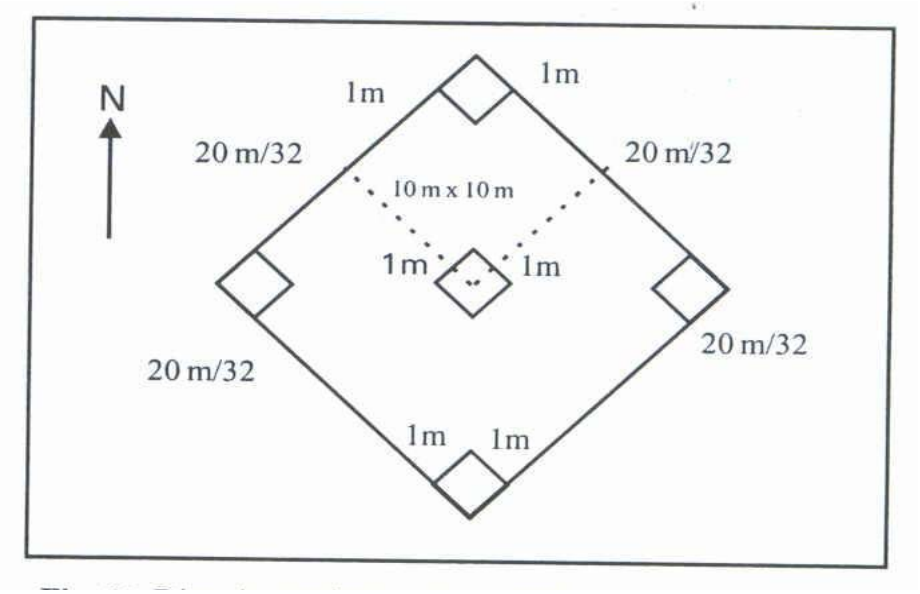


Fig. 13. Direction and position of samples in a nested quadrat.

Phytosociological Analysis

For each vegetation type the field data is analysed for various structural features and the computation of Importance Value Index (IVI) was done for each species (Table 1 to 26).

DISCUSSION AND CONCLUSION

Profound species hierarchy is one of the most striking features of the evergreen forests of the Western Ghats (Pascal,1988).The five main species viz. *Cullenia exarillata, Macaranga peltata, Agrostistachys borneensis, Mesua ferrea and Palaquium ellipticum* (in terms of IVI) representing 3.8% of the total species present, constitute more than 15% of the total IVI and 5% of the total basal area, subsequently this constitutes the frame work of the forest. Since each of these occupies in different layers, they invariably determine the vertical stratum of the stand. *Vateria indica* is one of the most common species in most sites, well represented in all girth classes and thus forming intermediate strata among dominants. This type of wide ecological amplitude of selected species in the study area, influenced by various edaphic factors like water regime, temperature, etc. creates a false impression of high diversity, if not all, in selected localities. The study also supports earlier findings that the forests of southern India can no more be regarded as a mosaic of mature and regeneration phases resulting from a single determining mechanism (Pascal and Raphael, 1996).

With regard to vegetation formations in the area, at least four different types of formations were noted from the study sites, viz:1) *Mesua-Cullenia* dominent formation, where species of *Palaquium, Calophyllum, Myristica* etc. often present as co-dominants; 2) *Syzygium-Xanthophyllum* dominant formation, where species of *Diospyros, Dipterocarpus* and *Vateria* as co-dominants; 3) *Hopea* dominant formation, where species of *Knema, Polyalthia* and *Baccauria* often present as co-dominants and 4) *Macaranga-Elaeocarpus* dominant formation in the more disturbed areas, where species of *Cedrela, Turpinia, Aglaia,* etc. are co-dominants. Again in strict sense we can consider these different types of formations can be considered as the transitional ones between Tropical wet evergreen forests and Tropical semi evergreen forests of Champion and Seth(1968).

Seven dominant species associations are noted from the different forest types viz: Tropical wet evergreen, Semi evergreen, Subtropical hill forests and Tropical moist deciduous forest type. They are, 1) *Syzygium* with *Macaranga* and *Dipterocarpus*; 2). *Macaranga* with *Myristica, Cedrela, Mesua and Cullinia*; 3).*Cullinia* with *Palaquium*, *Vernonia* and *Mesua*; 4).*Palaquium* with *Vateria, Elaeocarpus* and *Vitex*; 5). *Vateria* with

Dysoxylon and *Aglaia*; 6). *Elaeocarpus* with *Drypetes* and *Knema*; and lastly 7). *Knema* with *Hopea* and *Bombax.* The twenty five plots studied from the locality show dominance of 12 species viz: *Macaranga peltata, Cullenia exarillata, Mesua ferrea, Myristica dactyloides, Turpinia malabarica, Palaquium ellipticum, Vateria indica, Dysoxylum malabaricum, Aglaia lawii, Sterculia guttata, Elaeocarpus tuberculata* and *Hopea parviflora*.

Though the growing stock density of selected species is more in the study area, comparatively poor regeneration was observed. This can be correlated to the disturbance factor, as a result of selective felling in the area. It is true that intermediate disturbance results in the increase of alpha diversity (Connel, 1978), it may lead to the shift in the species composition due to the micro environmental changes and thus resulting in the shift of primary species to pioneer species and later to deciduous elements, which ultimately leads to habitat fragmentation due to vegetational type change. The patchiness formation of vegetation enhances the so called "edge effect" resulting in the proliferation of the shade-intolerant vegetation (Ranney *et al*., 1981, Lovejoy *et.al*., 1986). Such phenomena may be one of the reasons for the poor regeneration of selected species otherwise dominant in the area. The high initial mortality observed in some character species of the forest types can be attributed to such factors. Similar observations are made earlier from the northern part of the Western Ghats (Sringeswara *et al*., 2002)

With regard to species composition of the area, among 130 species recorded from the area (from all 25 plots), 27 species comprised 54.07% of the tree population and the rest 103 species together form 45.93% of the composition. Thus the character species of the area with respect to percentage frequency are *Actinodaphne malabarica, Aglaia lawii, Agrostistachys bornensis, Aporusa lindleyana, Canarium strictum, Cinnamomum malabaricum, Cullenia exarillata, Diospyros paniculata, Dysoxylum malabaricum, Elaeocarpus tuberculatus, Hydnocarpus pentandra, Lophopetalum wightianum, Macaranga peltata, Mallotus philippensis, Mesua ferrea, Myristica malabarica, Palaquium ellipticum, Persia macrantha, Polylathia fragrans, Strombosia zeylanica, Terminalia bellerica, Tetrameles nudiflora, Vateria indica, Vernonia arborea* and *Xanthophyllum arnottianum.*

The most dominant species as per IVI values (5 and above) of the area are *Agrostistachys borneensis, Baccaurea courtallensis, Cullenia exarillata, Dryptes elata, Hopea parviflora, Knema attenuata, Macaranga peltata, Palaquium ellipticum, Polyalthia fragrans, Sterculia guttata, Syzigium cuminii, Vateria indica* and *Vitex altissima*, (Table 1a.).

High density species are *Agrostistachys borneensis, Baccaurea courtallensis, Cullenia exarillata, Dryptes elata, Knema attenuata, Macaranga peltata, Mesua ferrea, Palaquium ellipticum, Strombosia zeylanica, Turpinia malabarica, Vateria indica* and *Vernonia arborea.*

With respect to status of distribution as per the Abundance/Frequency values, highly restricted distribution was observed in the case of *Aglaia perviridis, Diospyros nilgirica, Meliosma pinnata, Reinwardtiodendron anamalaiense* and *Syzygium garneri* (Ab/F one and above)

Different processes acts at different levels of space and time and the pluri-dimentional process of succession is controlled by various factors, mostly localized. Detailed study of structural variations with respect to micro environmental factors seems to be a good approach for highlighting the problem. Sampling based on microhabitats, rather than systematic, seems to be more useful for a realistic data generation from southern Western Ghats area. The dominance of small number of species in different plots studied with different population structures thus helps to classify the vegetation into small functional units for modeling the dynamics. This information along with microclimatic habitat together helps to classify the forests into a relatively homogenous unit. Such an approach will help to solve the localized habitat problems with respect to forest dynamics and regeneration status of selected species.

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From,
Dr.A.R.R.Menon

To,
Dr.R.Gnanaharan
Research Co-ordinator
RME

KFRI/FIMS/ARR/1822/06. Dt. 12/9/2006.

Sub: KFRI/385 Proj. Report – Reg.

Sir,
Please find herewith a copy of the final report of KFRI 385 Res. Project, after incorporating the comments and suggestions. Kindly issue the Report No. for further action.

Thanking you,

Dr.A.R.R.Menon

Plate 1.
MAJOR FOREST TYPES

Moist Deciduous Forest

Evergreen Forest