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B.R. Ramesh, M.H. Swaminath, Santhoshagouda Patil, Soupramanien Aravajy, Claire Elouard

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INSTITUTS FRANÇAIS DE RECHERCHE EN INDE
FRENCH RESEARCH INSTITUTES IN INDIA

PONDY PAPERS IN ECOLOGY

ASSESSMENT AND CONSERVATION OF FOREST BIODIVERSITY IN THE WESTERN GHATS OF KARNATAKA, INDIA. 2. ASSESSMENT OF TREE BIODIVERSITY, LOGGING IMPACT AND GENERAL DISCUSSION.

B.R. Ramesh
M.H. Swaminath
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UMIFRE 21 CNRS-MAEE

INSTITUT FRANÇAIS DE PONDICHÉRY
FRENCH INSTITUTE PONDICHERRY

7

PONDY PAPERS IN ECOLOGY No. 7

Assessment and Conservation of Forest Biodiversity in the Western Ghats of Karnataka, India. 2. Assessment of Tree Biodiversity, Logging Impact and General Discussion

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INSTITUT FRANÇAIS DE PONDICHÉRY

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Summary

PPE volumes 6 and 7 are parts of a project report published in 1999 in collaboration with the Karnataka Forest Department on the assessment and conservation of forest biodiversity in the Western Ghats of Karnataka. Project objectives and study area are introduced in the first volume (PPE 6). The present volume reports i) an assessment of forest biodiversity and its relationships with regional bioclimate and anthropogenic pressure from a network of 96 1-ha sampling plots, and ii) an in-depth study of impact of selective logging on the low elevation wet evergreen forest, which revealed that 30-40 years between successive harvests is the minimum period to allow the forest to recover. Conservation values maps and recommendations for forest management are then discussed from results of the whole project.

Keywords: Biodiversity, Karnataka, India, logging impact, tropical forests, Western Ghats.

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Chapter

7

Assessment of tree biodiversity: Part I

Data sources, sampling methods, data analysis

Materials and Methods

Introduction

Biodiversity (BD) has been defined as the variability among living organisms and the ecological systems of which they are part. Thus the term includes not only the species themselves, but also the roles they play in the ecosystem and the relationships between them. BD can be considered at genetic, taxonomic and ecosystem levels, and variety of sublevels of each of these.

Though there are several approaches to assess BD, a holistic approach in realisation with the human factor is the most important criteria for the assessment of biodiversity and prioritisation of conservation. The level at which the biodiversity can be assessed for concerted management practices is one of the major concerns of the foresters.

Habitats/ecosystems are defined as the space used by an organism, together with the other organisms with which it coexists, and the landscape elements that affect it. Once a meaningful classification (Pascal, 1986) of habitats is developed, habitat approach has some practical advantages as suggested by Johnson (1995) (Box 7).

Box 7 – Management at habitat level

Habitat size and distribution are easy to determine. If representative habitats are conserved in large areas, the vast majority of species and much of their genetic diversity will be protected as well.

Ecological processes (nutrient cycling, hydrological regulation, micro climatic regulation, and maintenance of disturbance regime) are essential for the survival of many species. Habitat-based approaches are most likely to ensure the protection of these vital links to BD.

Habitat-based approaches are the most cost-effective way to identify conservation priorities that include the wide spectrum of BD.

Using sampling plots, habitat status can be assessed and compared with another by applying ecological and resource indicator values such as those in Box 8, below.

The Western Ghats is one of the most widely studied regions in terms of flora and fauna, and ecology. Though there are numerous studies at macro and micro level (Pascal, 1988; Sukumar *et al* 1992; Swamy & Proctor, 1994; Ganesh *et al*, 1996; Ghate, 1998; Parthasararthy, 1999; Ayyappan & Parthasarathy, 1999), several of them fall short in providing a comprehensive picture on biodiversity at regional level.

Box 8 -Biodiversity indicators

Species richness - The number of species in a given unit of area.

Species diversity – The number of species and their relative proportion of individuals in a given unit of area.

Endemics – The species with restricted distribution, either geographically or ecologically.

Rarity of species – The species at very low frequency in a given unit of area inspite of their wide distribution or with a restricted distribution in a broad geographical area.

Unique ecosystems - A place occupied by a species and in where plays its role (eg. *Myristica* swamps).

Utility value – The values obtained through the uses (Timber forest product (TFP), Non timber forest product (NTFP) and medicinal plants) of species.

The Forest Research Institute (FORI) of Karnataka State Forest Department, within the frame work of the Western Ghats Forestry Project (WGFP) has established 102 one hectare Biodiversity Sampling Plots (BSP), covering a wide range of vegetation in Uttara Kannada and Shimoga forest administrative circles. The proximal objectives of the study are: 1) to establish base-line data regarding the spatial and floristic structure of the different habitat types and, 2) to monitor the changes in the structure due to biotic and abiotic interference.

French Institute of Pondicherry used its expertise in the floristics (Pascal & Ramesh, 1986) of the Western Ghats, to review these plots for the taxonomic identification of plants and also established a computerised database. The data were analysed statistically to determine the impact of disturbance on plant diversity.

Sampling method

Biodiversity monitoring plots

Sites for laying 101 plots were selected, based on the different vegetation (habitat) types, as depicted on vegetation maps (maps 1, 2, and 3) of the FIP. Initially, in Uttara Kannada circle, to enable the monitoring of these plots by Village Forest Committees (VFC), the plots were laid in the forest close to villages. However, in Shimoga circle, the plots are more widespread (Map Figures 4, 5 & 6).

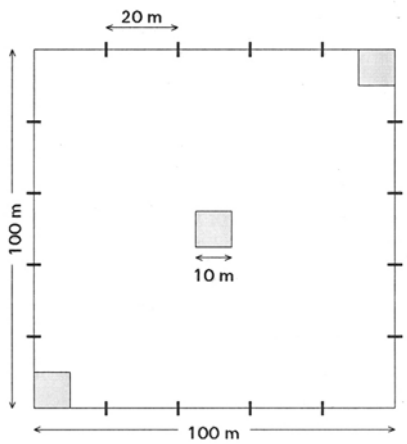


Figure 46: Layout of the one hectare plots. Micro plots in grey

Each plot measures 100 X 100 m (one hectare). At every 20 m along the boundary of the plot, permanent stone posts have been fixed (Figure 46). In the entire plot (macro plot), all the plant individuals equal to or more than 10 cm GBH (girth at breast height, that is at 137 cm from the ground) were tagged (aluminium plates) with serial numbers and botanically identified. Their GBH were measured and heights were estimated. General information on the plot, such as location, bio-climate, slope, aspect, vegetation type, and evidence of disturbance (fire, cut stumps, grazing and trails) were noted on a proforma (Annexe 2). On a whole plot basis parameters like canopy height (m), canopy cover (%) and number of strata were visually estimated.

In order to study the regeneration, 3 (10x10m) micro plots were established in a diagonal axis across the 1 ha plots. In these subplots all the individuals less than 10 cm girth and more than 1 m height were identified and counted. The individuals less than 1 m were enumerated. Canopy cover over each subplot was estimated and also any presence of cut stumps was counted.

For the present study only 96 plots have been considered. The remaining 6 plots are mixed with plantation trees.

Database and Application Development

The Sampling Plot Database was designed as a Relational Database Management System (RDBMS) using MS Access™. The database consists of a complex relational structure with 40 tables and some 42 queries (Figure 47). It consists of a built-in application for data-entry and front-end applications for calculating various statistical indices. The database is shared and kept on a central server. Various third party software packages, namely statistical packages like Statistica™ is connected directly to the database tables or queries through an external Other Database Connectivity (ODBC) connection.

The aim is to have an optimised database with high levels of normalisation to ensure a robust, distributable and compatible data-model that can be used and distributed through front-end tools and third party software packages.

Special care was taken to design the interface for making it compatible and convenient in terms of the existing data and the data-collection methods being followed.

The data can be classified into the following main categories:

- Sample Plots
- Sample Micro-plots
- Trees
- Species
- Physical Environment (Forest Types, Topography)
- Administrative Units
- Qualitative Plant Parameters (Habit, Endemic, Ecology, Phenology)
- Usage (Medicinal, TFP, NTFP)

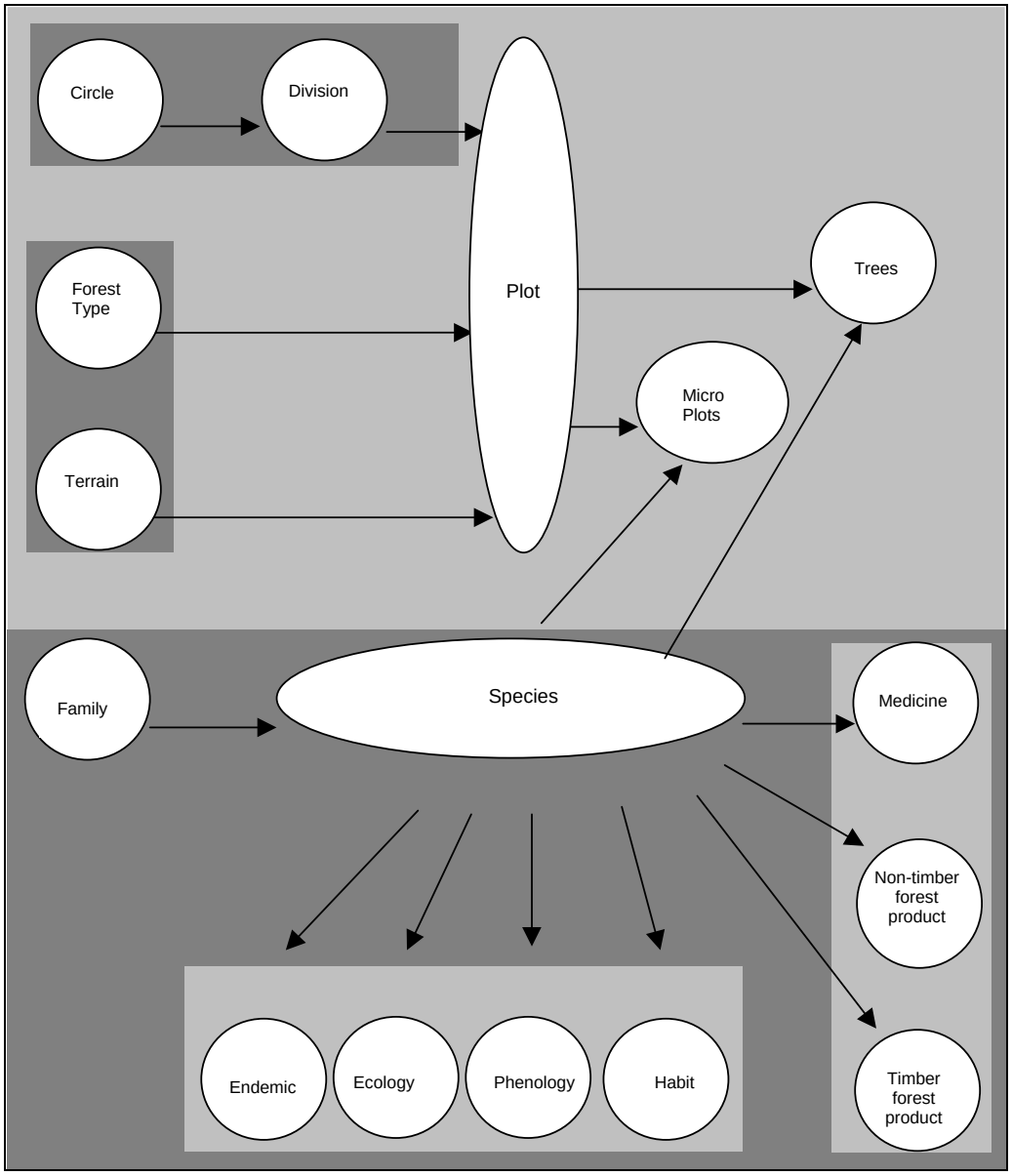


Figure 47: A block diagram showing the main relations between the tables of the database.

Report

A sophisticated report was designed for each plot. The report lists out the various parameters, calculated indices and qualitative plant parameters relating to the plot. Graphs for *Girth Distribution*, *Species Individual Curve*, *Individuals per Species* is also plotted dynamically for each plot in the report (Figure 48).

Macros (VBA™)

Macros were built using VBA™ (Visual Basic for Applications) for obtaining certain listings such as proportion of species relating to qualitative plant parameters at the plot and micro-plot levels.

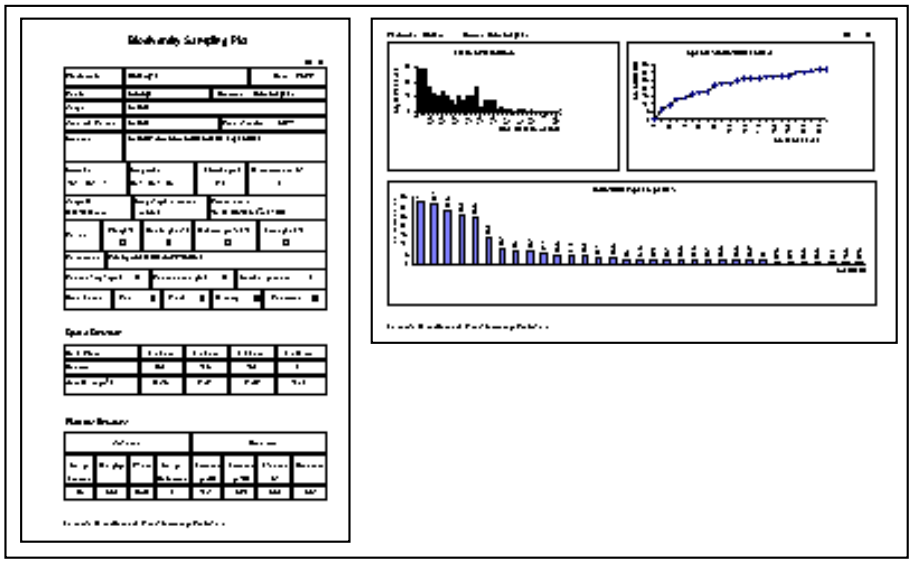


Figure 48: Layout of a sample plot report

Geo-referencing the database

The plot locations were geo-referenced and exported as an overlay to the existing geographical database on forest maps and bio-climatic data. Arc/Info™ GIS was used for this operation. The results were re-imported into the plot database for obtaining bio-climatic parameters and for comparison with existing Forest Type data (Figure 49).

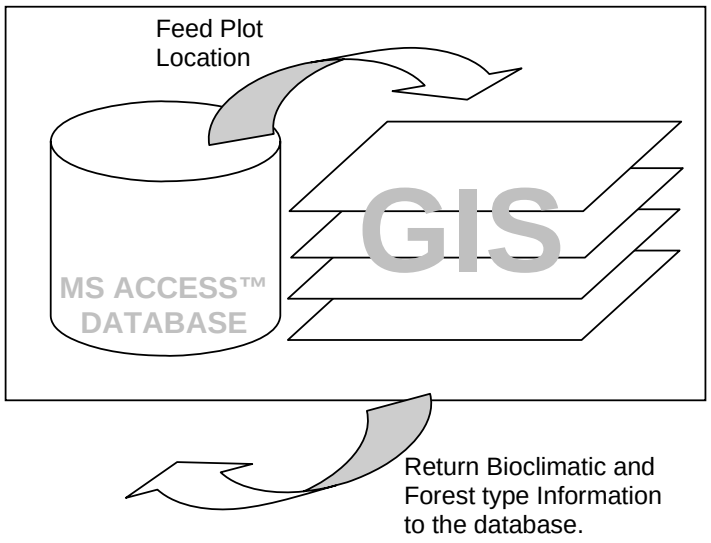


Figure 49: Passing through existing GIS database to retrieve geo-referenced information.

The GreenBase index calculation application

A windows application, GreenBase was developed using MS Visual Basic™. The purpose of the application is to calculate various statistical indices using a back-end database file. Currently the application expects to find a MS Access™ database file, structured in a particular manner. Efforts are under way to change the application as a customisable, user-friendly package that can connect to any database.

Below (Figure 50) is a screen shot of the various indices being calculated by GreenBase. This product effectively replaces a more complicated and time consuming methodology of obtaining the indices through MS Excel™.

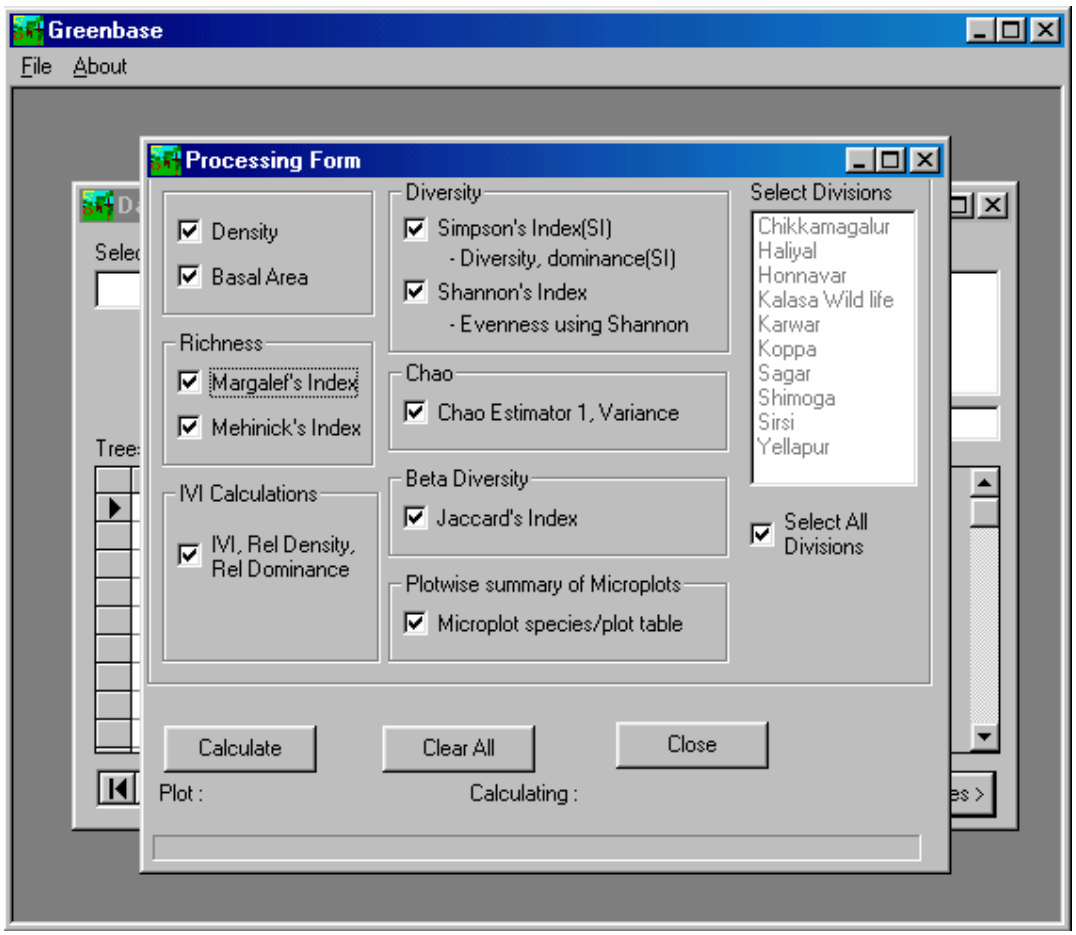


Figure 50: A screen shot of GreenBase

Diversity indices

Physical appearance and species composition of the vegetation depend on the magnitude of biotic and abiotic interference. The indices to measure the responses of vegetation to these factors are classified into two categories. They are spatial structure and floristic structure indices. These indices are calculated for each plot (alpha diversity).

Spatial structure

In the present study, the spatial structure of the plots are defined by the total stand density, girth distribution and basal area (Box 9). The height of individual trees in the plots is often either under or over estimated, thus it has not been considered for the analysis. The proportion of liana, an important indicator of disturbance, especially in the evergreen forests is also taken into account for the spatial structure.

Box 9 -Spatial Structural indices

Density: expressed in number of individuals per hectare. The limits of the girth are given in the table under 4 girth classes (>10, >30, 60, >120 cm).

Girth distribution: pattern at every 10-cm class is shown in the form of histograms for each plot.

Basal Area: It is sum of the cross-sectional area of the stems per hectare

$C^2 / 4\Pi$

(c = circumference or girth)

Floristic structure

The quantitative and qualitative characters of the species composition reflect the floristic structure of the vegetation. The quantitative characters in terms of total number of species and their relative abundance are determined by indices of Richness and Diversity respectively (Magurran, 1988). Some of these indices used in the present study are given in Box 10.

Among the qualitative characters of species composition, the proportion of evergreen and deciduous, and within evergreen species, the proportion of primary and secondary species are important criteria to determine the effect of bioclimate and disturbance on the vegetation. The evergreen species, which are considered as primary, include species characteristic to climax forests, which tend to become rare or disappear with the increase in disturbance. The secondary species includes pioneer species and species with a wider ecological amplitude.

Box 10 – Floristic Structural indices

Species richness

Species-individual curve: cumulative number of species with increase in number of individuals.

Marglef index (Mg): A simple procedure used to estimate the richness by equation $D_{Mg} = (S_{obs} - 1)/ \ln N$

Chao 1 index: It is used to include the role of rarity in estimating the richness. $S_1 = S_{obs} + (a^2/2b)$

Species diversity

Simpson's index: is defined from as probability that two individuals randomly and independently selected belong to the same species. This index has been calculated using the formula:

$$D = \sum \frac{n_i(n_i - 1)}{N(N-1)}$$

The Simpson index can be defined in two ways:

as λ = 1-D, also called dominance index ; it varies between 0 (for a one species community) to 1-1/*S* (for an even community composed of S species)

as λ' = 1/D; it varies between 1 (for 1 species community) and S.

Shannon's Index: This index is defined as:

$$H' = -\sum p_i \ln p_i$$

(*pi* = proportional abundance of the i th species)

$$p_i = (n_i / N)$$

Evenness using Shannon Index:

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

(H' = Shannon's index)

(S_{obs} = total number of species observed; ln = logarithm; *N* = total number of individuals; *ni* = number of individuals of the *i*th species; *a* = the number of observed species that are represented by a single individual; *b* = the number of observed species represented by two individuals in the sample)

Analyses

The statistical analyses for the macro plots were carried out in two steps: (1) According to global analyses involving all the 96 plots and 400 species (excluding 29 unidentified species, mostly from lianas) (2) Based on major vegetation types.

Global analyses

In order to assess the relationship between climate and vegetation types, and the effect of disturbance on spatial and floristic structure of the vegetation, the following multivariate analyses were conducted using ADE4 software package with an interface for Windows 98 (Thioulouse *et al*., 1995)

Correspondence analysis (CA) was performed on the data matrix composed of plots and species density to obtain a typology of forests.

Multiple correlation analysis (MCA) was accomplished using the data set between plot and bioclimatic variables (rainfall and length of the dry season) to characterise the main bioclimatic conditions.

To study the link between structural parameters and the typology of vegetation, principal component analysis (PCA) was done on the data matrix composed of spatial and floristic structural variables against plots.

To understand the relationship between bioclimate and vegetation types following methods were adopted.

For each plot, bioclimatic categories such as rainfall (>5000, 2000-5000, 1200-2000, 900-1200 and <900 mm) and length of the dry season (4, 5, 6 and 7 months were determined by superimposing the plots on bioclimatic map (Pascal, 1982). Since there are only two categories, temperature has not been considered.

As the bioclimatic categories are qualitative, coordinates of the factors obtained from the MCA and CA were used as synthetic variables for simple regression analysis to define the link between vegetation types and climate.

Forest type wise analyses

Based on the results of above analyses, which are more or less similar to our field observation, the plots were grouped into physiognomic classes. These groups are further classified under major vegetation types based on ecology and phenology.

In order to understand the significance and relationship of structural and floristic variables *vis a vis* disturbance gradient, the forest groups are subjected to following statistical analyses.

Analysis of variance (ANOVA) was performed to test the significant differences between forest groups for structural and floristic variables.

Those significant variables obtained for the groups from the above analysis are further subjected to *simple correlation* analysis to know the relationship between two variables.

Regeneration

For regeneration studies, 3 micro plots in each macro plot were merged as one sample (300 m^2). They are classified into similar groups as that of macro plots. In order to understand the effect of disturbance on the regeneration of tree species ANOVA was performed on the data composed of tree saplings.

Buffer analysis

This analysis was done to understand the effect of proximity and proportion of area covered by anthropogenic patches on the physiognomy of the forest sampled. A buffer was created around the BSPs using Arc/Info on the vegetation layer of 1997. The area thus created was clipped from the vegetation layer, and the proportion of total area covered by anthropogenic types was determined for each plot. A buffer and clip was performed for both buffer distances of 500 meters and 1000 meters (Figure 51).

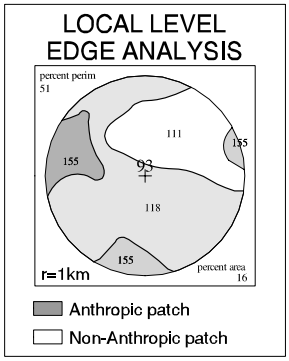


Figure 51: A clip of buffer area around sample plot no. 93.

The physiognomic levels of the forest plots sampled were classified in a similar way as previous analyses. For each physiognomic group mean area (in percentage) of anthropogenic patches were calculated and the results were depicted according to major vegetation types in the form of histograms.

Resource diversity

Resource value of species is also one of the important criteria in the evaluation of biodiversity. Non-sustainable harvesting of some of the species may have repercussion on the their population structure, and eventually on biodiversity. In the present study, attempts have been made to understand the resource value of habitats and the effect of degradation on the population structure of some useful species.

The utility values of the species recorded from the BSPs were determined by consulting several published literatures (Bourdillon, 1908; Caius, 1986; Chandrabose & Nair, 1987; Jain, 1981; Keshava Murthy & Yoganarasimhan, 1990; Rama Rao & Sahib, 1914; Subramanian, 1995; Subramanian, Venkatasubramanian & Nallaswamy, 1987). The values are classified into three categories: timber forest product (TFP), non-timber forest product (NTFP) and medicinal. A number of useful species present in the major types of vegetation have been determined. Population densities of some selected species were compared according to degradation stages.

Chapter

8

Assessment of tree biodiversity: Part II

Observations on biodiversity sampling plots (BSP) and on their species composition

Results

Biodiversity sampling plots

The Karnataka Forest Department (KFD) has three circles in its Western Ghats forestry project jurisdiction. In the first phase of their programme, 101 biodiversity plots have been established in Uttara Kannada (northern part) and Shimoga (central part) circles (Annexe-3). In these circles, plots are represented in 6 divisions in the former circle and 4 divisions in the latter.

Reserved Forests (RF) constitute the basic unit of the protected area (PA) network in the forest administration. Uttara Kannada and Shimoga circles have 368 (some time as blocks) and 175 RFs respectively. Among the BSPs, 57 covers only 33 RFs in total and rest of them are outside the PA net work.

In the map 1, 2 & 3 fiftyfour habitat types have been depicted. FORI initially planned to establish two plots per type. However, the superimposition of the plots on these maps shows that BSPs cover only in 28 types.

In the current study, 96 plots have been considered. The remaining 5 plots lie in plantation areas.

Species composition

Totally 498 taxa are encountered in 96 plots (Annexe-4). Of these, 429 are found in the macro plots. In the micro plots, 345 species of above 1 m height and <10 cm girth, and 240 species of below 1< m height are recorded (Table 7).*Table 7: Number of species according to habit encountered in BSPs*

Habit	Macro plot	Micro plot (≥1m h ≤10cm G)	Micro plot (<1 m)
Tree	351	262	165
Woody liana	78	41	30
Shrub		17	14
Herb		8	17
Climber		17	14
Total	429	345	240

Totally 61,971 individuals from macro plots and 16,755 from micro plots covering 498 species under 302 genera and 90 families have been recorded. Among the families Rubiaceae,

Euphorbiaceae, Lauraceae and Moraceae constitute 21% of the total number of species. The first two families have contributed more genera as well as species number (Table 8). Considering the total tree individuals in the macro plot, 60% of them come from 29 species only (Table 9). Within these species *Terminalia paniculata* (3,811) counted highest number of individuals followed by *Xylia xylocarpa* (3,498), *Terminalia tomentosa* (1,653), *Tabernamontana heyneana* (1,387) from Secondary and primary moist deciduous; *Poeciloneuron indicum* (2,220), *Hopea ponga* (1,873) and *Knema attenuata* (1,762) from Wet evergreen; *Aporosa lindleyana* (1,776), *Holigarna arnottiana* (1,341), *Olea dioica* (2,366*), Ixora brachiata* (1,396), and *Dimocarpus longan* (1187) from disturbed evergreen and semi evergreen forests; *Anogeissus latifolia* (938) from dry deciduous forest forests. The number of species and their individual contribution to total frequency for all the macro plots are shown under seven classes (Figure 52).

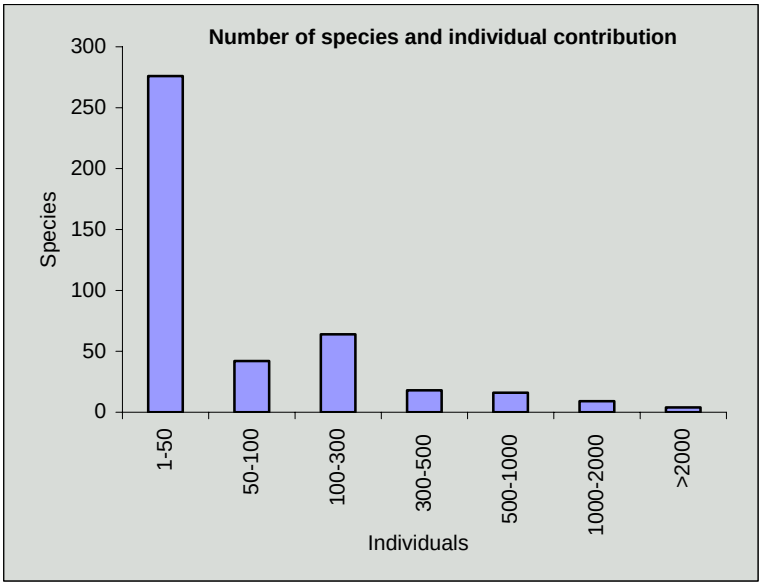


Figure 52: Number of species contributing to frequency classes

Further, these species are classified based on phenological and ecological characteristics. Evergreen species are higher in number (78%) compared to deciduous species (22%). Within evergreen, primary and secondary species represent 52 and 48% respectively (Figure 53).

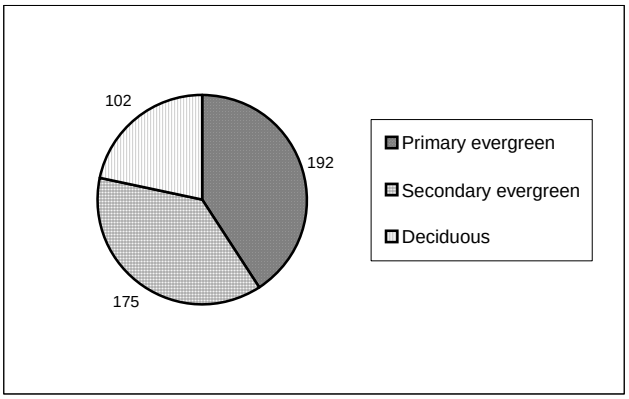


Figure 53: Repartition of species based on phenological and ecological characteristics

Table 8: List of families with number of genera and species encountered in the macro plots

Family	Genus	Species	Family	Genus	Species
Rubiaceae	19	32	Araliaceae	1	2
Euphorbiaceae	23	30	Capparidaceae	1	2
Lauraceae	8	23	Simarubaceae	1	2
Moraceae	4	21	Convolvulaceae	2	2
Fabaceae (Mimosoideae)	7	18	Hippocrateaceae	2	2
Meliaceae	14	18	Liliaceae	2	2
Ebenaceae	1	15	Olacaceae	2	2
Annonaceae	12	15	Theaceae	2	2
Rutaceae	12	15	Urticaceae	2	2
Fabaceae (Caesalpinioideae)	8	14	Zingiberaceae	2	2
Fabaceae (Faboideae)	10	13	Adiantaceae	1	1
Myrtaceae	3	11	Alangiaceae	1	1
Clusiaceae	5	10	Amaryllidaceae	1	1
Flacourtiaceae	5	10	Ancistrocladaceae	1	1
Anacardiaceae	7	10	Asclepiadaceae	1	1
Apocynaceae	7	9	Bombacaceae	1	1
Celastraceae	6	8	Cornaceae	1	1
Verbenaceae	7	8	Datiscaceae	1	1
Rhamnaceae	3	7	Dichapetalaceae	1	1
Combretaceae	4	7	Dilleniaceae	1	1
Sapotaceae	6	7	Elaeagnaceae	1	1
Sapindaceae	7	7	Gnetaceae	1	1
Melastomataceae	2	6	Lamiaceae	1	1
Sterculiaceae	3	6	Lecythidaceae	1	1
Dipterocarpaceae	4	6	Leeaceae	1	1
Symplocaceae	1	5	Magnoliaceae	1	1
Tiliaceae	1	5	Malpighiaceae	1	1
Boraginaceae	3	5	Malvaceae	1	1
Vitaceae	3	5	Ochnaceae	1	1
Bignoniaceae	4	5	Osmundacea	1	1
Icacinaceae	4	5	Oxalidaceae	1	1
Myrsinaceae	4	5	Pandanaceae	1	1
Oleaceae	4	5	Pittosporaceae	1	1
Ulmaceae	4	5	Poaceae	1	1
Acanthaceae	5	5	Polgonaceae	1	1
Arecaceae	5	5	Proteaceae	1	1
Elaeocarpaceae	1	4	Pteridaceae	1	1
Loganiaceae	2	4	Ranunculaceae	1	1
Lythraceae	1	3	Rhizophoraceae	1	1
Connaraceae	2	3	Rosaceae	1	1
Myristicaceae	2	3	Selaginelaceae	1	1
Piperaceae	2	3	Smilacaceae	1	1
Araceae	3	3	Solanaceae	1	1
Asteraceae	3	3	Staphylaceae	1	1
Burseraceae	3	3	Thymelaeaceae	1	1
Menispermaceae	3	3	Unidentified		29
Santalaceae	3	3	Total	302	498

Table 9: List of species, with over 500 individuals represented in macro plot

Species	Number of individuals
Terminalia paniculata	3811
Xylia xylocarpa	3498
Olea dioica	2366
Poeciloneuron indicum	2220
Hopea ponga	1873
Aporosa lindleyana	1776
Knema attenuata	1762
Terminalia tomentosa	1653
Ixora brachiata	1396
Tabernaemontana heyneana	1387
Holigarna arnottiana	1341
Catunaregam dumetorum	1209
Dimocarpus longan	1187
Lagerstroemia microcarpa	999
Tectona grandis	996
Anogeissus latifolia	938
Calycopteris floribunda	905
Memecylon umbellatum	890
Flacourtia montana	798
Symplocos racemosa	778
Aglaia barberi	713
Careya arborea	651
Holigarna grahamii	630
Callicarpa tomentosa	610
Chionanthus malabaricus	583
Syzygium cumini	570
Xantolis tomentosa	568
Garcinia morella	519
Diospyros candolleana	501
Total	**37128**

Vegetation types and its relationship with bioclimate

Correspondence analysis (CA) to determine the typology of the forests

Matrix of 96 plots and density of 400 species (excluding 29 unidentified) were subjected to CA. The first three factors F1, F2 and F3 accounts for 8, 7 and 5% of the total inertia respectively. F1 is determined by the extremely wet zone species like *Poeciloneuron indicum* (absolute contribution 14%) on the one hand and on the other by moist zone species like *Terminalia paniculata* (8%) and *Xylia xylocarpa* (9%). F2 is mostly determined by the wet zone species, and again maximum absolute contribution comes from *Poeciloneuron indicum* (22%). F3 axis determined by the dry zone species like *Anogeissus latifolia* (30%), *Chloroxylon switenia* (12%), *Albizia amara* (7%) *and Acacia catechu* (7%) on one side, and on the other *Xylia xylocarpa* (15%), a dominant species in the intermediate zone between the moist and dry.

With the ordination of F1 and F3, which gives a better dispersion of the plots (Figure 54), seven distinct groups of plots have been identified. These groups are derived from the combination of certain dominant species characteristic to particular vegetation types (Table 10). The groups A, B and C composed of plots from wet evergreen, semi evergreen and moist deciduous forest are aligned along F1 and group D having dry deciduous plots are arranged along F3.

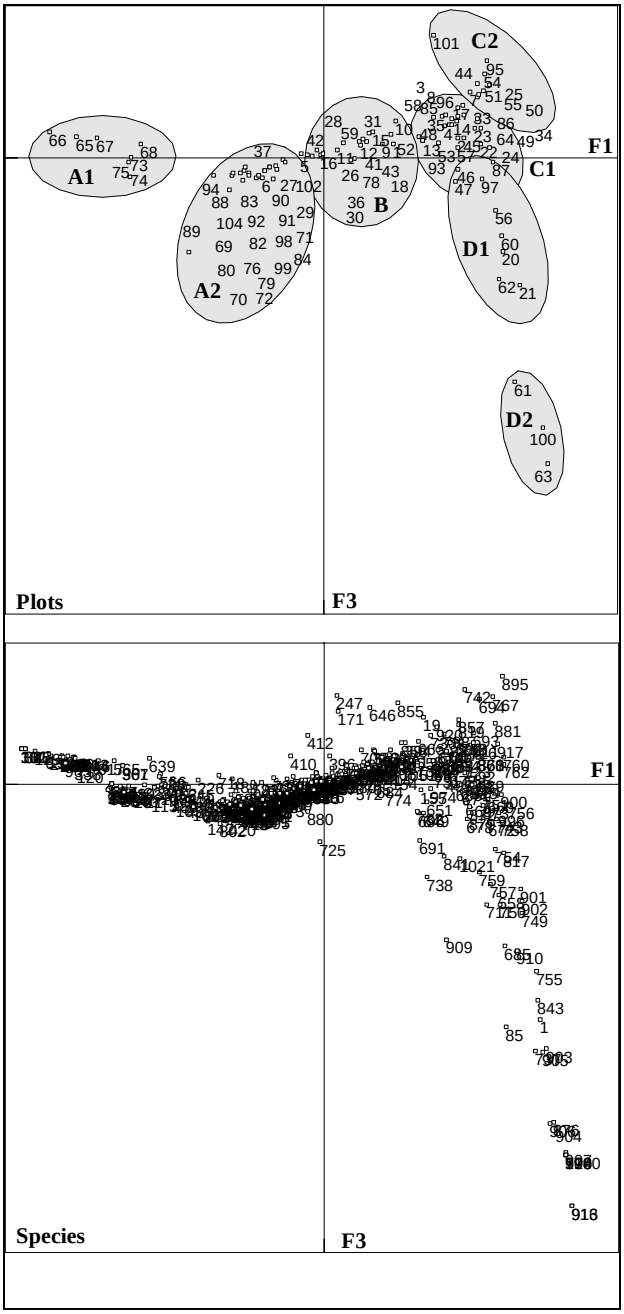


Figure 54: Correspondence analysis for 96 plots and 400 species on factor 1 and 3 (for species code see annex 4).

Table 10: Major forest types and dominant species belongs to groups obtained from factorial analysis of correspondence. Species with absolute contribution more than 7% to first three factors are highlighted.

Groups	Forest types	Dominant species
A1	Wet evergreen climax and non-climax forests	***Poeciloneuron indicum (F1, F2)*** ***Cleistanthus malabaricus (F2)*** *Dipterocarpus indicus*
A2		*Hopea ponga* *Knema attenuata* *Holigarna arnottiana* *Olea dioica* *Dimocarpus longan* *Memecylon umbellatum*
B	Semi evergreen and 'Kan' forests	*Olea dioica* *Aporosa lindleyana* *Holigarna arnottiana* *Ixora brachiata* *Flacourtia montana* *Chionanthus malabaricus*
C1	Secondary moist deciduous and Primary moist deciduous forests	***Terminalia paniculata (F1)*** *Terminalia tomentosa* *Lagerstroemia microcarpa* *Tectona grandis*
C2	Primary moist deciduous forests	***Xylia xylocarpa (F1, F3)*** *Terminalia tomentosa*
D1	Dry deciduous (transition)	*Anogeissus latifolia* *Terminalia paniculata* *Terminalia tomentosa* *Tectona grandis*
D2	Dry deciduous	***Anogeissus latifolia (F3)*** ***Chloroxylon swietenia (F3)*** ***Albizia amara (F3)*** ***Acacia catechu (F3)***

Group A1 represents climax evergreen forests (as shown on the maps 1 and 2) and is determined by the gregarious presence of *Poeciloneuron indicum*. Plots (ID) 65, 66 and 67, which are at medium elevation (>900 m) near the Kudremukh area are distinct within the group, due to the co-dominance of *Cleistanthus malabaricus* with *Poeciloneuron.* Whereas *Dipterocarpus indicus is* a characteristic canopy species of low elevation wet evergreen forests distinctly associated with *Poeciloneuron* in plot ID 75.

Group A2 represents both climax and non-climax disturbed wet evergreen forests. Even though *Hopea ponga* and *Knema attenuata* are understorey primary species, they tend to become dominant in areas at early stages of disturbance. *Dimocarpus longan, Olea dioica*, *Holigarna arnottiana* are very common in secondary forests. *Memecylon umbellatum* is abundant in the climax forests (plot ID 89, 90, 91), north of the Kali river valley.

Group C1 is composed of plots from primary and secondary moist deciduous forests. *Terminalia paniculata, Terminalia tomentosa, Lagerstroemia microcarpa* and *Tectona grandis* are the most common species in these forests. Group C2 plots are although of primary moist deciduous forests, they are dominated by *Xylia xylocarpa*.

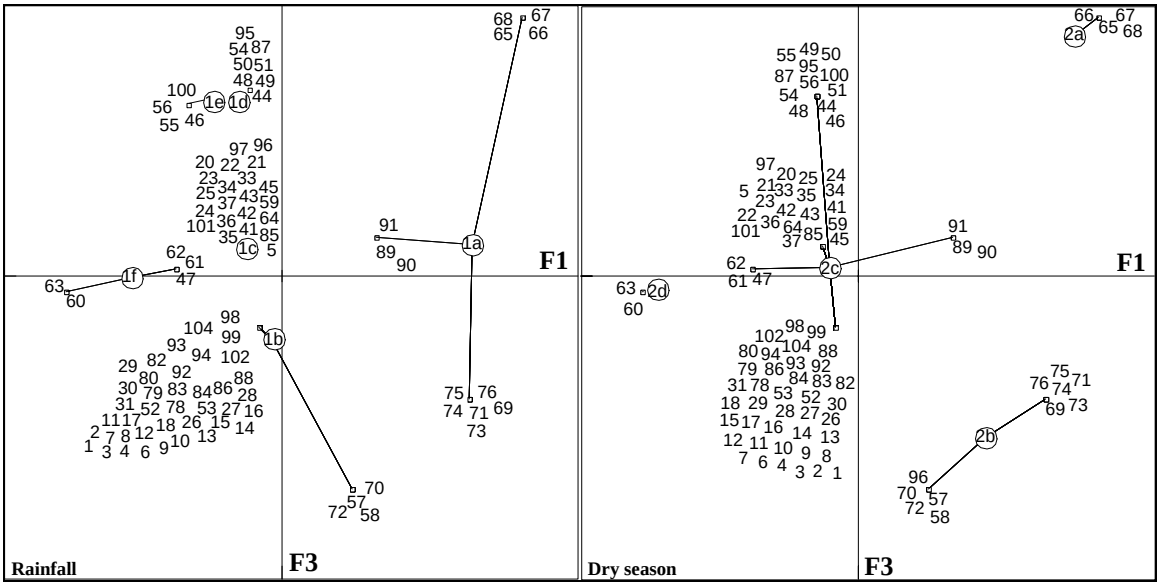
Group D plots in general are abundant with *Anogeissus latifolia*. However, D1 group, which is closer to C1 also have *Terminalia* spp. and *Tectona grandis* as common species. *Anogeissus latifolia, Chloroxylon switenia, Albizia amara* and *Acacia catechu*, which are typically of dry deciduous forests, dominate the group D2.

Multiple correlation analysis (MCA) of the distribution of forest types in relation to bioclimatic variables

MCA was performed on 96 plots and 10 bioclimatic variables (rainfall and dry season) (Figure 55). Factors 1, 2 and 3 account for 21, 20 and 13% respectively of the total inertia. F1 axis is mainly defined by high rainfall (>5000mm) and low number of dry months (4 and 5). F2 axis mainly explains lowest rainfall (900-1200 mm) and highest number of dry months (7). F3 axis has maximum contributions from the intermediate categories.

Regression (Figure 56) of the synthetic variables on F1 obtained from MCA and on F3 from CA clearly indicates that the increase in rainfall and decreases in the length of dry season correlate with the distribution of plots from dry deciduous to wet evergreen.

Wet evergreen, semi evergreen and secondary moist deciduous forest have come under high rainfall zone (>2000 mm) and 4 to 6 months dry period Figure 55



LEGEND: Rainfall (mm) - (1a) >5000; (1b) 2000-5000; (1c) 1500-2000; (1d) 1200-1500; (1e) 900-1200; (1f) 600-900;
Dry season (months) - (2a) 4; (2b) 5; (2c) 6 (2d) 7

Figure 55: Multiple correspondence analysis for 96 plots and 10 bioclimatic variables on F1 & F3

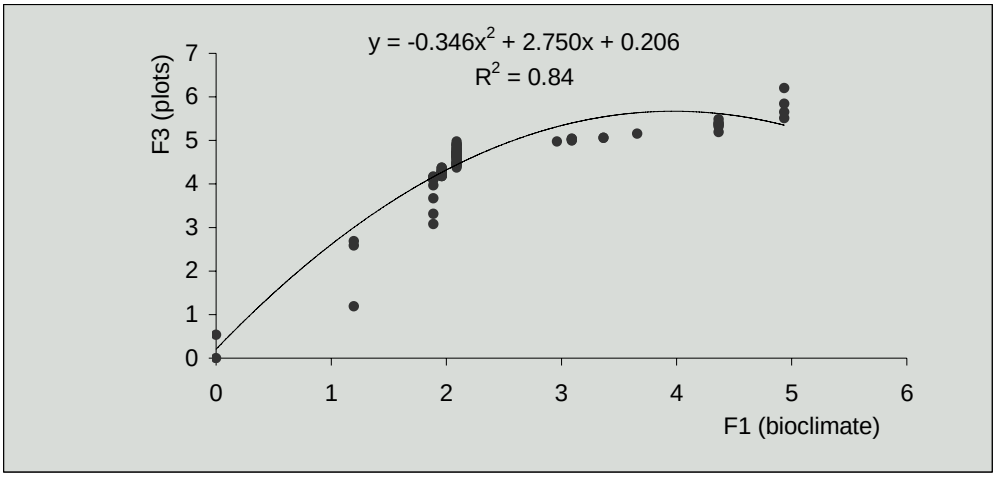


Figure 56: Regression analysis of synthetic variables obtained from MCA (F1, bioclimate) and CA (F3, plots)

Poeciloneuron dominates all the plots in A1 group (obtained from FCA). In A2, plots dominated by *Memecylon umbellatum* and some disturbed plots (71, 76 and 69), which are in the potential distribution area of *Poeciloneuron* corresponds to >5000 mm category of rainfall. However, when the length of the dry season is considered, the same plots, come under 3 categories of dry season. Plots in Kudremukh (southern most plots among BSPs) at medium elevation (>900 m) experience 4 months dry period, whereas *Memecylon* forests (northern most plots) encounter 6 to 7 months. Plots (73, 74, 75), particularly with *Poeciloneuron* and *Dipterocarpus indicus* together at lower elevations (600 – 700 m), have 5 months dry period. The rest of the plots in evergreen, semi evergreen and secondary moist deciduous are found in rainfall zone between 2000 to 5000 mm and 6 months dry period.

'Kan' evergreen forests (plots 5, 36, 37 and 42), an edaphic facies in Soraba region are found between 1500 to 2000 mm rainfall and 6 months dry period, similar to primary moist deciduous forests.

Primary moist deciduous forests come under 1200 to 2000 mm rainfall and 6 months dry period and dry deciduous forests experience 600 to1200 mm rainfall and 6 to 7 months dry period.

Vegetation types in relation to spatial and floristic parameters

Ninety-six plots were ordinated with 11 spatial and floristic variables (as given in Figure 57) in a principal component analysis (PCA).

The F1 and F2 account for 29 and 17% of the total variations respectively. The combination of these two factors Figure 57 indicates that the density of evergreen species is the most influencing variable. It ordinates the plots along the F1, in the order of phenological groups from evergreen, semi evergreen to deciduous.

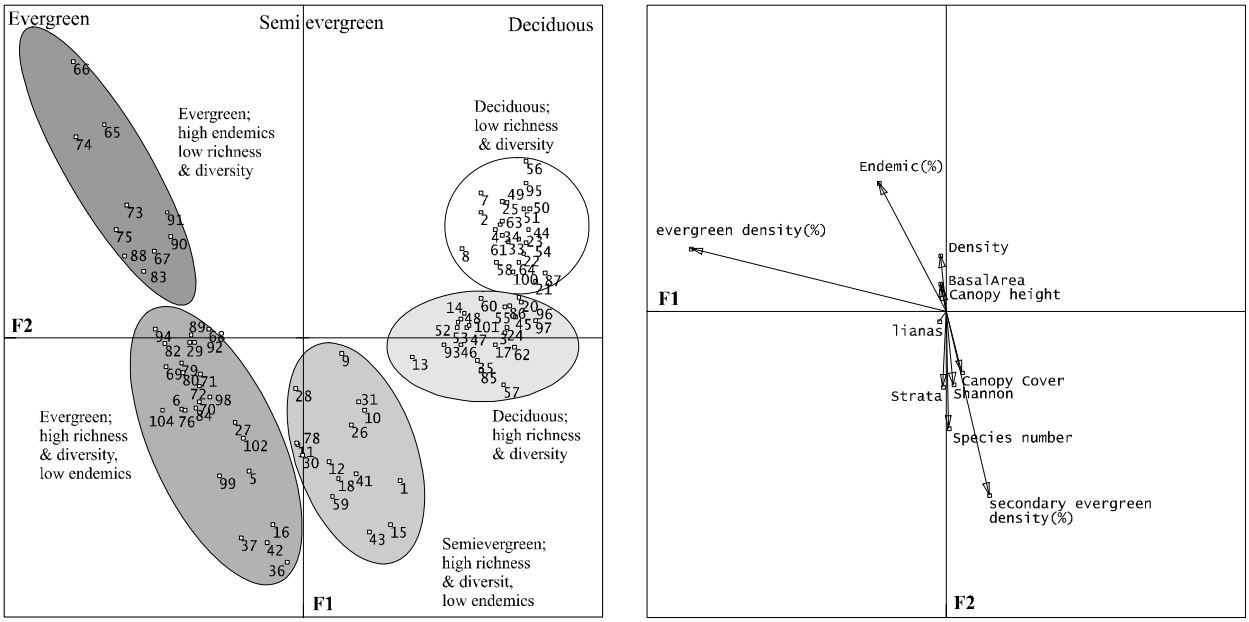


Figure 57: PCA - Ninety-six plots ordinated with eleven spatial and floristic variables

The density of secondary evergreen species and the percentage of endemics, significantly determines the second axis. Richness (Species number) and diversity (Shannon) also have considerable contribution to F2. Other spatial parameters show little significance to F2. All the plots in each phenological group, at first, align them selves with increasing values of richness and diversity downward of the F2 and towards the upper end with the decreasing values of the same variables. Further, the evergreen group is strongly separated into two subgroups, one determined by a high rate of endemism and low population of secondary evergreen species and the other with low rate of endemism and higher density of secondary species.

In the evergreen group, plots dominated by *Poeciloneuron* and *Memecylon,* in very high rainfall zone (>5000 mm) have high rate of endemics and low richness and diversity. Contrary to that, the 'kan' evergreen forests (plots 5, 36, 37 and 42) in the low rainfall area (1500 – 1800 mm) are with lowest rate of endemism and highest number of secondary species.

Spatial and floristic structural variations in the major vegetation types

By taking into consideration the results from the multivariate analysis and our own field observation, forests are classified in to 5 major types: wet evergreen, semi evergreen, secondary moist deciduous, primary moist deciduous and dry deciduous. Each type is further divided into physiognomic groups. Based on the floristic classification in the vegetation maps 1 and 2, the wet evergreen type is further classified into climax (when the species used for typification of climax forests in the vegetation maps are present in the sampling plots) and non-climax types.

Finally, the replicates of each group, under the respective types were subjected to ANOVA. The analysis was conducted separately for evergreen (including semi evergreen) and deciduous categories (Tables 11,12,13 & 14). Histograms of the selected parameters are given in Figures 65,66,67 and 68.

Evergreen and semi evergreen category

Wet evergreen climax forests

Thirteen BSPs represent 4 floristic climax types: *Poecilineuron indicum* dominated type (POIN), *Dipterocarpus indicus – Diospyros candolleana – Diospyros oocarpa* type (DDD*), Persea macrantha – Diospyros* spp. – *Holigarna* spp. type (PDH), transition *Memecylon umbellatum – syzygium cumini – Actinodaphne angustifolia* type (trMSA). In fact, the first type also includes the low elevation dipterocarp forests described in map 2, however, in association with *Poeciloneuron indicum*. As the samplings in these forests are uneven, they are grouped together as *Poecilineuron indicum* dominated type.

Table 11: Mean variation (ANOVA) of spatial parameters in the evergreen and semi evergreen forest types.

Spatial structure									
Forest types		**Density**				**Basal area (m^2)**			
		G>10cm	**G>30cm**	**G>60cm**	**G>120cm**	**G>10cm**	**G>30cm**	**G>60cm**	**G>120cm**
Climax	POIN	1230.8	542.5	189.25	59.75	37	34.75	29.75	22.75
	DDD	1192.7	640.67	274.67	59.67	32	30	24.67	13
	PDH	1159.7	631.67	293.33	61.67	35.67	34.67	29.33	16.67
	trMSA	1047.3	659.67	293.33	47.33	31.67	30	24.67	10.67
Non climax	Dense	1254	540	244.4	78.2	42.2	40	36	26.4
	Dist	738.83	375.67	200.67	62.5	29.83	28.67	25.83	17.83
	Wl-Scw	629.33	358.67	182.67	66.33	31	30.33	28	21.33
Semi evergreen	Dense	1117.5	498.25	259.5	60.25	31.25	29.5	26	13.75
	Dist	575.75	377	244.25	75.5	29.25	29	27	15.75
	Wl-Scw	488.75	217.75	124.75	30.5	15	14.5	13	7.25
Kan		849.75	249	144.75	83.5	33.25	31.25	30.25	26.5
CD at 5%		**235.75**	**120.25**	**56.92**	**28.75**	**13.25**	**13.10**	**12.10**	**6.3**

(Dist = disturbed; Wl = woodland; Scw = scrub woodland)

Table 12: Mean variation (ANOVA) of floristic structural parameters in the evergreen and semi evergreen forest types.

Floristic structure																	
Forest types		***S***	***Mg***	***Chao1***	***End***	***1/D***	***1 - D***	***H'***	***E***	***Psp(s)***	***Psp(D)***	***Ssp(s)***	***Ssp(D)***	***Egsp(s)***	***Egsp(D)***	***Desp(s)***	***Desp(D)***
Climax	POIN	56.25	7.76	88.34	49.75	7.32	0.83	2.52	0.62	69.75	84.75	26	14.75	98	99.75	2	0.25
	DDD	67	9.32	90	43.67	15.16	0.93	3.23	0.77	60	68.33	31.67	28.67	90.67	96.33	9.33	3.67
	PDH	74.33	10.39	87.31	38.67	13.85	0.93	3.23	0.75	58.67	68	30	28.33	89.67	96.33	10.33	3.67
	trMSA	47	6.61	55.03	34.67	8.3	0.86	2.6	0.67	58	71.33	27.33	24	85	95.67	15	4.33
Non climax	Dense	77	10.69	96.76	37	14.05	0.9	3.14	0.73	48.6	67.6	33.4	29.6	90.8	97.2	8.8	2.8
	Dist	69.83	10.44	100.57	32.67	14.31	0.93	3.25	0.77	43	48.17	38	42	86.67	89.33	14.33	14.83
	Wl-Scw	70.33	10.8	95.23	27.67	13.18	0.92	3.22	0.76	47.33	46.67	36.33	41.33	84	89.67	15.33	10.33
Semi evergreen	Dense	66.5	9.33	86.71	22.25	12.97	0.92	3.11	0.74	26.5	15	38.75	51.5	66.5	66.75	33.5	33.25
	Dist	58.25	9.04	76.28	20	17.34	0.94	3.22	0.79	33	17.5	35.5	41	69.5	59.25	30.5	40.75
	Wl-Scw	59	9.38	87.33	17.5	19.4	0.94	3.3	0.82	22.25	13.5	42.25	51.75	65	65.25	35	34.75
Kan		68.75	10.06	89.59	23.5	18.08	0.95	3.33	0.79	33.25	23.5	47	66	80.5	89.25	19.5	10.75
CD at 5%		**11.1**	**2.01**	**12.24**	**2.4**	**3.37**	**0.02**	**0.10**	**0.03**	**4.15**	**2.4**	**5.65**	**12.58**	**2.9**	**5.81**	**6.5**	**10.3**

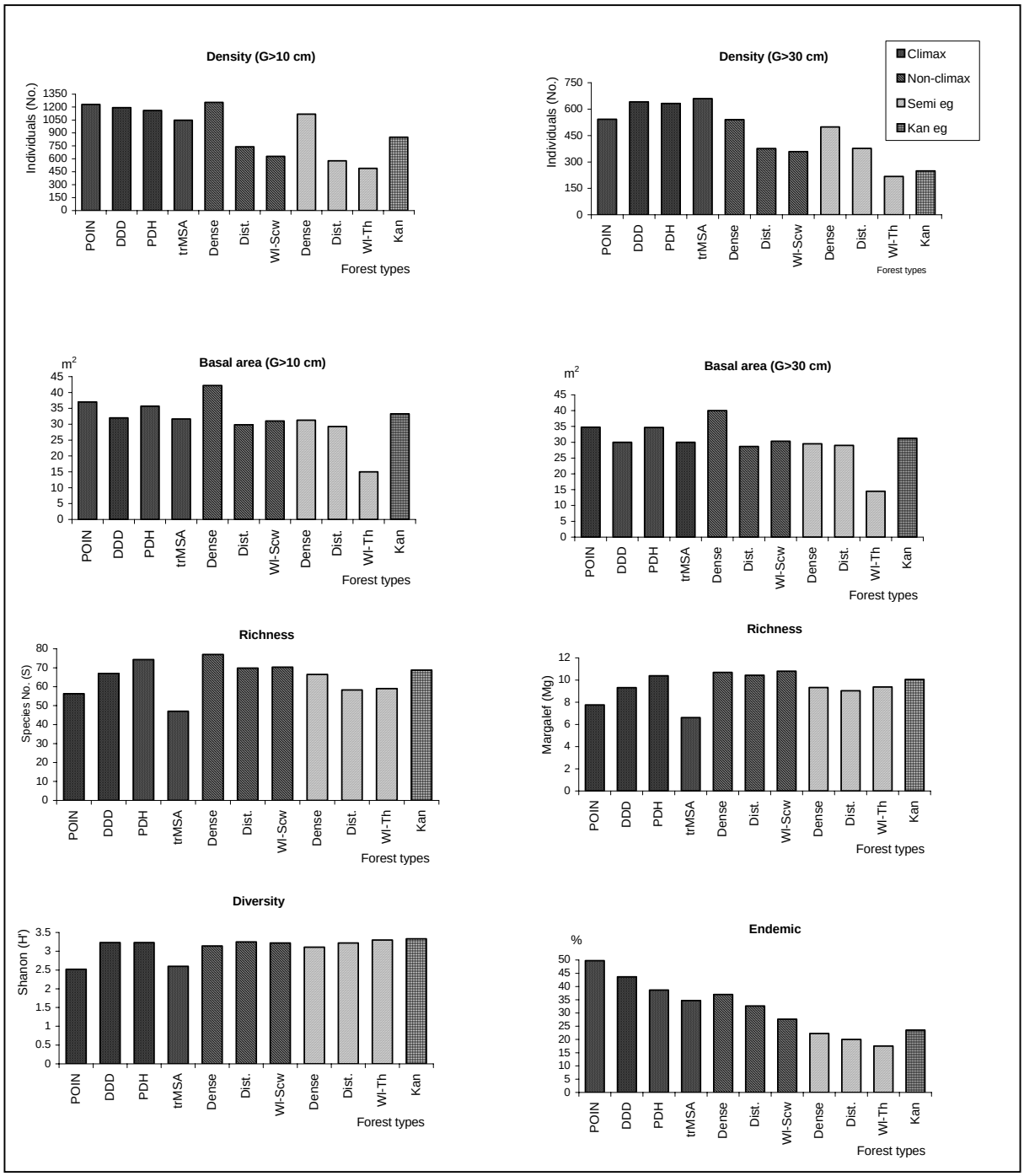


Figure 58: Mean variations in spatial and floristic structural parameters according to evergreen and semi evergreen forest types (POIN = *Poiciloneuron indicum* dominated types; DDD = *Dipterocarpus indicus-Diospyros candolleana- D.oocarpa* type; PDH = *Persea macrantha-Diospyros* spp.-*Holigarna* spp. type; trMSA = *Transition Memecylon umbellatum-Syzygium cumini-Actinodaphne angustifolia* type; Dist. = Disturbed; Wl = Woodland; Scw = Scrub woodland; Th = Thicket)

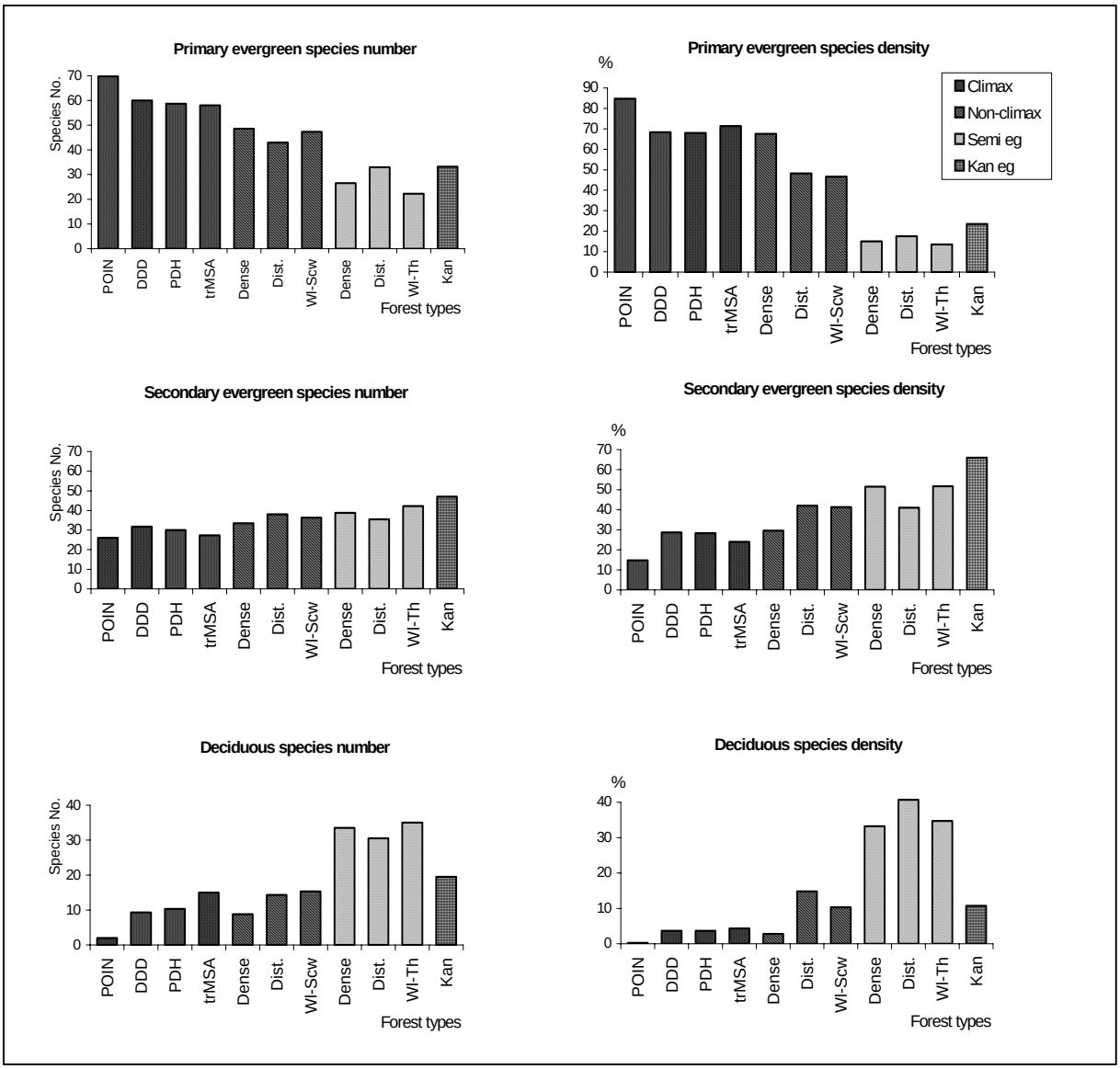


Figure 59: Phenological parameters according to evergreen and semi evergreen forest types

In the analysis, these climax floristic types are arranged with increase in latitude, which also reflects the increase in dry period. POIN forests come under 4-5 months dry period, where as DDD and PDH 5-6 and trMSA 6-7 months. POIN and trMSA experience >5000 mm rainfall, whereas, others fall under 2000-5000 mm.

Though some of these plots are moderately disturbed due selective logging, they have retained the respective climax species of the type, however, with various frequencies.

With regard to the spatial structure, when the density of individuals with G>10 cm is considered, there is a slight decrease in the types with increasing latitude (Figure 58). However, when the individuals G>30 cm are considered, there is a reverse tendency, indicating a higher number of individuals in the smaller girth class in the forest types of southern latitude. This increase is either due to high regeneration of *Poeciloneuron indicum* in moderately disturbed plots or higher number of individuals from the species belonging to strata 4. In the basal area, there is not much difference

between G>10 cm and G>30 cm classes of individuals. DDD and trMSA show relatively less (G>10 = 32 m^2) compare to other two (36 – 37 m^2) climax types.

In the floristic structure, the species richness (S and Mg) and diversity (Shannon) are relatively low in *Poeciloneuron* and *Memecylon* (trMSA) dominated forests compared to DDD and PDH.

When the percentage of endemics are considered, there is a gradual decline in the rate, from 50% to 35% with increase in latitude, which is attributed to increase in length of the dry season from 4 to 6 months.

Among evergreen tree species, primary ones vary from 58 to 60% between DDD, PDH and trMSA type. However, it accounts for 70% in POIN forests. Secondary evergreen species have variations between 26 to 36%. Deciduous species show increase from 2 (POIN) to 15% (trMSA) which may be linked to an increase in dry period (Figure 59).

Non-climax evergreen forests

These forests, also under >2000 mm rainfall zone, are moderately to heavily disturbed; consequently, the species which are typified as climax, are either absent or rarely present. Based on the degree of disturbance, four physiognomic stages (dense, disturbed and wooldland to scrub-woodland) have been identified (Figures 58 & 59).

The forests which are considered as dense have more than 1000 individuals and the density shows a drastic decline to 740 in disturbed forests, and further to 640 in woodland to scrub woodland stages.

The dense forests are similar to climax forests in the total density (1254). However, when the individuals of girth above 30 cm (G>30 cm) are considered, they are fewer (540) than in climax forests. This indicates that more than half the total number of individuals comes from lower girth class. The basal area in the dense forests is much higher (42 m^2) compared to all other forest types. Due to the presence of some big trees in the disturbed and woodland to scrub woodland, the basal area (around 30 m^2) is nearly similar to climax type and dense or disturbed of semi evergreen type.

Among the floristic structural parameters, species richness shows relatively less variations (70-77 species) between the dense, disturbed and woodland to scrub woodland formations. The diversity value (H') varies from 3.03 – 3.25. The percentage of endemic species decreases with the increase in disturbance. In all the groups, the number of primary evergreen species varies between 42 and 48% and its density steeply decreases (67 to 35 %) with the increase in degradation. Although the number of secondary evergreen species is less (36 – 39%), its overall density is higher (49-52%) than that of primary species. Numbers of deciduous species also show an increase with degradation. However, its density in dense forest is as low (5%) as climax forest.

Semi evergreen forests

In the dense semi evergreen forests, total density is more than 1100 individuals and in other groups (disturbed to scrub woodland – thickets) it is nearly half of this or less. The basal area in dense and disturbed groups varies between 29 and 31 m^2 and in others it accounts for only 15m^2 (Figure 58).

Richness (S 58-66) and diversity (H' 3.3-3.22) in all the physiognomic stages, vary little although endemics show a gradual decline from 22 to 17%.

Predictably in semievergreen forests, evergreen species accounts for 65 to 66% (density 59-67%) and deciduous species represent 30 to 35 % (density 59-67%) of the total number of species. Among the evergreen species, both the number and density, of primary species are less than 33% and secondary species are more than 35% (Figure 59).

'Kan' evergreen forests

'Kans' are the patches of remnant evergreen forests in the midst of moist deciduous forest where the rainfall is less than 1800 mm. In spite of the constraint in rainfall, 'Kan' forests are to a certain extent structurally and floristically, similar to wet evergreen forests. Four plots, which were studied under this type, are moderately disturbed.

Contrasting difference between total density (850) and density (249) of big trees (G>10 cm) indicates the high concentration of individuals at the lower strata. Basal area (33 m^2) is nearly equal to dense and disturbed groups of other evergreen and semi evergreen types. Richness (68 species) and diversity (H' 3.33) is nearly similar to other types. Number of endemics (23%) is equal to dense semi evergreen and less than all the physiognomic groups in other types (Figures 58 & 59).

In the richness and density of evergreen species, 'Kan' forests are equal to wet evergreen types. However, within the evergreen, primary species are fewer and secondaries are more numerous compared to wet evergreen types.

Deciduous category

This category is represented by 3 main types: secondary moist deciduous, primary moist deciduous and dry deciduous.

Secondary moist deciduous forests

The deciduous forests in the >2000 mm rainfall zone are considered as secondary, because they are derived from the gradual degradation of wet evergreen forest. Eventhough, the floristic composition among big trees is similar to the primary moist deciduous forests, the undergrowth is well represented by evergreen species, whose density varies between 8-23% and also have 9-15% endemics (Figures 60 & 61).

The total stand density in dense forest is 790. It declines sharply (312) in disturbed woodland stage. However, shows an increase (415-547) with increasing in degradation. And in extreme open conditions like open thickets, density become very low (160)(Figure 60).

In spite of a low density in woodland, when compared to dense forest, its basal area is high (27 m^2). In others groups, basal area decreases (15-8 m^2) with the increase in degradation.

Table 13: Mean variation (ANOVA) of spatial structural parameters in the deciduous forest types.

Spatial structure									
Forest types		***Density***				***Basal area (m^2)***			
		G>10cm	***G>30cm***	***G>60cm***	***G>120cm***	***G>10cm***	***G>30cm***	***G>60cm***	***G>120cm***
Secondary moist deciduous	Dense	790	400	194	47	23	22	18.5	10
	Wl	312	216.6	171	82.2	26.8	26.6	25.8	20
	Dist-Wl	415	208.25	125.75	35.5	14.75	14.25	13.25	7.5
	Wl-Scw	547	277.67	101	29.33	14	13	10.33	6.67
	Scw-Op_Th	160	82.5	53	14.75	7.95	7.74	7.29	4.8
Primary moist deciduous	Wl	484.87	285.25	175.25	59.87	24.25	23.63	22.13	15.25
	Dist-Wl	289.25	196.25	146.25	54.5	18.75	18.5	17.75	11.75
	Scw	381.6	103.8	44.2	14	7.8	7	6.2	4.2
Dry deciduous	Wl-scw	551.8	164	66.4	7	7.6	6.2	4.6	1.4
	Op-Th	217.5	32.75	6.75	1	1.5	0.75	0.5	0.25
CD at 5%		**56.5**	**48.75**	**21.2**	**5.75**	**5.9**	**5.3**	**3.9**	**1.05**

(Op_Th = open thicket)

Table 14: Mean variation (ANOVA) of floristic structural parameters in the deciduous forest types.

Floristic structure																
Forest types		***S***	***Mg***	***Chao1***	***End***	***1 - D***	***H'***	***E***	***Psp(s)***	***Psp(D)***	***Ssp(s)***	***Ssp(D)***	***Egsp(s)***	***Egsp(D)***	***Desp(D)***	***Desp(s)***
Secondary moist deciduous	Dense	32	4.64	9	7.1	0.86	2.38	0.69	6	0.5	30	8	35.5	8.5	91.5	64.5
	Wl	35.8	5.97	15	9.8	0.86	2.53	0.73	13.8	4	37.4	16.8	51.6	21	79	48.4
	Dist-Wl	45.25	7.36	10.75	8.7	0.88	2.72	0.71	10.5	1.75	32.5	16.25	43	18.25	81.75	57
	Wl-scw	39	6.04	8.33	9.27	0.88	2.64	0.72	5.33	5.33	33.33	12.67	38.67	18	82	61.33
	Scw-Op_Th	31.25	5.97	10.21	14.55	0.92	2.89	0.84	8.41	3.19	31.55	19.5	40.72	22.8	77.2	59.28
Primary moist deciduous	Wl	31.5	4.94	5	5.55	0.78	2.14	0.62	3.5	0.87	27.25	9.75	31.75	10.75	89.25	68.25
	Dist-Wl	28	4.79	1.75	6.98	0.83	2.29	0.69	0.75	0	17.25	4	18.75	4	96	81.25
	Scw	28	4.64	3.2	5.84	0.79	2.14	0.64	1.8	0.4	28.4	9.8	31	10.8	89.2	69
Dry deciduous	Wl-scw	36.2	5.64	1.2	7.16	0.85	2.45	0.69	1.4	0.2	30.2	11.4	31.2	11.8	88.2	68.8
	Op_Th	29	5.15	3.5	10.4	0.86	2.54	0.76	2.5	1	26.25	16	28.75	17	83	70.5
CD at 5%		**4.8**	**0.9**	**3.2**	**2.9**	**6.5**	**6.29**	**0.06**	**1.5**	**0.9**	**3.8**	**5.6**	**9.8**	**6.6**	**8.4**	**5.1**

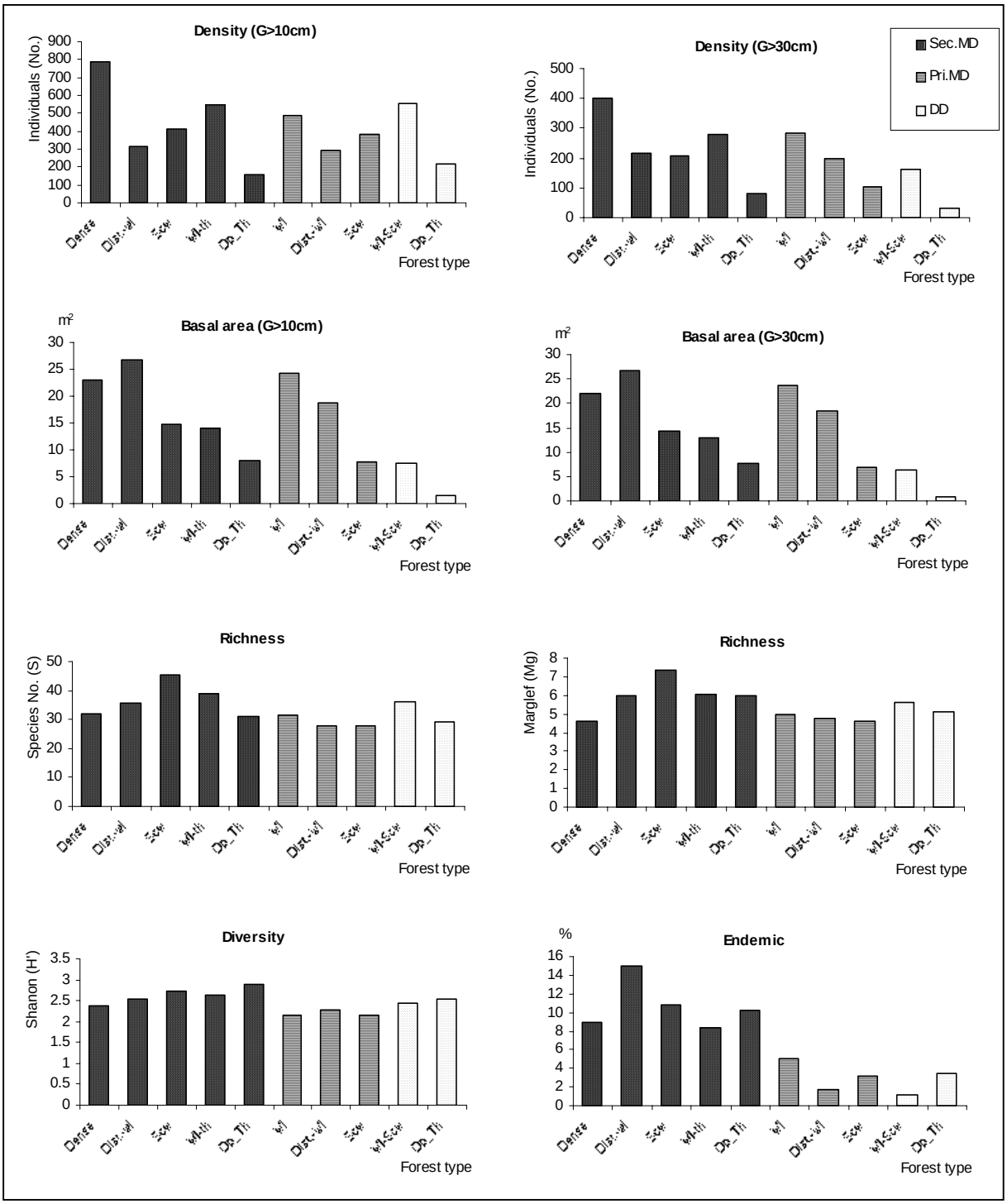


Figure 60: Mean variations in the spatial and structural parameters according to deciduous types

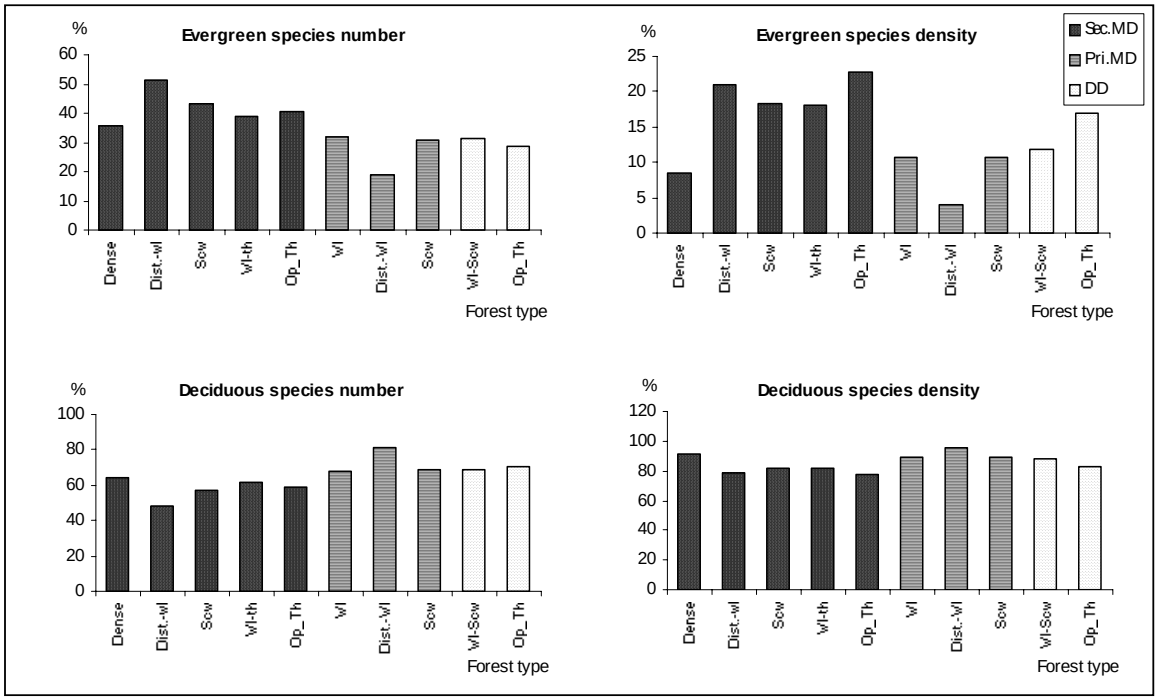


Figure 61:Phenological parameters according to deciduous forest types

Primary moist deciduous forests

Primary moist deciduous forest in the study area, according to map 1 and 2 is represented by *Lagerstroemia microcarpa – Tectona grandis – Dillenia pentagyna* floristic type. The last species is typical of both the moist deciduous types, along with *Tabernaemontana heyneana*, which is endemic to the Western Ghats. The sampling plots cover 3 physiognomic groups: woodland, disturbed woodland and scrub woodland. The total density in these groups varies between 381 and 485. Basal area (G>10 cm) decreases from 24 to 9 m^2 with increasing degradation.

Species richness (S 28 to 31) and diversity (H' 2.14 - 2.29) in all the groups are lower compared to secondary moist deciduous and dry deciduous types. The number of evergreen species varies from 19 to 31%, however, its density is lower (4 to 11%) compared to secondary moist deciduous and dry deciduous type. Endemics are represented by 9 species (mostly secondary evergreen species), which varies between 1.7 and 5%. *Bauhinia foveolata,* a canopy tree, is particularly endemic to the Uttara Kannada region (Figures 60 & 61).

Dry deciduous forests

Dry deciduous forests are represented by *Anogeissus latifolia – Tectona grandis – Terminalia tomentosa* type and has 2 physiognomic groups: Woodland to scrub woodland and open thickets. Total stand density (551) and basal area (7.6 m^2) is higher in the first group. Richness (S 29-36) and diversity (H' 2.45-2.54) do not vary much between the groups. Evergreen species density is marginally higher compare to primary moist deciduous, due to some additional species like *Ixora brachiata, Strebulus asper, Polyalthia cerasoides, Cassine glauca, Santalum album* and *Pongamia pinnata* which are typical evergreen species generally found in dry deciduous forests. Endemics are represented by only 3 species that are mostly in the plots close to moist deciduous zones (Figures 60 & 61).

Impact of disturbance on structural parameters

Evergreen to semi evergreen forests

Spatial parameters like total density and basal area vary between and within the major types based on the degree of disturbance in the stand. Except in trMSA the mean number of species in all the types, is more than 50 Figure 58. Similarly, except in POIN and trMSA, the diversity (mean Shannon value) is between 2.6 and 3.33 irrespective of the physiognomic stage. The lower variability between these two is due to turnover in the rate of primary evergreen to secondary evergreen species with the increase in degradation.

Primary evergreen species number on average account for 62% in climax forests, gradually decreasing to 45% in non-climax forests and 27% in semi evergreen forests Figure 59. On the other hand, secondary evergreen species number, which are 29% in climax gradually increase to 36% in non-climax disturbed forests, and to 47%, further up in semi evergreen forests. The density of primary and secondary evergreen species also shows the same trend. Endemics show decline from 42% to 20% from climax to semi evergreen. Deciduous species, which occupy the openings, represent 9% in climax and increase to 13 in non-climax forests, and further show 3-fold increase in semi evergreen forests.

In 'Kan' forests, the number of secondary evergreen species (47) and its density (66) is higher compare to other wet evergreen types and the number of deciduous species is also higher except in semi evergreen forests.

PCA and simple correlation analysis have shown that the secondary evergreen species is the most significant variable linked to several other parameters Table 15, Figure 62. On spatial structure, the increase in secondary species decreases the density of bigger trees (G>30 cm). Among floristic parameters, with the increase in secondary species, diversity (Shannon) and dominance (Simpson) are positively correlated, and primary and endemics are negatively correlated. On the contrary, an increase in primary species increases the endemics and density of big trees (G>30 cm).

Deciduous forests

In the deciduous types, the impact of disturbance has been generally reflected in the total basal area and density of big trees (G>30 cm), which show a decline with the increase in degradation. The overall decreases in evergreen species among the deciduous types is more related to climate rather than degradation. Richness and diversity show slight variation with degradation in each type (Figure 60).

In simple correlation analysis richness is positively associated with diversity. However, when the endemics are considered, there is a negatively correlated with the increase in deciduous species (Table 16, Figure 63). Among the deciduous species encountered in the study area, only *Bauhinia foveolata and Tabernaemontana heyneana* are endemics. Apart from these two, other endemics are evergreen, mainly found in secondary and primary moist deciduous types.

Table 15: Correlation between the different spatial and floristic parameters in the evergreen and semi evergreen forest types.

Parameter	S	Mg	Chao 1	End	1 - D	H'	E	Psp (s)	Psp (D)	Ssp (s)	Ssp (D)	Egsp (s)	Egsp (D)	De_sp (no.)	Desp (D)	D (G>10cm)	D (G>30cm	BA(m^2) (G>10cm)	BA(m^2) (G>30cm)
S	1	**0.89***	**0.85***	0.07	0.41	**0.62***	0.23	-0.03	0.06	0.23	0.06	0.2	0.18	-0.2	-0.16	0.4	0.18	0.53	0.54
Mg		1	**0.8**	-0.2	**0.66***	**0.82***	0.55	-0.29	-0.22	0.49	0.36	-0.02	-0.02	0.01	0.05	-0.05	-0.23	0.17	0.2
Chao 1			1	0.1	0.29	0.51	0.17	-0.06	0.02	0.29	0.06	0.19	0.1	-0.19	-0.06	0.27	-0.01	0.34	0.34
End				1	**-0.7***	**-0.55***	**-0.7***	**0.95***	**0.95***	**-0.79***	**-0.82***	**0.93***	**0.84***	**-0.93***	**-0.84***	**0.65***	**0.67***	**0.58***	0.56
1 - D					1	**0.96***	**0.95***	**-0.68***	**-0.7***	**0.76***	**0.74***	-0.55	-0.49	0.55	0.5	-0.46	-0.49	-0.38	-0.35
H'						1	**0.9***	**-0.6***	**-0.58***	**0.72***	**0.64***	-0.42	-0.38	0.42	0.4	-0.33	-0.42	-0.23	-0.2
E							1	**-0.72***	**-0.73***	**0.77***	**0.76***	**-0.6***	-0.54	**0.61***	0.55	**-0.65***	**-0.64***	**-0.59***	**-0.56***
Psp (s)								1	**0.97***	**-0.86***	**-0.86***	**0.92***	**0.84***	**-0.92***	**-0.85***	0.57	**0.69***	0.57	0.56
Psp (D)									1	**-0.84***	**-0.88***	**0.93***	**0.88***	**-0.93***	**-0.88***	**0.64***	**0.72***	**0.61***	**0.6***
Ssp (s)										1	**0.96***	**-0.64***	-0.52	**0.64***	0.53	-0.52	**-0.77***	-0.44	-0.44
Ssp (D)											1	**-0.69***	-0.55	**0.7***	0.55	**-0.62***	**-0.8***	-0.053	-0.053
Egsp (s)												1	**0.94***	**-1***	**-0.93***	0.54	0.52	**0.64***	**0.63***
Egsp (D)													1	**-0.94***	**-1***	0.51	0.47	0.56	0.54
Desp (no.)														1	**0.94***	-0.54	-0.52	**-0.65***	**-0.64***
Desp (D)															1	-0.52	-0.48	-0.57	-0.55
D(G>10cm)																1	**0.87***	**0.83***	**0.8***
D(G>30cm)																	1	**0.69***	**0.68***
BA (m^2) (G>10cm)																		1	**1***
BA (m^2) (G>30cm)																			1

(Psp = Primary evergreen species; Ssp = Secondary evergreen species; D = Density; BA = basal area; *s* = number of primary or secondary evergreen species)

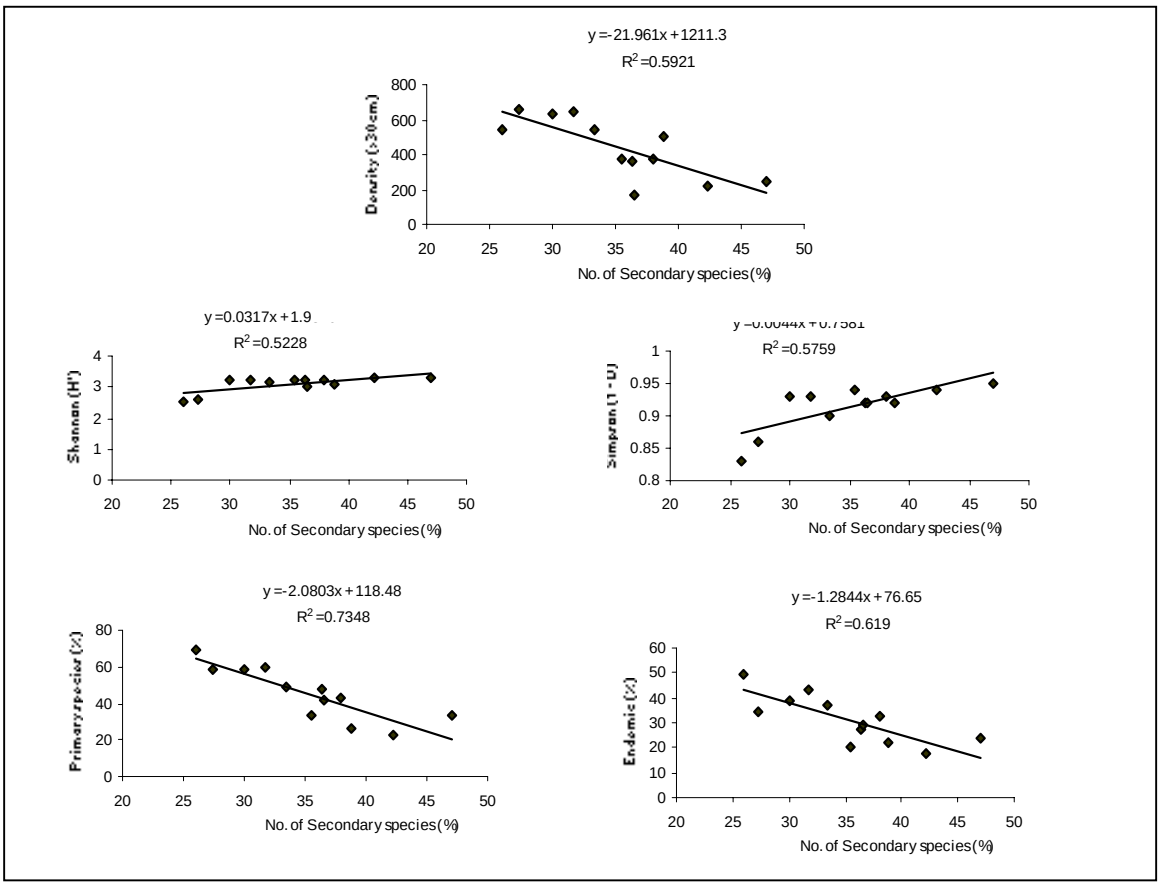


Figure 62: Correlation regression analysis for some parameters in evergreen and semi evergreen forest types

Table 16: Correlation between the different spatial and non-spatial parameters in deciduous forest types.

Parameter	S	Mg	Chao 1	End	1 - D	H'	E	Egsp(s)	Egsp(D)	Desp(s)	Desp(D)	D (G>10cm)	D (G>30cm)	D (G>60cm)	BA(m^2) (G>10cm)	BA(m^2) (G>30cm)	BA(m^2) (G>60cm)
S	1	**0.89***	**0.82***	0.5	0.43	0.52	0.08	0.6*	0.5	-0.6*	-0.5	0.27	0.29	0.21	0.15	0.14	0.12
Mg		1	**0.87***	0.56	0.62*	**0.76***	0.42	**0.7***	**0.7***	**-0.7***	**-0.7***	-0.18	-0.08	-0.04	-0.05	-0.05	-0.03
Chao 1			1	0.45	0.26	0.43	0.07	0.5	0.5	-0.5	-0.5	-0.12	-0.03	0.09	0.06	0.07	0.1
Endemic				1	0.53	0.56	0.41	**0.9***	**0.7***	**-0.9***	**-0.7***	-0.02	0.29	0.41	0.48	0.49	0.5
1 - D					1	**0.96***	**0.89***	0.5	**0.7***	-0.5	**-0.7***	-0.19	-0.13	-0.19	-0.24	-0.23	-0.24
H'						1	**0.89***	0.6	**0.8***	-0.6	**-0.8***	-0.32	-0.24	-0.27	-0.29	-0.27	-0.27
E							1	0.4	**0.7***	-0.4	**-0.7***	-0.54	-0.44	-0.4	-0.38	-0.36	-0.33
Egsp(s)								**1**	**-0.7***	**-1***	0.38	0	0.2	0.2	0.3	0.3	0.3
Egsp(D)									1	**-0.8***	**-1***	-0.4	-0.3	-0.3	-0.2	-0.2	-0.2
Desp(s)										1	**0.8***	0	-0.1	-0.2	-0.3	-0.3	-0.3
Desp(D)											1	0.4	0.3	0.3	0.2	0.2	0.2
D(G>10cm)												1	**0.83***	0.51	0.39	0.35	0.25
D(G>30cm)													1	**0.87***	**0.79***	**0.77***	**0.69***
D(G>60cm)														1	**0.97***	**0.97***	**0.94***
BA(m^2) (G>10cm)															1	**1***	**0.99***
BA(m^2) (G>30cm)																1	**0.96***
BA(m^2) (G>60cm)																	1

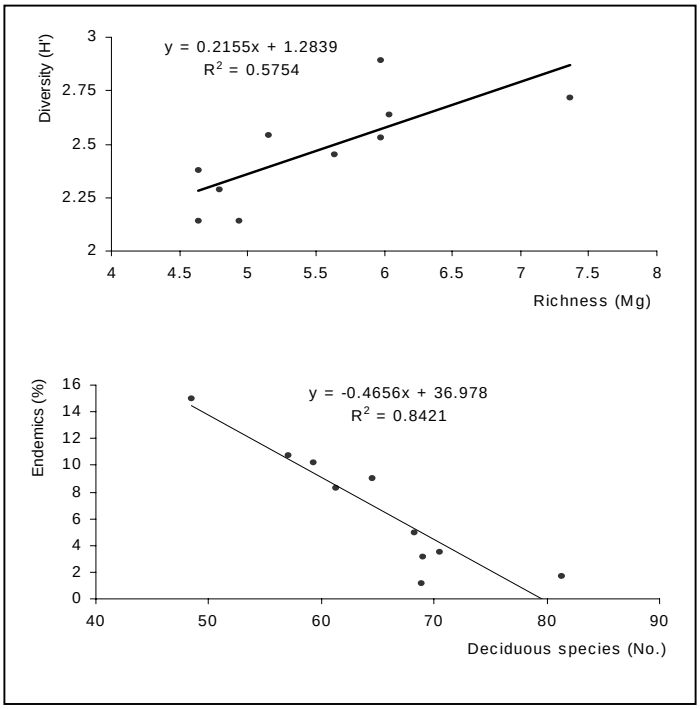


Figure 63: Correlation regression analysis of some floristic parameters in deciduous forest types

Effect of anthropogenic patch proximity on the physiognomy of the forests

Buffer analysis around the BSP plots indicates that the forests which are closer to larger anthropogenic patches are severely degraded compared to farther ones (Figure 64).

Within 500 m buffer circle, highly degraded stages like scrub woodland to open thickets are surrounded by 35 to 37% area of anthropogenic patches. However, when the buffer distance was increased to 1000 m there was a considerable increase in area of anthropogenic patches around other less degraded forest, eventually, it may become a major threat to these forests.

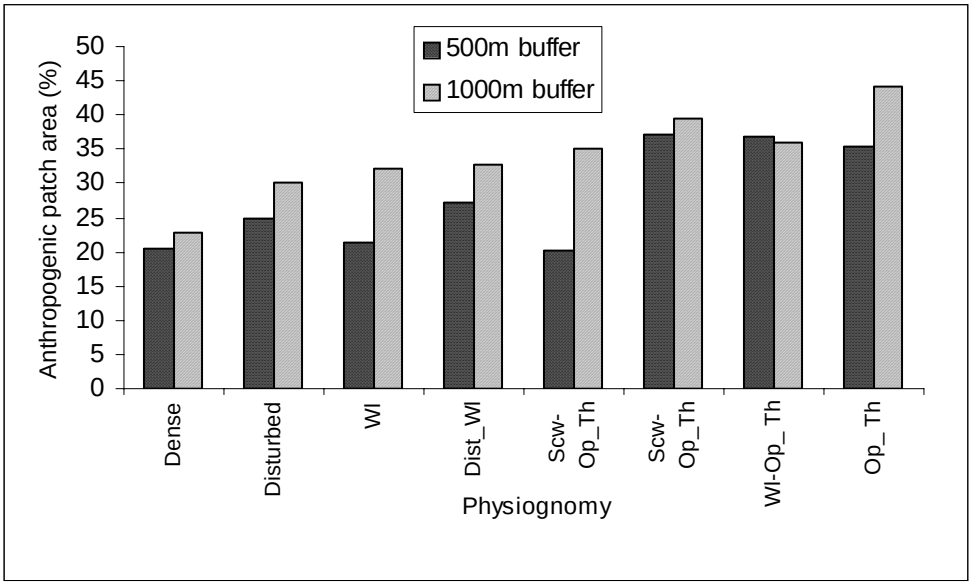


Figure 64: Area of anthropogenic patches around the sampled physiognomic formations within 500 and 1000m buffer circles.

Regeneration

From 288 micro plots (10 X 10 m) in the above 1m category, 345 species have been encountered from 14,868 individuals. In the below one metre height category, out of 1887, records 240 species were listed. Overall 70 species, which were not represented in the macro plots, are found in micro plots.

Among the tree species, 55 of them have just one record. *Aporosa lindleyana*, an heliophylus species alone has 624 records. Other arborescent species with considerable regeneration include *Xylia xylocarpa* (438), *Knema attenuata* (409), *Dimocarpus longan* (334), *Terminalia paniculata* (312), *Poeciloneuron indicum* (292), *Olea dioica* (274), *Hopea ponga* (240), *Calycopteris floribunda* (204) and *Anogeissus latifolia* (183).

Psychotria nigra (749) and *Leea indica* (595) are the dominant among shrubs.

The relative proportions of evergreen and deciduous tree species, which are indicators of the future succession of the forest, are considered for ANOVA (Tables 17 & 18).

Table 17: Mean variation (ANOVA) of regeneration of tree species saplings in evergreen forest types.

Forest type		***Egsp(s)***	***Psp(s)***	***Psp(D)***	***Ssp(s)***	***Ssp(D)***	***Desp(s)***	***Desp(D)***
Climax	POIN	26	23	177.5	6.5	15.75	0.25	0.25
	DDD	34	24.75	137.5	10.75	36.75	0.75	1
	PDH	27	21.5	141.75	6.5	18	0.25	0.5
	trMSA	29.67	22.33	145	9.67	29	0.33	0.33
Non climax	Dense	31	25.4	254.8	6.8	57.8	1.2	2
	Dist.	29.17	18.33	104.17	11.17	42.5	2.67	3.67
	Wl-Scw	23	14.33	90.67	9.33	86.33	1	1.33
Semi evergreen	Dense	25	8.6	55.2	12.8	144.4	6.8	11.4
	Dist.	25.75	11.75	75.75	11.5	41	5.5	8.5
	Scw-Th	22.25	5.25	61	11	104.75	7.75	23.25
Kan		33.25	16	98.75	15	107.5	5	9.25
CD at 5%		**3.75**	**3.35**	**19.55**	**3.17**	**14.2**	**0.51**	**1.75**

Table 18: Mean variation (ANOVA) of regeneration of tree species saplings in deciduous forest types

Forest type		***Tree species (S)***	***Tree species (D)***
Secondary moist deciduous	Dense	15	47
	Wl	21.6	30.6
	Dist._wl	14.8	36.6
	Wl-Scw	12.5	42.25
	Scw-Op_Th	12.8	20.8
Primary moist deciduous	Wl	4.25	34.13
	Dist-Wl	3.5	14.75
	Scw	5.6	51
Dry deciduous	Wl-Scw	6.4	45.2
	Op_Th	11	73
CD at 5%		**2.90**	**6.05**

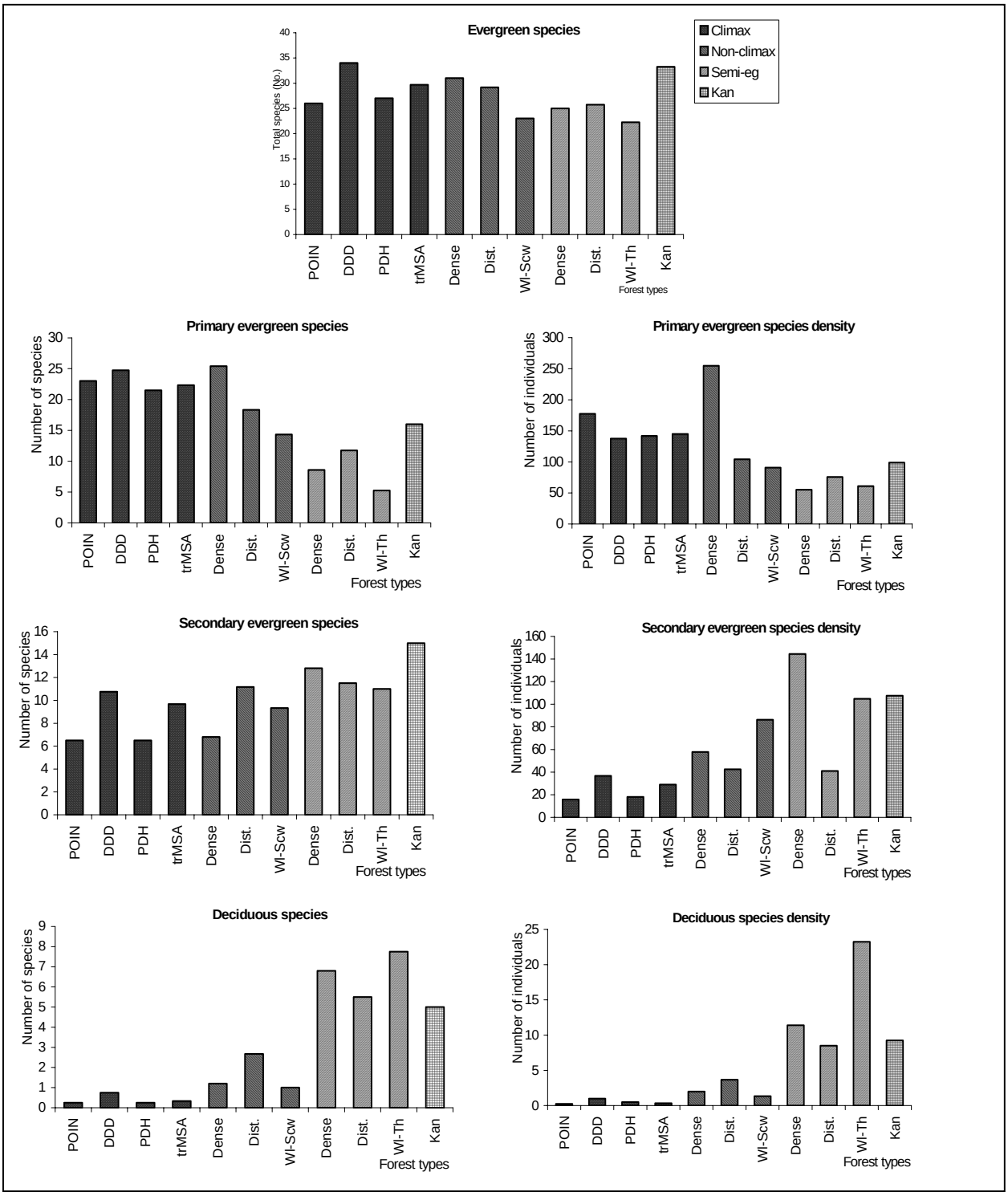


Figure 65: Mean variations of tree species saplings (evergreen and deciduous) in evergreen and semi evergreen forest types.

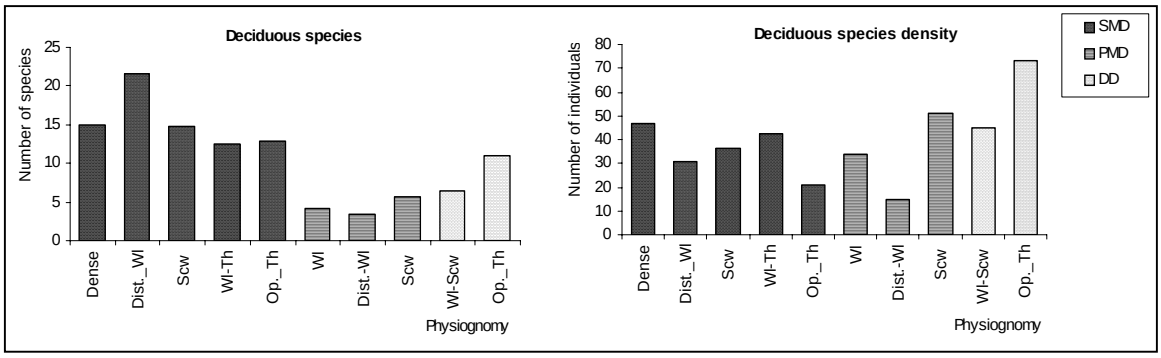


Figure 66: Mean variations of tree species saplings deciduous forest types (SMD = secondary moist deciduous; PMD = primary moist deciduous: DD = Dry deciduous)

In the evergreen and semi evergreen forests, parameters like species richness and relative proportion of evergreen (primary and secondary) and deciduous species in the tree saplings, follow similar trend like that of adult individuals in the macro plots (Figure 65). Species richness in DDD and Kan forests is marginally higher (>33) compared to other groups. The density of primary species saplings is much higher in the dense non-climax forests compared to climax forests. Similarly in dense semi evergreen forest density of secondary evergreen species is much higher (144) compared to all other groups. This increasing trend in the regeneration of evergreen species indicates the succession of dense non-climax forests towards the original primary status and dense semi evergreen forests, on its way to secondary evergreen status. The increasing number of deciduous tree saplings in highly degraded stage (woodland – thickets) in the semi evergreen type may gradually lead this group into secondary moist deciduous.

In deciduous types, there is no definite pattern of tree species sapling density with degradation, except a higher regeneration in the open thickets of dry deciduous type (Figure 66). The total number of deciduous tree species is higher in the secondary moist compared to other types.

Resource diversity

Out of 498 species recorded from the BSPs, several of them have multiple uses. The number of species, which are useful as timber forest product (TFP), non-timber forest product (NTFP) and medicinal plants account for 202,150 and 300 species respectively (Figure 67). The repartition of these species according to major vegetation types, reveals that the wet evergreen climax forests are richest in all the three categories. However, when these forests are disturbed (non-climax) there is a drastic decline in all these categories, even becoming marginally lower than dry deciduous forests. ‘Kan’ forests in the relatively drier areas also have a similar number of species of utility as disturbed wet evergreen forests. Semi evergreen forests with a considerable proportion of evergreen and deciduous species are richer in medicinal species and in proportion of TFP and NTFP, is similar to moist deciduous forests (Figure 68).

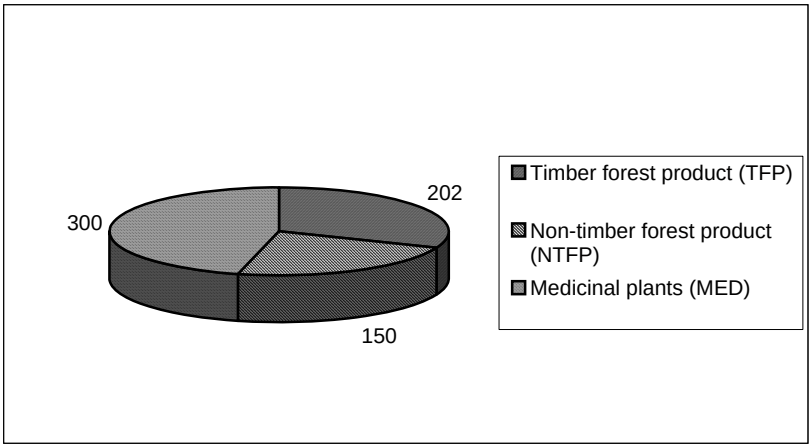


Figure 67: Number of resource species encountered in all the BSPs.

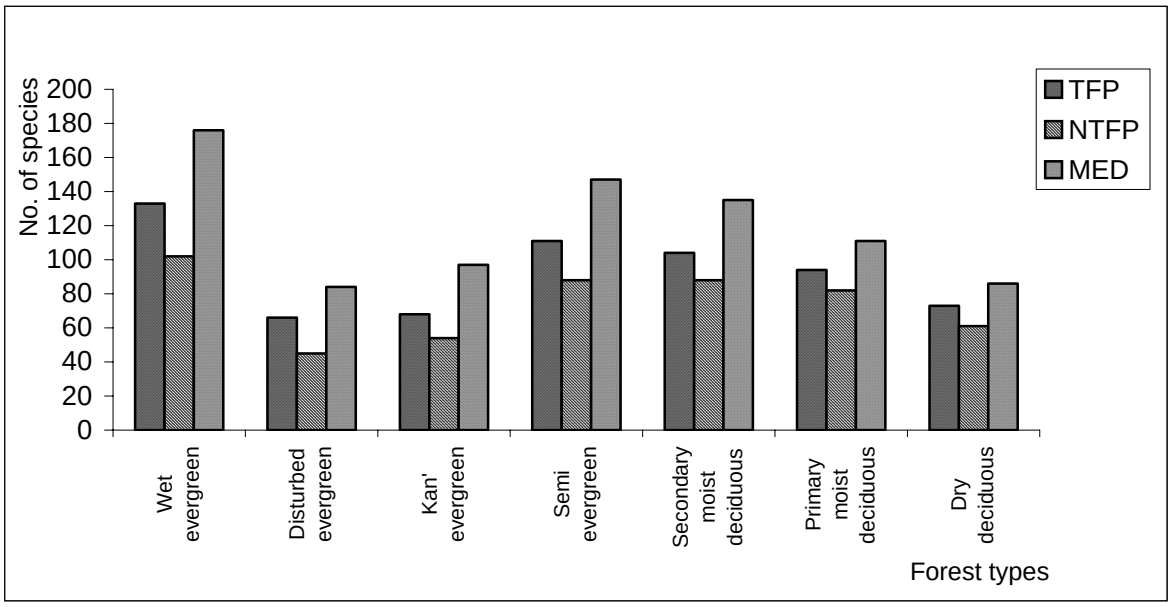


Figure 68: Number of resource species according to forest types

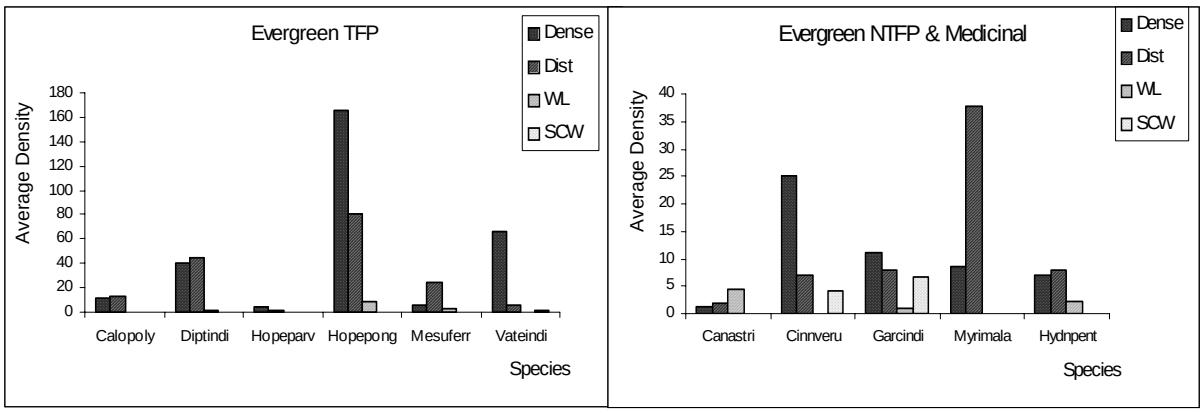


Figure 69: Population of some selected TFP, NTFP and Medicinal species according to physiognomic formations.

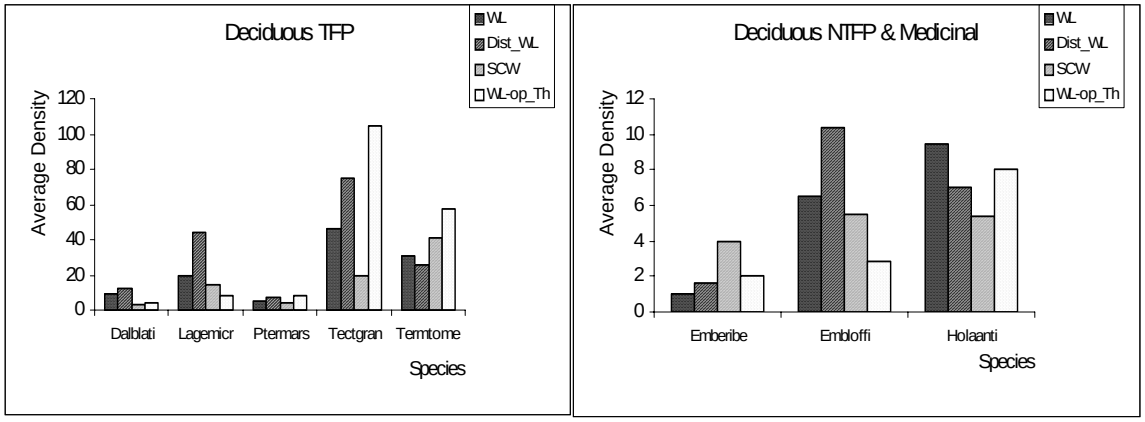


Figure 70: Population of some selected TFP, NTFP and Medicinal species according to physiognomic formations of deciduous type

Population density of selected TFP, NTFP and medicinal species according to degradation

Eighteen species with high potential of economic and medicinal values have been considered. Some of these TFP species were heavily exploited in the past (Figures 69 & 70).

Among the evergreen species, *Dipterocarpus indicus* (Diptindi) and *Vateria indica* (Vateindi) are softwood canopy and emergent trees often reaching more than 40-m height. These species were selectively logged in the past by plywood industries. Although the population of *Vateria indica* is considerably higher in the dense forest, it has sharply decreased in disturbed forests. Contrary to that, the population size of *Dipterocarpus indicus*, a characteristic species of the low elevation evergreen forest has not been much altered between the dense and disturbed forests (Figure 69).

Hopea ponga (Hopepong), another dipterocarp, is one of the dominant under-storey species of the evergreen forests in the study area. The wood of this species is used extensively by locals for agricultural implements and furniture. In dense forest its average density is 165, however, its population declines to half of this in the disturbed forests due to over exploitation.

Calophyllum polyanthum (Caloppoly), Hopea parviflora (Hopeparv) and *Mesua ferrea* (Mesuferr) are hardwood canopy species. During the colonial period the wood of these species were extensively used for railway sleepers. Their populations severely dwindled, and are currently low in the study area.

Principal TFP species in deciduous forests are *Dalbergia latifolia* (Dalblati) (rose wood), *Lagerstroemia microcarpa* (Lagemicr)*, Pterocarpus marsupium* (Ptermars), *Tectona grandis* (Tectgran) (teak) and *Terminalia tomentosa* (Termtome). In the study area, the overall populations of the first three species are less compared to the last two (Figure 70). Population of *Tectona grandis* and *Terminalia tomentosa* are found to be higher in the most degraded forests.

Among the NTFP species in the evergreen forest, *Cinnamomum verum* (Cinnveru) and *Myristica malabarica* (Myrimala) are commercially important for the spice industry. In the former, bark and leaves and in the latter the arils on the seeds are being exploited. *C. verum* shows sharp decline in population with degradation, whereas in *M. malabarica* it is much higher in the disturbed forest than in the dense. *Garcinia indica* (Garcindi) is a species endemic to study area. Even though its population is not much affected by degradation, in recent years it has been over exploited for its

fruit pulp, which has a sour taste and is used as an ingredient in food preparations, especially in coastal Karnataka and in Kerala. It is also exported in large quantities.

The seeds of *Hydnocarpus pentandra (Hydnpent)* an evergreen tree species, are widely used for various skin diseases. Since the species has wider ecological amplitude its population is not much affected, even in degraded forest.

Embelia ribes (Emblribe) and *Holarrhena antidysenterica* (Holaanti)(root, bark and seed used for dysentery and urinary disorders) are medicinal plants encountered in the deciduous forests. The former species is a climber and more confined to scrub woodland in secondary moist deciduous type and sometimes in highly disturbed evergreen forests. Latter is a small tree and is common in primary moist deciduous forest, irrespective of degradation.

Emblica officinalis (Embloffi) is mainly a species of dry deciduous forests and is exploited for its fruits which has a tremendous commercial value in the food industry. In degraded forest, which are closer to human settlements, its population is dwindling due to over-harvesting of fruits, resulting in low regeneration of this species.

Chapter

9

Assessment of tree biodiversity: Part III

Comments on the outcome of analyses

Discussion

The Western Ghats of Karnataka

Despite the high rainfall, the Karnataka part of the Western Ghats (KWG) is floristically less diverse compared to its counterpart in Kerala state due to longer dry period (4 – 7 months). The vegetation map prepared by the FIP reveals that KWG represent 14 climax types, with tree species richness, especially in the evergreen types, varying between 92 – 166 species. Whereas, the southern parts have 16 types with high numbers of species (ranging from 260 to 380). The low richness in KWG also reflects in the BSPs, where only 498 species have been encountered from nearly 100,000 records. A comparison with the ≥1-ha sampling plots in the southern part of the Western Ghats shows that even at the limit of ≥10 DBH (diameter at breast height) the species richness and basal area is considerably lower in the present study area (Table 19). When compared to some of the neotropical and south-east Asian forests, the species richness in BSPs is far lower (Table 19).

The Western Ghats is one of the 'mega centres' of endemism (Nayar, 1996). Nearly 56% of the total evergreen species (650) found here are endemic to the Ghats. Length of the dry season is an important factor in the distribution of endemics (Ramesh & Pascal, 1997). With a higher number of dry months, KWG accounts for nearly 171 of the total endemics (352). Species like *Bauhinia foveolata, Garcinia indica, Mamea suriga, Hopea canarensis, Hopea jacobi* are exclusive to KWG.

In spite of climatic constraints, KWG is unique in several ways. The Kodagu region (the southern part of KWG) where the length of dry season is around 4 months is as rich as southern part of the Western Ghats. It acts like a transition zone, with the presence of certain typical species of the southern part, which are generally adopted to shorter dry period like *Dipterocarpus bourdillonii, Semecarpus auriculata, Diospyros nilagirica, Diospyros bourdillonii* on one hand and on the other some of the typical species adapted to a longer dry period like *Garcinia indica, Diospyros oocarpa, Diospyros buxifolia*. Unfortunately the BSP do not cover this region in the current phase. However, permanent plots (around 5-ha) established by FIP reveal that the low elevation evergreen forest is nearly as rich as similar forests in the south (Table 19) (Pascal & Pelissier, 1996).

The Western Ghats are the western-most limit of the dipterocarp domain (Ramesh *et al*., 1996). Due to high population pressures in Kerala State, the low elevation dipterocarp forests are severely fragmented (Ramesh *et al*., 1997). Currently, the best parts of the dipterocarp forest lie in the KWG.

Poeciloneuron, one of the few endemic genera in the Western Ghats, has 2 species. *P. pauciflorum* is endemic to extreme southern part of the Western Ghats (Ramesh & Pascal, 1997) Where as *P. indicum* is patchily distributed throughout the Ghats. However, in KWG it nearly becomes monodominant, in very high rainfall zones (>5000 mm).

Table 19: Density, Basal area and species richness recorded in 1-ha or more size of plots in the evergreen forests of the Western Ghats of India and other parts of tropics.

Site		Plot size (ha)	Altitude (m)	Rainfall (mm)	Density (>10 DBH)	Basal Area (m^2)	No. of species	Source
Western Ghats	Sengaltheri Kalakad Tamil Nadu	1	1170	3000	720	55.3	95	Parthasarathy, 1999
	Kakachi Kalakad Tamil Nadu	3.82	1250-1450	3000	582.7	42.03	90	Ganesh *et al*., 1996
	Nelliampathy Kerala	1	950		496	61.9	30	Chandrasekar, a 1994
	Uppangala, Karnataka	3.12	500	5100	635 (ha^{-1})	40 (ha^{-1})	91	Pascal & Pelissier, 1996
	BSP24(ID73)	1	640	>5000	976	32	53	Present study (only least disturbed plots that belong to climax evergreen forests are given in this table)
	BSP26(ID74)	1	680	>5000	535	41	44	
	BSP28(ID66)	1	1060	>5000	376	60	21	
	BSP53(ID80)	1	520	2000-5000	683	29	56	
	BSP51(ID83)	1	540	2000-5000	710	29	51	
	PSPLD3(ID6)	1	500	2000-5000	480	32	56	
	BSP54(ID84)	1	55	2000-5000	755	32	73	
	BSPNK4(ID88)	1	160	2000-5000	660	40	50	
	BSPNK6(ID89)	1	390	>5000	619	29	49	
	BSPNK4(ID90)	1	615	2000-5000	609	33	38	
	BSPNK8(ID91)	1	610	>5000	751	28	34	
Neo-tropics and south-east Asia	Amasonia Ecuador		260	3.5	693		30	Valencia *et al*., 1994
	Mishana Peru	1	140	3000	858		289	Gentry, 1988b
	Choco Colombia	1	100		675		258	Faber-Langendoen and Gentry, 1991
	CMBRS PNG	1	900	6400	693		228	Wright *et al*., 1997
	Gunung Mulu Sarawak	1	200	5100	778		214	Proctor *et al.,* 1983
	Pasoh Malaysia	1	200	2000	530		210	Kochummen *et al*., 1990
	Cocha Cashu Peru	1	100	2000	673		201	Gentry and Terborgh, 1990
	Queenland Australia	1	730	2000	957		108	Phillips et al., 1994
	La Selva Costa Rica	1	100	4000	447		96	Lieberman *et al*., 1985
	BCI Panama	1	10	2500	414		93	Gentry, 1990
	Amazon Venezuela	1	100	3500	744		83	Uhl and Murphy, 1981

The 'Kan' evergreen forests in Soraba region are like 'ecological islands' in the midst of primary moist deciduous forests. In this region the rainfall is low (1500 – 1800 mm) for evergreen forests which is comparable to wet evergreen at the same latitudes (Pascal *et al*, 1988). Edaphic conditions like water holding capacity of soils and its gradual release during the dry period are the mechanisms for their maintenance (Bourgeon & Pascal, 1986).

Some of the other unique features in the KWG include Myristica swamps (typically represented by *Myristica fatua* var. *magnifica* and *Gymnacranthera canarica* in water-logged flat terrain in the Kathlekan and Hulical Ghats, and evergreen forest dotted with *Corepha umbraliculifera*, a monocarpic palm between the *Devimane* and *Arabail* Ghats in Uttara Kannada region which is not seen naturally elsewhere in the Western Ghats.

Factors influencing the degradation of forests

The flora and fauna evolved *vis a vis* local and global climatic changes since geological past. Currently they are being subjected to yet another kind of evolution (or devolution) influenced by human activities.

The wide array in bioclimate and edaphic conditions, which influences the land use patterns and high utility value of numerous species, are the prime factors altering the landscapes as well as the original status of the biodiversity of the Ghats.

Like in other regions of the Western Ghats, in KWG the forests are being exploited in various ways. During the colonial period a large extent of the hardwood species were removed for railway sleepers (Nadkarni, 1989). The 'selective' logging which was in force till 1986 had contributed to altering the biomass and floristic diversity in the forests. According to Karnataka forest statistics (1984), 173,846 m^3 of rosewood, teakwood, other timbers, plywood, firewood have been extracted between 1976 and 1985. Large-scale forest and commercial plantations and proliferation of reservoirs have also contributed to massive loss, and the deterioration of surrounding forests.

Non sustainable harvesting of NTFP has also pushed some species to the stages of imbalance in their population structure. For example, due to over harvesting, regeneration of *Garcinia indica* and *Myristica malabarica* is extremely low compared to their adult population in the BSPs. A similar observation on *Myristica dactyloides* has also been made by Pélissier (1997). Even in TFP, just one sapling has been recorded for *Vateria indica*.

Forest structure and influence of degradation

Although the bioclimate has separated the major types, various degrees of degradation have considerably altered the spatial and floristic structure of the vegetation. Out of 96 BSPs, 86 plots have either one or more signs of degradation in the form of fire, cut stumps or trails. The degradation stages encountered in BSPs nearly matches with the concept drawn in the Figure 7.

In order of progressive degradation, from low to high, in the potential area of wet evergreen forests, moderately disturbed climax types are least affected as far as the populations of primary species are concerned. Decline in endemics between these climax types is more attributed to increase in number of dry months. Even though some of the climax forests were logged in the past, they have still retained typical climax species and show marginal decline in biomass (Loffeier, 1989). The *Poeciloneuron* forests especially when moderately disturbed, show very high regeneration (30 to 37% of the total individuals) compared to undisturbed forests.

However, when these forests are repeatedly logged, the typical climax species either disappear or become very rare. Thus, the forest becomes "non-climax". Further heavy exploitation of these disturbed forests may result in woodland to scrub woodland stages or it may gradually turn into semi evergreen with the colonisation of deciduous species in the openings and finally to secondary moist deciduous formations with the increasing anthropogenic pressures. Daniels *et al.* (1995) in Uttara Kannada also observed a similar tendency in their studies along the gradient of disturbance.

It is possible that with protection, some of the non-climax forests and semievergreen forests are in the process of recovery, as manifested in their high density in the lower girth classes and also in regeneration. A relatively high basal area in disturbed non-climax forests may be attributed to low competition and availability of ample space for the remaining big trees after early stages of disturbance.

In terms of total species richness and diversity there is no big difference between climax, non-climax and semi evergreen forests. Even the degradation of the latter two has not severely affected the richness and diversity. Although the biomass has been altered. However, when the qualitative nature of the species composition are considered, there is a decline in the proportion of primary evergreen species and concomitant increase in the secondary evergreen species. As 95% of the endemic species are primary, their decline with the degradation is obvious.

'Kan' evergreen forests are naturally characterised by high proportion of secondary species like *Aporosa lindleyana, Xantolis tomentosa, Flacourtia montana, Ixora brachiata, Holigarna grahamii, Olea dioica, Vitex altissima*. In addition to climatic constraints 'Kans' are highly threatened by anthropogenic pressures from the surrounding human habitation. This has already been reflected in the increasing number of deciduous species, which may eventually push this unique ecosystem into moist deciduous forms.

Primary moist and dry deciduous forests are also not affected in terms of total richness and diversity with the disturbance. However, a big difference lies in the decrease in biomass in the form of density of big trees and basal area with the increase in degradation.

The relative proportions of primary and secondary evergreen and deciduous species are the most important indicators of the qualitative changes in the biodiversity. Several primary species like *Hopea canarensis, Cleistanthus malabaricus, Casearia wynadensis* have restricted distributions. The disappearance of these species may result in either extirpation or extinction of one or more species on this planet. Climax evergreen forests are not only ecologically significant with the high rates of endemism but also the gene banks of several economically and medicinally important species. In consideration of these factors, climax evergreen forests are the high priority areas for conservation.

Chapter 10

A case study of logging impact

Floristic composition and structure of a low elevation wet evergreen forest

Kadamakal Reserve Forest, Kodagu District

Introduction

Forest management rests upon knowledge of floristic composition and structure as well as on forest dynamics and functioning. With the intention of providing these tools to be used in decision-making for the management of the forest, studies have been conducted in a low elevation wet evergreen forest of the Western Ghats of Karnataka, in Kodagu District. This was done in collaboration with the Karnataka Forest Department.

Presentation of the study site

The experimental station is located within a 28 ha area of undisturbed forest in the Kadamakal Reserve Forest of the Kodagu District, near the village of Uppangala (12°30'N; 75°39'E), at an elevation that ranges from 400 to 600 m above sea level. The Kadamakal Reserve Forest comes under the *Dipterocarpus indicus - Kingiodendron pinnatum - Humboldtia brunonis* type of the low elevation dense wet evergreen forests of this region. Annual rainfall is about 5200 mm with a marked dry season of 3-4 months, from December to March. The mean annual temperature is 27°C, and the minimum mean temperature of about 25°C coincides with the rainfall peak in July.

Floristic composition and structure

The experimental station, first surveyed in 1990, comprises transects that are 20 m wide, 180 to 370 m long and 100 m apart. This constitutes a systematic sample of 3.12 ha and rectangular plots devoted to the study of the forest mosaic and spatial distribution (Figure 71). In each plot, all the trees with girth at breast height (gbh) above 30 cm were recorded, numbered, and identified.

Forest structure

In the five bands (3.12 ha), 1981 trees of girth size above 30 cm were recorded. The mean density was 635 trees per ha and the basal area 123.8 m^2, *i.e.* 39.7 m^2 per ha (Pascal & Pélissier, 1996). The distribution of girth classes follows the classic negative exponential pattern found in undisturbed rainforests (Fig. 72).

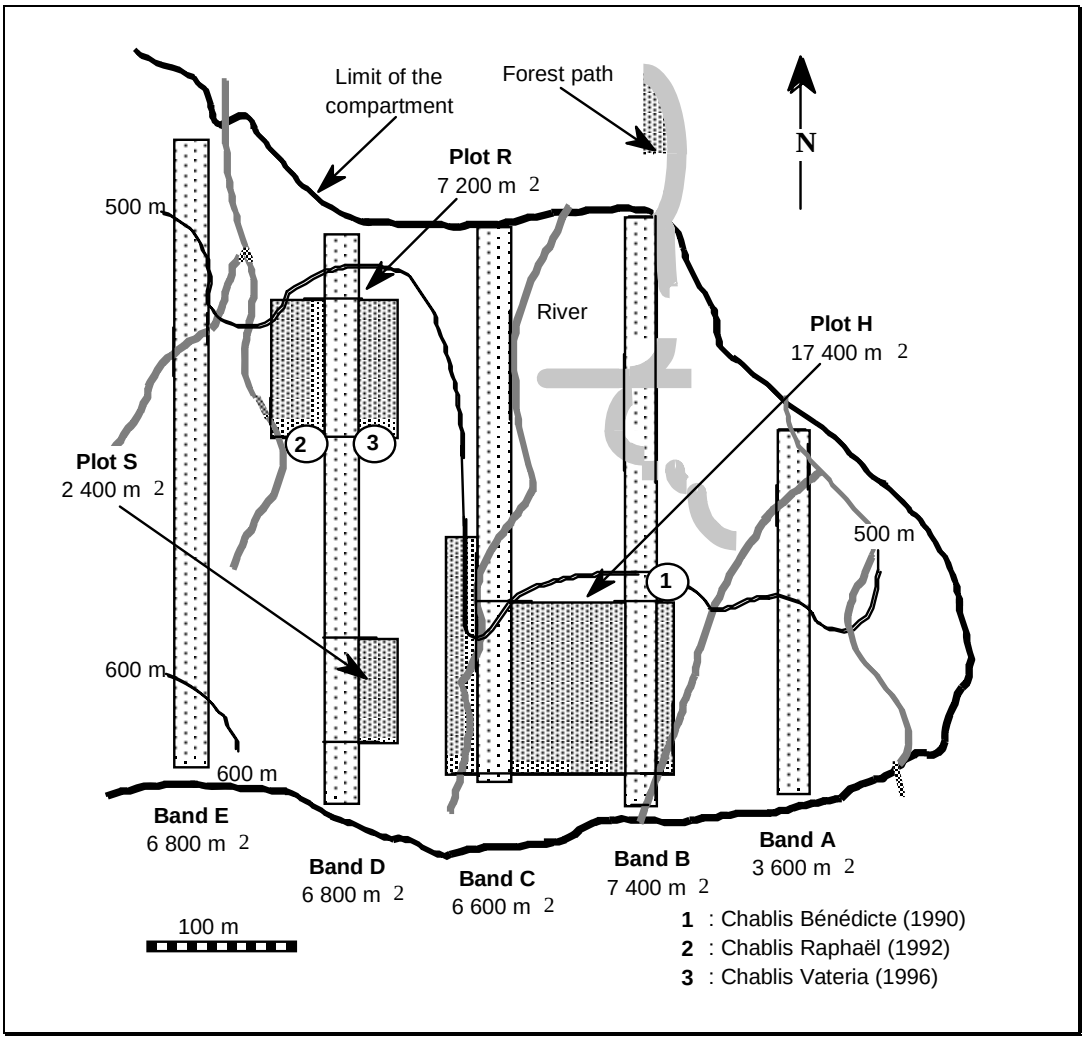


Figure 71. Sampling design in the 28 ha undisturbed compartment (from Elouard et al., 1997).

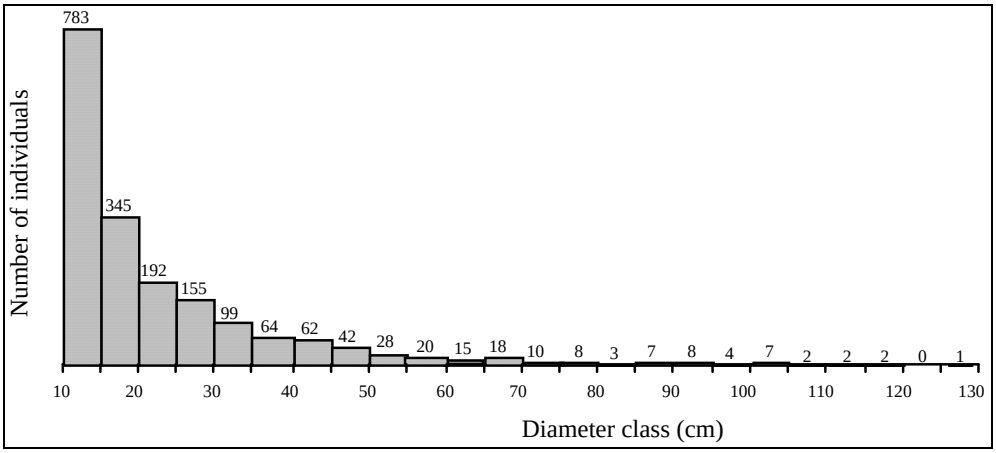


Figure 72. Diameter class distribution of trees above10 cm dbh in 3.12 ha sampled area (from Pélissier, 1997)

Floristic composition, richness and diversity

The north-south bands established throughout the compartment aim at providing a good statistical frequency of the site with an assessment of species diversity. A total of 91 species belonging to 31 families were recorded within the five bands. However, 12 species recorded in this forest were not observed in the sampled area. The well-represented families are Euphorbiaceæ (20 species), Anacardiaceæ (7), Lauraceæ, Ebenaceæ and Meliaceæ (6 species each), Dipterocarpaceæ, Annonaceæ and Clusiaceæ (5 each). The Dipterocarpaceæ is the most represented family in individuals, constituting 21.1% of the stand in terms of relative density of trees. Myristicaceæ, represented by 3 species, and Fabaceæ, represented by 2 species, constitute 19.4% and 15.9% respectively of the total individuals. Half of the species (48%) are endemics to the Western Ghats, and about 80% of the trees belong to these endemic species.

The Simpson's diversity index (D) is equal to 0.92 and the Shannon index (H)' is 4.56 for a maximum diversity (H max) of 6.54 and an equitability (E) of 0.70. The floristic structure, studied by the Importance Value Index IVIr was calculated based upon relative density and relative basal area, without taking the relative occurrence in the quadrats, rF, into account (IVI* = rD + rBA). The total value IVI* for all the species is 200, and it is rapidly decreasing, with values below 25 for the second species, below 15 for the fifth species and below 5 beyond the tenth species.

The dominant families are Dipterocarpaceæ (IVI*=63.3), Myristicaceæ (35.9) and Fabaceæ (23.2). The dominant species are *Vateria indica* L. (IVI*=46.0), *Myristica dactyloïdes* Gaertn. (24.6), *Humboldtia brunonis* Wall. (17.6) and *Dipterocarpus indicus* Bedd. (15.0) (Figure 73). These four species represent more than 48% of the individuals and 55% of the basal area. The first three species represent more than 45% of the effective (*Vateria indica*, 16.7%; *Myristica dactyloïdes*, 13.2% and *Humboldtia brunonis*, 11.4%). The most important basal area is shown by *Vateria indica* (29.3%), *Dipterocarpus indicus* (12.1%) and *Myristica dactyloïdes* (11.4%).

There are 56 rare or low frequency species (maximum 2 individuals per hectare), representing two-third of the inventoried species (Pélissier, 1997). The species richness is not very high, but diversity is high due to the fact that a few species are very abundant and a large number of species are rare or with low frequency.

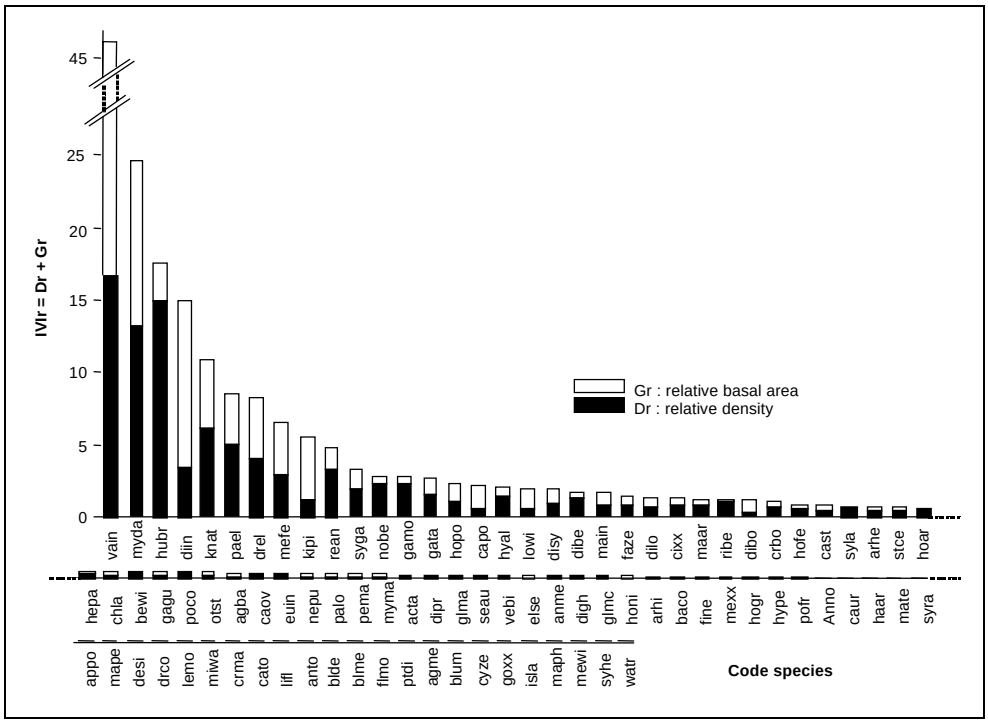


Figure 73. Importance value index for the 91 species sampled

arhe*: Artocarpus heterophyllus*; bewi: *Beilschmiedia wightii*; capo: *Calophyllum polyanthum*; cast: *Canarium strictum*; cixx: *Cinnamomum* sp.; crbo: *Cryptocarya bourdillonii*; dobe: *Dimorphocalyx beddomei*; diin: *Dipterocarpus indicus*; dilo: *Dimocarpus longan*; disy: *Diospyros sylvatica*; drel; *Drypetes elata*; faze: *Fahrenheitia zeylanica*; gamo: *Garcinia morella*; gata: *Garcinia talbotii*; hoar: *Holigarna arnottiana*; hofe: *Holigarna ferruginea*; hopo: *Hopea ponga*; hubr: *Humboldtia brunonis*; hyal: *Hydnocarpus alpina*; kipi: *Kingiodendron pinnatum*; knat: *Knema attenuata*; lowi: *Lophopetalum wightianum*; maar: *Mastixia arborea*; main: *Mangifera indica*; mefe: *Mesua ferrea*; myda: *Myristica dactiloïdes*; nobe: *Notopegia beddomei*; pael: *Palaquium ellipticum*; poco: *Polyalthia coffeoïdes*; rean: *Reinwardtiodendron anaimalaiense*; ribe: *Rinorea bengalensis*; stce: *Strombosia ceylanica*; syga: *Syzygium gardneri*; syla: *Syzygium laetum*; vain: *Vateria indica.*

Species population

Derouet (1994) and Pascal & Pélissier (1996) defined groups of tree species that have a similar diametric structure corresponding to distinct ecological behaviours and functions in forest dynamics. Four groups of species were recognised from the correspondance analysis with axis I separating a group of small-sized species from other medium- and larged-sized species, and axis II distinguishing three patterns of girth distribution (Figure 74):

(i) Group 1: species with flat girth distribution, showing a relatively high proportion of large trees. The mortality rate of young trees (girth <45 cm) seems very high and the survivors have a better chance of growing into large trees. The big emergent such as *Dipterocarpus indicus*, *Lophopetalum wightianum* and *Kingiodendron pinnatum* are in this group. (ii) Group 2: species with a negative exponential distribution and attaining large girths, *e.g. Vateria indica*, *Hopea ponga*, *Mesua ferrea*, *Cinnamomum* sp., *Diospyros sylvatica* and *Palaquium ellipticum*. (iii) Group 3: species also with a negative exponential distribution, with small girth classes and part of the understorey, *e.g. Humboldtia brunonis*, *Syzygium laetum*, *Rinorea bengalensis* and *Dimorphocalyx beddomei*. (iv) Group 4: species belonging to medium and small girth classes, with as the characteristic species the two most common Myristicaceæ *Myristica dactyloïdes*, *Knema attenuata* and the Euphorbiaceæ *Drypetes elata*. *Garcinia morella* is also part of this group.

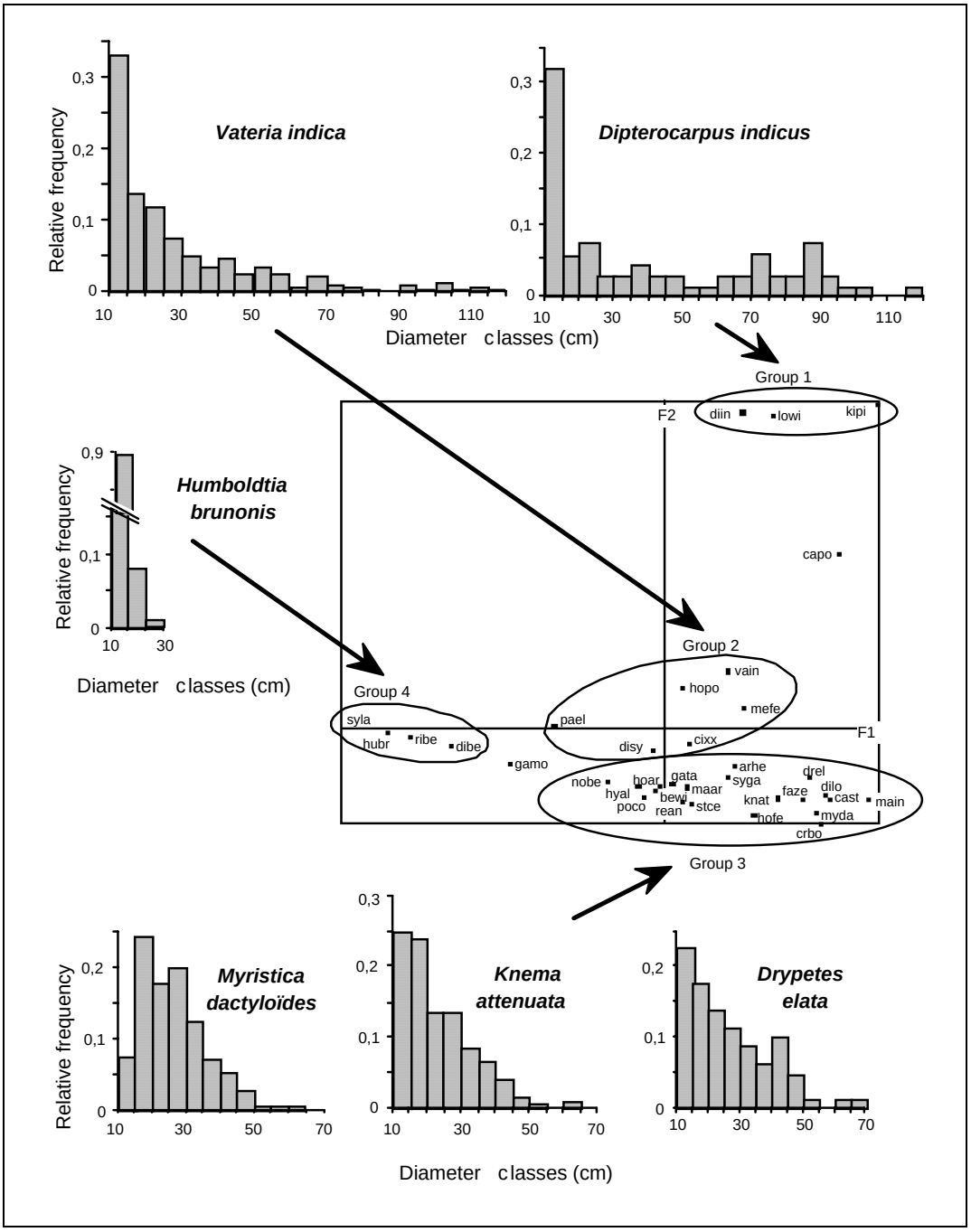


Figure 74. Correspondance analysis performed on the girth class distributions of 35 species (frequency >2 trees/ha) and examples of distributions corresponding to the four identified groups (from Pélissier, 1997).

Logging impact

Analysis of the reconstitution of an area that had previously been selectively exploited showed that about ten years after harvesting, the frequency of light-demanding pioneer species, which had colonized the large openings, has sharply diminished; the net change in basal area remains positive at +0.56 m^2 ha^{-1} yr^{-1}, and the inter- and infra-specific variability in individual diameter increment is very high.

Though the area has been logged once and the timber extracted using elephants for hauling, the selective exploitation did not deeply alter the forest structure and diversity, and the recovery in biomass and basal area was fairly rapid (Table 20) with a strong stimulation of individual growth.

Table 20: Density and basal area balance in the undisturbed and once-logged compartments. Minimum dbh=10 cm

	Initial state (ha^{-1})	Final state (ha^{-1})	Mortality ($ha^{-1}.yr^{-1}$)	Recruitment ($ha^{-1}.yr^{-1}$)	Growth ($ha^{-1}.yr^{-1}$)	Balance ($\%.yr^{-1}$)
Once-logged compartment A - Sampled area: 0.6 ha - Period: 1986-1993						
Density (stems)	578	617	5.0	10.5	—	+0.95
Basal area (m^2)	34.8	38.8	0.40	0.10	0.86	+1.61
Unlogged compartment B - Sampled area: 3.12 ha - Period: 1990-1994						
Density (stems)	606	619	5.2	8.5	—	+0.54
Basal area (m^2)	39.3	41.0	0.26	0.07	0.59	+1.02

Note: mortality and recruitment were assessed once, at the end of the period of study.

The minimum rotation between two successive moderate selective harvests should be more than 30-40 years in order to allow the forest to recover, not only in terms of biomass but also of stand structure and composition. The minimum felling age (*i.e.*, time before reaching a dbh of 60 cm) of two commercially and ecologically important dipterocarp species, *Vateria indica* and *Dipterocarpus indicus,* was estimated through an average growth model built by Loffeier: about 120 years for *V. indica* and 200 years for *D. indicus*.

Forest transformation and degradation

As demonstrated above, selective logging with hauling by elephants had a minimum disturbance on the regeneration. Ten years after the logging, the stand characteristics are still close to the undisturbed forest floristic composition and structure. However, heavy and/or repeated exploitation has a strong long term impact on the forest composition and dynamics with the disappearance of the commercially interesting emergent and upper canopy species.

An on-going study along a degradation gradient from an undisturbed area to village sites, which includes past logging activities as well as present human activities (firewood and green manure collection, grazing) demonstrates that heavy logging in this forest has changed the floristic composition by eliminating the timber species from the tree stand and favouring the establishment and dominance of light demanding species such as *Dillenia pentagyna*, *Artocarpus hirsutus*, *Holigarna arnottiana*, and *Carallia brachiata*. Large openings resulted in the establishment of moist deciduous species such as *Lagerstroemia microcarpa*, *Terminalia paniculata*, *T. bellerica*, *Albizzia chinensis*, *Dalbergia latifolia* (rosewood), and *Pterospermum* spp.

The forested areas near the villages, due to over-exploitation over decades, have been transformed into highly degraded stages defined as secondary moist deciduous forests. Along with the establishment of the light demanding species in the disturbed and semi-evergreen forests, the disappearance of the rare and low frequency species was observed.

Along this gradient, the regenerative stand in the disturbed and semi-evergreen forests has shown a potential for rehabilitation of the primary forest. On the other hand, the regenerative stand in the forest areas heavily exploited in the past and presently degraded by human activities is poor and devoid of evergreen species. Degradation is at a level too high to allow rehabilitation of the original forest type.

This phenomenon may also occur when secondary forest products are over-exploited for commercial purposes, in an unsustainable manner. Local people collect the fruits of *Myristica dactyloides* (Myristicaceae) to derive a yellowish dye. This species is one of the four most common trees species and the collection of these fruits impoverishes the regenerative pool of the species. Eventually, a change of the forest composition and structure may occur and various scenarios can be envisaged: either one species will take over the position of *M. dactyloides* in the tree population, or several species will increase their respective occurrence.

Conclusion

The Kadamakal Reserve Forest is one of the rare well-preserved sites of low elevation evergreen forest in the Western Ghats. Though species richness is not very high compared to other forest sites, the high species diversity with the dominance of four species shows peculiar characteristics of the forest structure. Topography, which varies from 15 to 40 degrees of slope, plays an important role in the spatial distribution of the trees. Various studies on regeneration, spatial distribution, phenology, architecture and regenerative processes in tree-fall gaps have built up knowledge of the dynamics and functioning of this forest type. This knowledge allows defining tools for biodiversity conservation as well as rehabilitation of degraded areas.

Chapter

11

Conservation value maps

Conservation priority areas; gaps in the protected area network

Synthesis of spatial and non-spatial data

Deriving conservation values, and the spatial representation of these

Since we possessed both an extensive (though coarse) spatial description of forest cover, and intensive field data from representative Biodiversity Sampling Plots (BSPs) we attempted to link the two in order to produce spatial descriptions of species diversity and other selected indicators.

This was done initially by overlaying the locations of the BSPs onto the updated (1997) vegetation layers. The habitat types thus covered were represented by BSPs, which provided data on tree species diversity, species richness, basal area, and endemics. The data were extrapolated to cover other forest areas classed as identical habitats. Ultimately, each point on the map, covered by forest types had these four attributes.

Table 21: Biodiversity indicators, ranges and values.

Indicator	Range	Number of habitat types	Assigned value
Richness (S)			
class 1	28-37	11	10
class 2	37-46	7	20
class 3	46-55	2	30
class 4	55-74	9	40
Shannon (H')			
class 1	2.1-2.38	5	10
class 2	2.38-2.66	10	20
class 3	2.66-2.94	7	30
class 4	2.94-3.4	7	40
Endemic (%)			
class 1	1-17	15	10
class 2	17-32	3	20
class 3	32-48	8	30
class 4	48-63	3	40
Basal area G>30 cm (m2)			
class 1	1-13	13	10
class 2	13-26	5	20
class 3	26-38	8	30
class 4	38-50	3	40

Table 22: Indicator sum values, areas, and conservation value classes.

sum	Number of patches	Area (ha)	Area (km^2)	Conservation value class
40	205	34,537.5	345.4	1
50	641	328,458.2	3,284.6	1
60	1090	283,686.6	2,836.9	1
70	0	0	0.0	2
80	776	112,709.6	1,127.1	2
90	1208	151,810.2	1,518.1	3
100	6	975.345	9.8	3
110	22	15,218.7	152.2	4
120	0	0	0.0	4
130	1244	236,846.2	2,368.5	4
140	72	20,026.4	200.3	5
150	50	27,031.1	270.3	5
160	0	0	0.0	5

Forest areas were assigned classes between 1 and 4 for each indicator depending on the value range (Table 21). So for example, a forest habitat that had a species richness between 28 and 37 would be assigned class 1 for species richness. And class 1 carried a value of ten towards an overall conservation value.

Conservation values (CV) were derived by combining values of indicators, such as species richness, for each forest patch (Figure 75). Thus, each patch had values between 40 and 160 (Table 22). All classes are of equal value intervals. Forest patches were then each assigned an overall conservation value, between 1 and 5, based on their range of summed indicator values. The conservation value classes between 1 and 5 were translated into the qualitative descriptors; Low, Low-medium, Medium, High-Medium, and High. The black and white, A4-sized maps (map figures 7 to 14) of spatial representations of species richness, diversity, endemics and basal area, respectively, illustrate the outcome of this procedure. These maps are based on a generalised representation (generalised arc topology) of the forest for the purposes of legibility, i.e., the arcs have been simplified. However, detailed quantitative analyses on gaps have been carried out on the complete spatial information.

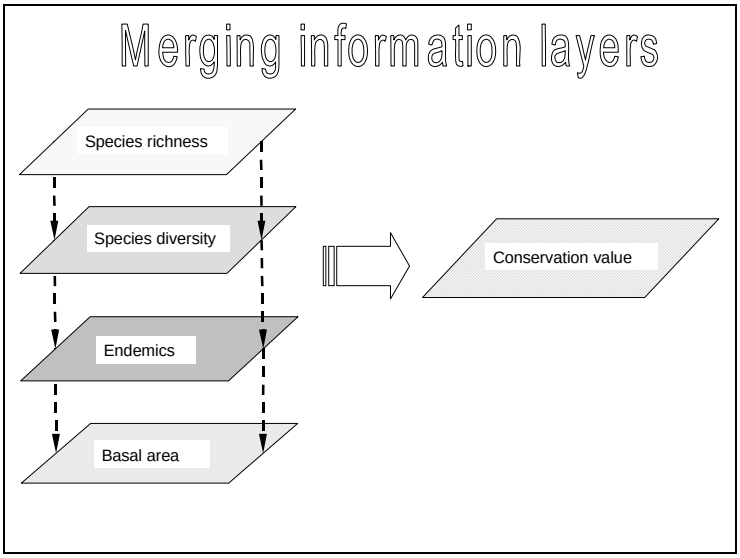


Figure 75: Conceptual diagram illustrating the building of a conservation value map

Since we derived our Conservation Values exclusively from the BSPs established by the KFD, a number of information gaps are apparent. Firstly in terms of areas covered, plots have not been established in Coorg (Kodagu) Circle, and therefore for conservation value purposes, this entire area, which includes sheet 3 of the Forest Map, has been omitted from consideration. Secondly, there are several habitat types that are not covered by the BSPs, and these too have not been considered. They are described in Annexe 1, and are indicated as forest habitats with no data on the maps. These areas include disturbed medium elevation forests, some of which are within the boundaries of the Kudremukh National Park. In addition, some habitats are poorly sampled, leading to potentially misleading conservation value estimates. A number of additional sampling errors exist, and these are described in other sections of this report.

Finally we overlaid the protected area (PA) network (boundaries of Reserve Forests, National Parks, and Wildlife Sanctuaries) on the conservation value maps. This "gap analysis" produced firstly, a spatial description of the PA network and conservation values, and secondly, quantitative descriptions of areas and percent areas of forests covered by the protected area network. This method has been previously used by Ramesh *et al.* (1997) in the Agastyamalai region of the southern Western Ghats.

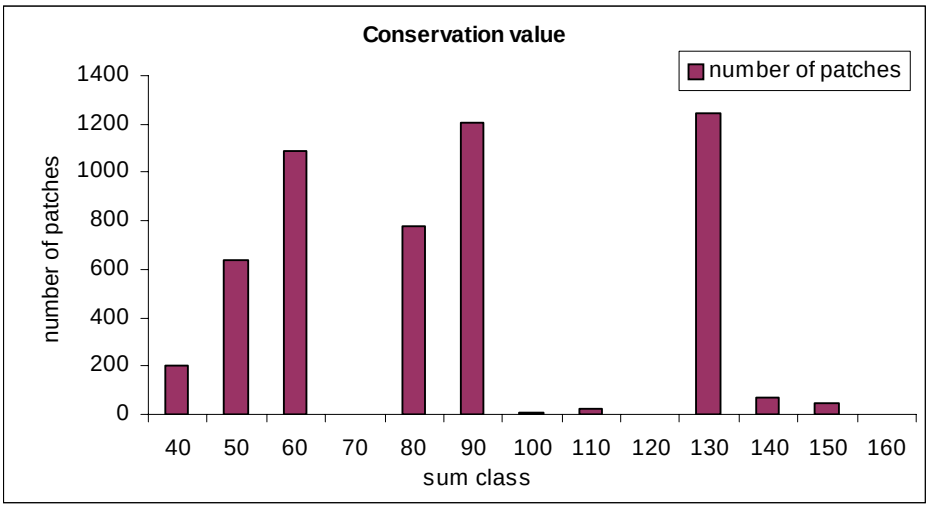


Figure 76: Number of landscape forest patches in each indicator sum class

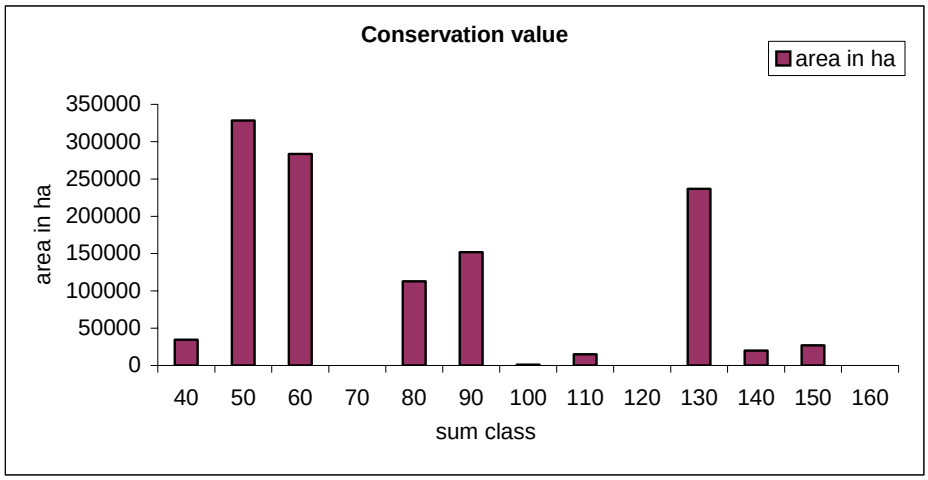


Figure 77: Forest area in each indicator sum class

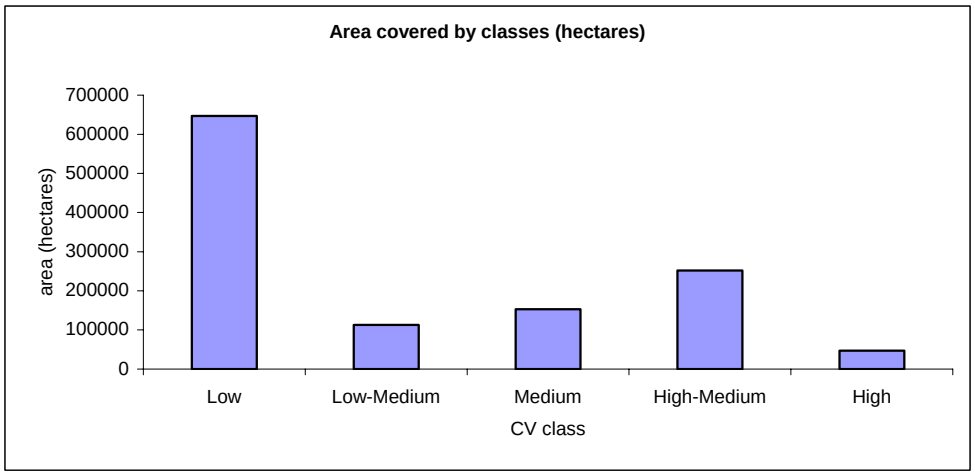


Figure 78: Forest area in each CV class

Figures 76 & 77 show number of patches and area in hectares respectively under each indicator sum class as defined. Figure 78 shows the areas in hectares under each conservation value class after combining the indicator sum classes for each forest type.

Across the conservation value maps, it is apparent that the forest areas that have been attributed high and high-medium conservation values, are those areas that have higher proportions of endemic species, high basal areas, high species richness and diversity. These include the areas of climax evergreen forests, moderately disturbed evergreen forests, and forests considered to be in recovery. Evergreen scrub woodland and dense thickets are among those classed as having medium conservation value due to high contributions from species richness and species diversity indicators. Secondary moist deciduous woodlands are classed as low-medium due to their low scores on endemics and species richness. All primary moist and dry deciduous forests are classed as low conservation value areas.

Gap analysis

A visual check of the conservation value maps will show that forest areas in Uttara Kannada are reasonably well covered by the PA network. This is not the case in Shimoga Circle however, where there are numerous gaps in the evergreen belt that runs along the Ghats' crestline and *Malnad* areas.

Overall, the conservation value of the forest areas and their protection status is described in absolute quantitative terms in the Table 23 below, and in percentage terms in the chart Figure 79 below.

Table 23: Areas (in hectares) of conservation value classes under different protection regimes

Cons. Val.	No protection	Reserve Forest (rf)	Wildlife Sanctuary (wls)	National Park (np)	Total
Low	4,568.75	4,255.12	744.00	1.56	9,569.43
Low-Medium	801.12	1,493.19	200.57	136.10	2,630.99
Medium	1,138.56	323.22	55.44	22.04	1,539.26
High-Medium	1,478.67	2,565.33	377.49	427.81	4,849.31
High	38.73	347.50	199.71	0.00	585.93

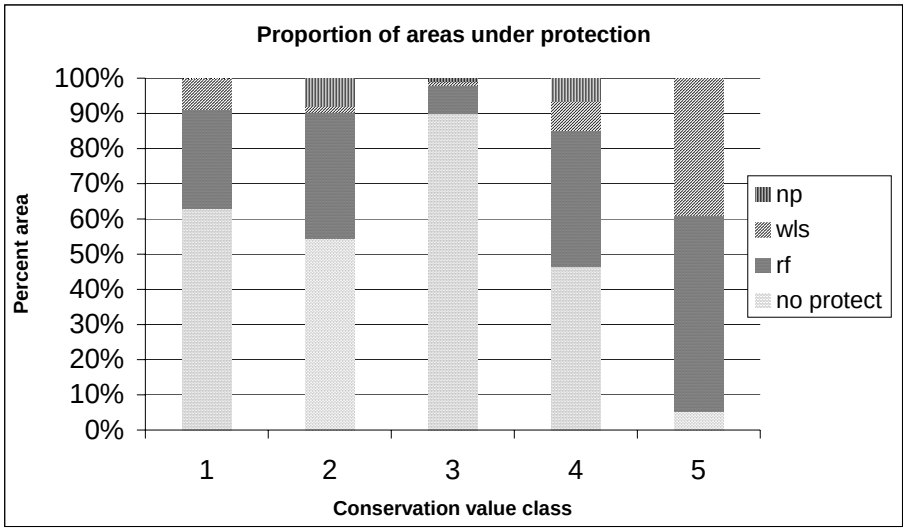


Figure 79: Protection status according to conservation value class

It is apparent that 93% of the High CV. (class 5) areas are under some form of protection. The other 7% are to be found outside the PA network. Most critically, thirty percent of forest areas classified as having high-medium conservation value (class 4 areas) are outside state protection. These areas generally surround the core areas of dense climax forests and areas of high endemicity along the crestline. They may be considered as important buffer areas, serving to modulate anthropogenic impact on the core. Furthermore, they are largely in a more fragmented condition and include areas such as *Kan* forests, which are unique ecosystems highly threatened by surrounding anthropogenic land cover types. Currently 58.48% of a total of 8,412 ha of this type is *outside* state protection. These areas may be expected to further deteriorate or disappear if not afforded protection.

It is worth emphasising that our conservation values were derived from tree biodiversity indicators that were for the most part inadvertently biased against such formations as deciduous forests. Although these areas scored highly in terms of basal area, they scored very low in terms of endemics, and species diversity. Ultimately, this may be misleading and certainly cannot be taken at its face value. It is well known that primary moist and dry deciduous forests in the study area are a vital habitat for large mammals, and the (continued) preservation of these habitats in large, contiguous expanses is of crucial importance. It is recommended that further work be carried out to expand and diversify the indicators used in deriving conservation values to include such categories as diversity of fauna (insects, birds, and large mammals), and presence of species with high economic and use values such as timber hardwood species and bamboo.

Chapter
12

Conclusions and Recommendations

A summary of the main findings, some suggestions towards the management of forests, and further work.

The main findings

Biodiversity assessment

A number of significant outcomes have emerged from the study. From the tree biodiversity assessment track, we can derive the following;

Due to a longer dry period, the Karnataka part of the Western Ghats (KWG) is relatively less diverse in terms of species richness when compared to the southern region of the Western Ghats. Despite the low diversity, *Poeciloneuron* forests, *Memecylon* forests, *Corypha umbraculifera* facies, *Myristica* swamps, and *Kan* forests, as well as pockets of *Saraca asoca* and *Mamea suriga* are unique formations in the study area.

The KWG represents 171 (49%) of the 352 endemic tree species recorded in the Western Ghats. Of these 30% (51 endemic species) are recorded in the BSPs. Species such as *Garcinia indica, Mamea suriga, Hopea canarensis, Hopea jacobi, Bauhinia foveolata*, are endemic to KWG.

At the regional level, the major types of vegetation are basically determined by bioclimate. However, the different intensity and mode of anthropogenic pressures have modified the vegetation into various degrees of degradation stages. These changes are reflected in the spatial and floristic structural parameters.

In the potential zone of evergreen forests, the changes are more apparent in the ecological and phenological characteristics of the species composition. Although the total species richness and diversity vary less among the different degradation stages of the evergreen forest, the proportion of primary evergreen species and endemics decreases with increasing degradation. On the other hand, secondary evergreen and deciduous species show an increase. The forests with moderate disturbance are in a state of recovery with good regeneration.

In the deciduous forest types, since the species are mostly those with wider ecological amplitude, degradation may not affect the overall species composition. However, changes are manifested in the basal area, which shows a sharp decline with increasing degradation.

The evergreen forests are rich in resources (timber, NTFPs, and medicinal plants) compared to other types. However, with the disturbance there is a drastic reduction in these resource species, which may be more attributed to the mode of harvesting as seen in the examples of *Hopea ponga, Vateria indica* and *Garcinia indica*.

Landscape ecology

The studies of landscape ecology showed that forests have been lost in the study area at the annual rate of 0.63%. This, however, does not consider the fact that rates of loss have been higher in some districts, and less in others.

Forest loss has been mitigated in areas of "Reserve Forest" under State protection. This also needs to be qualified. Many Reserve Forests are located in steep, inaccessible terrain that does not favour alternative use. Therefore, it may be that factors other than state protection are moderating forest loss.

Forest patches that were already degraded or fragmented lost relatively more area than dense or undisturbed forest. This indicates that forest loss in the study area for the most part may be an incremental process that proceeds first through degradation and fragmentation, and then to loss and conversion to other types of land-cover.

The exception to the above is in cases where forests have been cleared outright to make way for reservoirs, dams, mining projects and associated developmental activity. Over the last twenty years large reservoirs have come up in the study area. Dams continue to be built in the region, in many cases, such as in the Sharavati river valley this entails large losses of biodiverse forest.

Most critically, it has been shown that the phenomenal and unchecked increase in coffee cultivation in the districts of Kodagu, Hassan and Chickmagalur has destroyed and continues to seriously threaten the biodiversity of forests in the study area.

The degradation of *betta* lands are an important source of forest area loss in Uttara Kannada. Landscape analyses carried out within this study have supported ground observations on the effect and extent of arecanut cultivation on surrounding forest structure.

Gaps in the protected area network

There are numerous gaps in the PA network. Our studies have shown that there are large areas of biologically diverse forest that are not under conventional forms of protection. Notably, 30% of areas we have designated as having high-medium conservation value are outside State protection. Many of these areas are within the Shimoga circle. Figures from Uttara Kannada circle show that most areas of high-medium conservation value forest are within the protected area network. High-medium conservation value areas outside the PA network include unique ecosystems such as 'Kan' forests, and forests that were moderately disturbed in the past, and may be considered "in recovery" at present following the ban on green felling and timber extraction.

Suggestions on management

As an initial step towards the delineation of zone 1 (ecologically important areas), we suggest that those areas we have designated as having high and high-medium conservation value be incorporated into this zone. Within this, there will be a core of high conservation value areas that are to be monitored and managed with conservation of biodiversity, water, and soil as the highest priorities. Areas under zone 1 may be subsequently enlarged to include dense primary deciduous forests as an important habitat for wildlife.

Medium conservation value areas as defined by this study may constitute one of the other zones under the WGFP objectives. These areas would include fragmented and relatively degraded patches of forest which still contain high species richness and diversity. These areas may be managed carefully for regeneration, and eventually for mixed commercial production.

The remaining areas may be designated according to Forest Department priorities in consultation with local people. Fuelwood, construction timber, fodder, green manure, and other NTFP needs of people have to be met from as many alternative sources as possible in order to reduce pressures on remaining areas of dense forest. Co-operative management must be emphasised wherever possible. From empirical studies and from the historical literature, it appears that local populations are largely undeterred by punitive measures, and will seek to satisfy local needs regardless.

Although there is presently a ban on green felling in place, there as still a number of species, including endemics, which are endangered due to over-exploitation of their non-timber product. For example, *Garcinia indica* and *Myristica spp*. are harvested for their fruit. This has led to enormous quantities being removed out of commercial pressure, and regeneration is now almost non-existent in certain areas. This sort of overuse must be carefully monitored and guidelines put in place.

Suggestions on further work

The areas of essential further work can be described broadly as follows;

The permanent biodiversity monitoring plots are a valuable source of data on extent of disturbance, species diversity and regeneration, among other factors. They serve to gauge the state of the forest, to provide baseline data, and to monitor ecosystem changes. Currently there are too many gaps in their coverage. It is imperative that more plots be established, particularly in forest areas that are not presently covered such as in Coorg circle, as well as the numerous habitat types, such as medium and high elevation evergreen forests for which little or no usable data exists. Thus there is a need to consolidate and extend the network of plots so as to create a “permanent observatory” of the biodiversity of the Karnataka Western Ghats and to assist the refining of management practices.

It is necessary to carry out studies or to incorporate existing data that would enable the expansion of conservation priority indicators to include parameters of wider ecological significance. For example, the importance of certain habitat types to large fauna, the presence of species of economic, medicinal or other use value, unique habitat areas, areas of cultural importance, among others. The use of multiple biological and non-biological criteria in setting conservation priorities has also been emphasised elsewhere (Johnson, 1995). The use of Geographical Information Systems and spatial management systems would enable the integration and consolidation of data of a range of hierarchical levels, and from diverse sources. Spatial databases have the potential to be disseminated and used widely on desktop systems, thus enabling decentralised decision making and management based on readily available, up to date spatial information.

With the available data on changes to biodiversity indicators with varying degrees of disturbance, it may be possible to construct models that simulate disturbance regimes and their impacts upon the forest physiognomy and species composition. Modelling the effect of various types of activity, particularly on sensitive areas, would allow an informed assessment of potential environmental impact and a comparison of costs and benefits, which also takes into account the losses of biological diversity.

There is a need to carry out or incorporate data on finer scale studies of forest and landscape change linked to social and economic studies of forest use and management. These would shed light on some of the proximate and underlying causes of deforestation and loss of biodiversity. Wherever feasible, this may be extended to cover larger areas, and would lead to more effective regional natural resource management.

New approaches that are holistic, integrative, and involve multiple agents would require a degree of coordination and cooperation between institutions. It would be useful for the State Forest Department to assume a leading role in this, and to invite participating institutions to share their findings and to propose resource management alternatives based on empirical studies. There also needs to be better coordination among government agencies and research institutions. For example, between the state Forest Departments and the Revenue Department, who between them administer vast tracts of land in India.

The links between Research & Development and Extension services need to be better defined and better implemented. The Joint Forest Planning and Management (JFPM) experiment, according to some reports (Outreach, 1998), has been a good attempt overall by the Forest Department to enter into a participatory mode. These projects will need to be continued, extended to cover a broader geographical area, and closely monitored for their impact on forests and on the livelihood security of the participants.

Most critically perhaps, we reiterate here that biodiversity conservation must be integrated with national planning and economic / infrastructural priorities. Article 6 of the Convention on Biological Diversity calls upon signatory countries to approach biodiversity planning in a comprehensive manner (Johnson, 1995). Biological diversity must be assigned a high priority based upon long-term planning and studies of human-ecosystem relationships.

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Annexe 1

A table describing forest classification on sheets 1 to 3 of the Forest Map

(Forest habitat types not represented by BSPs are shaded grey)

group1	mainGroup	SubGroup	Physiognomy	elevation	Type
wet evergreen climax and related forests	Wet evergreen and semi - evergreen climax forests and degradation stages	Wet evergreen or semi - evergreen climax and potentially related forests	Disturbed to semi-evergreen	Low elevation	*Dipterocarpus indicus - Humboldtia brunonis - Poeciloneuron indicum* type
wet evergreen climax and related forests	Wet evergreen and semi - evergreen climax forests and degradation stages	Wet evergreen or semi - evergreen climax and potentially related forests	Dense evergreen	Low elevation	*Dipterocarpus indicus - Humboldtia brunonis - Poeciloneuron indicum* type
wet evergreen climax and related forests	Wet evergreen and semi - evergreen climax forests and degradation stages	Wet evergreen or semi - evergreen climax and potentially related forests	Disturbed to semi-evergreen	Low elevation	*Poeciloneuron indicum* facies of *Dipterocarpus indicus - Kingiodendron pinnatum - Humboldtia brunonis* type
wet evergreen climax and related forests	Wet evergreen and semi - evergreen climax forests and degradation stages	Wet evergreen or semi - evergreen climax and potentially related forests	Dense evergreen	Low elevation	*Poeciloneuron indicum* facies of *Dipterocarpus indicus - Kingiodendron pinnatum - Humboldtia brunonis* type
wet evergreen climax and related forests	Wet evergreen and semi - evergreen climax forests and degradation stages	Wet evergreen or semi - evergreen climax and potentially related forests	Disturbed to semi-evergreen	Low elevation	*Dipterocarpus indicus - Kingiodendron pinnatum - Humboldtia brunonis* type
wet evergreen climax and related forests	Wet evergreen and semi - evergreen climax forests and degradation stages	Wet evergreen or semi - evergreen climax and potentially related forests	Dense evergreen	Low elevation	*Dipterocarpus indicus - Kingiodendron pinnatum - Humboldtia brunonis* type
wet evergreen climax and related forests	Wet evergreen and semi - evergreen climax forests and degradation stages	Wet evergreen or semi - evergreen climax and potentially related forests	Kan	Low elevation	*Diospyros spp. - Dysoxylum malabaricum - Persea macrantha* "kan" forest type
wet evergreen climax and related forests	Wet evergreen and semi - evergreen climax forests and degradation stages	Wet evergreen or semi - evergreen climax and potentially related forests	Disturbed to semi-evergreen	Low elevation	*Poeciloneuron indicum* facies of *Dipterocarpus indicus - Persea macrantha* type
wet evergreen climax and related forests	Wet evergreen and semi - evergreen climax forests and degradation stages	Wet evergreen or semi - evergreen climax and potentially related forests	Disturbed to semi-evergreen	Low elevation	*Dipterocarpus indicus - persea macrantha* type
wet evergreen climax and related forests	Wet evergreen and semi - evergreen climax forests and degradation stages	Wet evergreen or semi - evergreen climax and potentially related forests	Disturbed to semi-evergreen	Low elevation	*Persea macrantha - Diospyros spp. - Holigarna spp.* type
wet evergreen climax and related forests	Wet evergreen and semi - evergreen climax forests and degradation stages	Wet evergreen or semi - evergreen climax and potentially related forests	Dense evergreen	Low elevation	*Dipterocarpus indicus - Diospyros candolleana - Diospyros oocarpa* type
wet evergreen climax and related forests	Wet evergreen and semi - evergreen climax forests and degradation stages	Wet evergreen or semi - evergreen climax and potentially related forests	Dense evergreen	Low elevation	*Poeciloneuron indicum* facies of *Dipterocarpus indicus - Diospyros candolleana - Diospyros oocarpa* type

wet evergreen climax and related forests	Wet evergreen and semi - evergreen climax forests and degradation stages	Wet evergreen or semi - evergreen climax and potentially related forests	Disturbed to semi-evergreen	Low elevation	*Dipterocarpus indicus - Diospyros candolleana - Diospyros oocarpa* type
wet evergreen climax and related forests	Wet evergreen and semi - evergreen climax forests and degradation stages	Wet evergreen or semi - evergreen climax and potentially related forests	Disturbed to semi-evergreen	Low elevation	*Poeciloneuron indicum* facies of *Dipterocarpus indicus - Diospyros candolleana - Diospyros oocarpa* type
wet evergreen climax and related forests	Wet evergreen and semi - evergreen climax forests and degradation stages	Wet evergreen or semi - evergreen climax and potentially related forests	Dense evergreen	Medium elevation	*Cullenia exarillata - Mesua ferrea - palaquium ellipticum*
wet evergreen climax and related forests	Wet evergreen and semi - evergreen climax forests and degradation stages	Wet evergreen or semi - evergreen climax and potentially related forests	Disturbed to semi-evergreen	Medium elevation	*Memecylon umbellatum - Syzygium cumini - Actinodaphne anguistifolia* type
wet evergreen climax and related forests	Wet evergreen and semi - evergreen climax forests and degradation stages	Wet evergreen or semi - evergreen climax and potentially related forests	Disturbed to semi-evergreen	High elevation	*Schefflera spp. - Gordonia obtusa - Meliosma arnottiana* type
wet evergreen climax and related forests	Wet evergreen and semi - evergreen climax forests and degradation stages	Wet evergreen or semi - evergreen climax and potentially related forests	Dense evergreen	Medium elevation	*Mesua ferrea - Palaquium ellipticum* type
wet evergreen climax and related forests	Wet evergreen and semi - evergreen climax forests and degradation stages	Wet evergreen or semi - evergreen climax and potentially related forests	Disturbed to semi-evergreen	Medium elevation	*Mesua ferrea - Palaquium ellipticum* type
wet evergreen climax and related forests	Wet evergreen and semi - evergreen climax forests and degradation stages	Wet evergreen or semi - evergreen climax and potentially related forests	Dense evergreen	Medium elevation	*Palaquium ellipticum - poeciloneuron indicum - Hopea canalensis* type
wet evergreen climax and related forests	Wet evergreen and semi - evergreen climax forests and degradation stages	Wet evergreen or semi - evergreen climax and potentially related forests	Dense evergreen	High elevation	*Schefflera spp. - Gordonia obtusa - Meliosma arnottiana* type
wet evergreen climax and related forests	Wet evergreen and semi - evergreen climax forests and degradation stages	Wet evergreen or semi - evergreen climax and potentially related forests	Disturbed to semi-evergreen	Medium elevation	*Palaquium ellipticum - poeciloneuron indicum - Hopea ponga* type
moist deciduous forests	Deciduous climax forests and degradations	Moist deciduous forests	Scrub woodland to thicket		*Lagestroemia microcarpa - Tectona grandis - Dillenia pentagyna* type
moist deciduous forests	Deciduous climax forests and degradations	Moist deciduous forests	Woodland to savanna woodland		*Lagestroemia microcarpa - Tectona grandis - Dillenia pentagyna* type
moist deciduous forests	Deciduous climax forests and degradations	Moist deciduous forests	Dense		*Lagestroemia microcarpa - Tectona grandis - Dillenia pentagyna* type
moist deciduous forests	Deciduous climax forests and degradations	Moist deciduous forests	Discontinuous thicket to low scattered shrubs		*Lagestroemia microcarpa - Tectona grandis - Dillenia pentagyna* type
dry deciduous forests	Deciduous climax forests and degradations	Dry deciduous forests	Scrub woodland to thicket		*Anogeissus latifolia - Tectona grandis - Terminalia tomentosa* type
dry deciduous forests	Deciduous climax forests and degradations	Dry deciduous forests	Tree savanna		*Anogeissus latifolia - Tectona grandis - Terminalia tomentosa* type
dry deciduous forests	Deciduous climax forests and degradations	Dry deciduous forests	Woodland to savanna woodland		*Anogeissus latifolia - Tectona grandis - Terminalia tomentosa* type
dry deciduous forests	Deciduous climax forests and degradations	Dry deciduous forests	Dense		*Anogeissus latifolia - Tectona grandis - Terminalia tomentosa* type

dry deciduous forests	Deciduous climax forests and degradations	Dry deciduous forests	Discontinuous thicket to low scattered shrubs		*Anogeissus latifolia - Tectona grandis - Terminalia tomentosa* type
dry deciduous forests	Deciduous climax forests and degradations	Dry deciduous forests	Scrub woodland to thicket		*Anogeissus latifolia - Chloroxylon swietenia - Albizia amara* type
dry deciduous forests	Deciduous climax forests and degradations	Dry deciduous forests	Discontinuous thicket to low scattered shrubs		*Anogeissus latifolia - Chloroxylon swietenia - Albizia amara* type
wet evergreen climax and related forests	Wet evergreen and semi - evergreen climax forests and degradation stages	Wet evergreen or semi - evergreen climax and potentially related forests	Disturbed	Transition type	Transition type
wet evergreen secondary semi-evergreen forests	Wet evergreen and semi - evergreen climax forests and degradation stages	Secondary or degraded stages; evergreen and semi -evergreen forests	Disturbed	Low elevation	
wet evergreen secondary semi-evergreen forests	Wet evergreen and semi - evergreen climax forests and degradation stages	Secondary or degraded stages; evergreen and semi -evergreen forests	Secondary	Low elevation	
wet evergreen secondary semi-evergreen forests	Wet evergreen and semi - evergreen climax forests and degradation stages	Secondary or degraded stages; evergreen and semi -evergreen forests	Disturbed	Transition type	
wet evergreen secondary semi-evergreen forests	Wet evergreen and semi - evergreen climax forests and degradation stages	Secondary or degraded stages; evergreen and semi -evergreen forests	Disturbed	Medium elevation	
wet evergreen secondary semi-evergreen forests	Wet evergreen and semi - evergreen climax forests and degradation stages	Secondary or degraded stages; evergreen and semi -evergreen forests	Secondary	Medium elevation	
wet evergreen secondary semi-evergreen forests	Wet evergreen and semi - evergreen climax forests and degradation stages	Secondary or degraded stages; evergreen and semi -evergreen forests	Disturbed	High elevation	
wet evergreen secondary moist deciduous forests	Wet evergreen and semi - evergreen climax forests and degradation stages	Secondary or degraded stages; secondary moist deciduous forests	Dense		
wet evergreen secondary moist deciduous forests	Wet evergreen and semi - evergreen climax forests and degradation stages	Secondary or degraded stages; secondary moist deciduous forests	Woodland to savanna woodland		
wet evergreen other degraded forests	Wet evergreen and semi - evergreen climax forests and degradation stages	Other degraded stages	Dense thicket	Low elevation	
wet evergreen other degraded forests	Wet evergreen and semi - evergreen climax forests and degradation stages	Other degraded stages	Dense thicket	Medium elevation	

wet evergreen other degraded forests	Wet evergreen and semi - evergreen climax forests and degradation stages	Other degraded stages	Dense thicket	High elevation	
wet evergreen other degraded forests	Wet evergreen and semi - evergreen climax forests and degradation stages	Other degraded stages	Tree savanna to grass savanna	Low elevation	
wet evergreen other degraded forests	Wet evergreen and semi - evergreen climax forests and degradation stages	Other degraded stages	Tree savanna to grass savanna	Medium elevation	
wet evergreen other degraded forests	Wet evergreen and semi - evergreen climax forests and degradation stages	Other degraded stages	Tree savanna to grass savanna	High elevation	
wet evergreen other degraded forests	Wet evergreen and semi - evergreen climax forests and degradation stages	Other degraded stages	Scattered shrubs	High elevation	
wet evergreen other degraded forests	Wet evergreen and semi - evergreen climax forests and degradation stages	Other degraded stages	Scattered shrubs	Low elevation	
wet evergreen other degraded forests	Wet evergreen and semi - evergreen climax forests and degradation stages	Other degraded stages	Scattered shrubs	Medium elevation	
moist deciduous forests	Deciduous climax forests and degradations	Moist deciduous forests	Tree savanna		
plantation	Plantations	Coffee	Commercial Plantations		
plantation	Plantations	Tea	Commercial Plantations		
non forest	Non Forest	Agricultural	(Non-physiognomy)		
water bodies	Water bodies	Water Tanks	(Non-physiognomy)		
plantation	Plantations	Miscellaneous	Commercial Plantations		

Annexe 2

A sample proforma used to record data

ID 36

Plot Number	BSP5		*Date* 9/14/98
Circle	Shimoga	*Division* Shimoga	
Range	Sorab		
Reserved Forest	Karjikoppa	*Topo sheet No.* 48N/3	
Location	Ulavi - Shiralkoppa Road (0.9km from Ulavi)		
Latitude 14 ° 16 ' 55 "	*Longitude* 75 ° 7 ' 1 "	*Altitude (m)* 620	*Orientation to N°* 100
Rainfall 1500-2000 mm	*Length of dry season* 6 months	*Temperature* 16 < t < 23°C	

Terrain	*Flat (0°)* ☑	*Gentle (<15°)* ☐	*Medium (15-30°)* ☐	*Steep (>30°)* ☐

Forest type	Kan Evergreen-Disturbed		
Canopy height (m) 28	*Canopy cover (%)* 55	*Number of strata* 3	

Disturbance	*Fire* ☐	*Trail* ☑	*Grazing* ☐	*Cut stump* ☑

Annexe 3

Biodiversity Sampling plots and Forest types

ID	Plot	Circle	Division	Forest Type
1	PSPD1	Uttara Kannada	Sirsi	Secondary moist deciduous-Scrub woodland-Open thickets
2	PSPD2	Uttara Kannada	Sirsi	Secondary moist deciduous-Open thickets
3	PSPD3	Uttara Kannada	Sirsi	Secondary moist deciduous-Woodland-Open thickets
4	PSPLD1	Uttara Kannada	Sirsi	Secondary moist deciduous-Woodland-Dense thickets
5	PSPLD2	Uttara Kannada	Sirsi	Kan Evergreen-Disturbed
6	PSPLD3	Uttara Kannada	Sirsi	Wet Evergreen-Dense
7	PSPD1	Uttara Kannada	Yellapur	Secondary moist deciduous-Woodland
8	PSPD2	Uttara Kannada	Yellapur	Secondary moist deciduous-Woodland
9	PSPD3	Uttara Kannada	Yellapur	Scrub woodland-Open thickets
10	PSPLD1	Uttara Kannada	Yellapur	Semi-Evergreen-Dense
11	PSPLD2	Uttara Kannada	Yellapur	Semi-Evergreen-Dense
12	PSPLD3	Uttara Kannada	Yellapur	Semi-Evergreen-Dense
13	PSPD1	Uttara Kannada	Karwar	Secondary moist deciduous-Woodland-Open thickets
14	PSPD2	Uttara Kannada	Karwar	Secondary moist deciduous-Scrub woodland
15	PSPD3	Uttara Kannada	Karwar	Semi-Evergreen-Disturbed
16	PSPLD1	Uttara Kannada	Karwar	Semi-Evergreen-Disturbed
17	PSPLD2	Uttara Kannada	Karwar	Secondary moist deciduous-Scrub woodland
18	PSPLD3	Uttara Kannada	Karwar	Semi-Evergreen-Disturbed
20	PSPD1	Uttara Kannada	Haliyal	Primary moist deciduous-Woodland
21	PSPD2	Uttara Kannada	Haliyal	Primary moist deciduous-Woodland
22	PSPD3	Uttara Kannada	Haliyal	Primary moist deciduous-Woodland
23	PSPLD1	Uttara Kannada	Haliyal	Primary moist deciduous-Disturbed-Woodland
24	PSPLD2	Uttara Kannada	Haliyal	Primary moist deciduous-Disturbed-Woodland
25	PSPLD3	Uttara Kannada	Haliyal	Primary moist deciduous-Disturbed-Woodland
26	PSPD1	Uttara Kannada	Honnavar	Semi-Evergreen-Disturbed
27	PSPD2	Uttara Kannada	Honnavar	Wet Evergreen-Disturbed
28	PSPD3	Uttara Kannada	Honnavar	Wet Evergreen-Woodland-Open thickets

29	PSPLD1	Uttara Kannada	Honnavar	Wet Evergreen-Disturbed
30	PSPLD2	Uttara Kannada	Honnavar	Semi-Evergreen-Disturbed
31	PSPLD3	Uttara Kannada	Honnavar	Semi-Evergreen-Disturbed
33	BSP3	Shimoga	Shimoga	Primary moist deciduous-Disturbed-Woodland
34	BSP13	Shimoga	Shimoga	Secondary moist deciduous-Disturbed-Woodland
35	BSP12	Shimoga	Shimoga	Secondary moist deciduous-Disturbed-Woodland
36	BSP5	Shimoga	Shimoga	Kan Evergreen-Disturbed
37	BSP1	Shimoga	Shimoga	Kan Evergreen-Disturbed
41	BSP2	Shimoga	Sagar	Semi-Evergreen-Disturbed
42	BSP4	Shimoga	Sagar	Kan Evergreen-Disturbed
43	BSP6	Shimoga	Sagar	Secondary moist deciduous-Woodland
44	BSP15	Shimoga	Sagar	Primary moist deciduous-Woodland
45	BSP16	Shimoga	Sagar	Secondary moist deciduous-Disturbed-Woodland
46	BSP47	Shimoga	Sagar	Dry deciduous-Open thickets
47	BSP56	Shimoga	Sagar	Dry deciduous-Open thickets
48	BSP57	Shimoga	Sagar	Primary moist deciduous-Scrub woodland-Open thickets
49	BSP58	Shimoga	Sagar	Primary moist deciduous-Open thickets
50	BSP59	Shimoga	Sagar	Primary moist deciduous-Dense thickets
51	BSP6	Shimoga	Sagar	Primary moist deciduous-Scrub woodland
52	BSP7	Shimoga	Sagar	Secondary moist deciduous-Open thickets
53	BSP8	Shimoga	Sagar	Secondary moist deciduous-Woodland-Open thickets
54	BSP1	Shimoga	Shimoga	Primary moist deciduous-Woodland
55	BSP11	Shimoga	Shimoga	Primary moist deciduous-Woodland
56	BSP14	Shimoga	Sagar	Dry deciduous-Open thickets
57	BSP17	Shimoga	Sagar	Secondary moist deciduous-Woodland-Open thickets
58	BSP2	Shimoga	Sagar	Secondary moist deciduous-Woodland-Dense thickets
59	BSP22	Shimoga	Shimoga	Semi-Evergreen-Disturbed
60	BSP43	Shimoga	Shimoga	Dry deciduous-Woodland-Open thickets
61	BSP44	Shimoga	Shimoga	Dry deciduous-Open thickets
62	BSP45	Shimoga	Shimoga	Dry deciduous-Woodland
63	BSP46	Shimoga	Shimoga	Dry deciduous-Scrub woodland-Open thickets
64	BSP48	Shimoga	Shimoga	Secondary moist deciduous-Woodland-Open thickets
65	BSP27	Shimoga	Kalasa Wild life	Wet Evergreen-Dense
66	BSP28	Shimoga	Kalasa Wild life	Wet Evergreen-Dense
67	BSP29	Shimoga	Kalasa Wild life	Wet Evergreen-Disturbed
68	BSP3	Shimoga	Kalasa Wild life	Wet Evergreen-Disturbed-Tree savanna
69	BSP18	Shimoga	Shimoga	Wet Evergreen-Dense
70	BSP25	Shimoga	Koppa	Wet Evergreen-Dense
71	BSP19	Shimoga	Shimoga	Wet Evergreen-Disturbed-Tree savanna
72	BSP23	Shimoga	Koppa	Secondary Evergreen-Woodland-Savanna woodland-Scrub woodland
73	BSP24	Shimoga	Shimoga	Wet Evergreen-Disturbed
74	BSP26	Shimoga	Shimoga	Wet Evergreen-Dense
75	BSP41	Shimoga	Sagar	Wet Evergreen-Disturbed
76	BSP42	Shimoga	Sagar	Wet Evergreen-Woodland
78	BSP49	Uttara Kannada	Sirsi	Semi-Evergreen-Scrub woodland
79	BSP5	Uttara Kannada	Sirsi	Secondary Evergreen-Dense
80	BSP53	Uttara Kannada	Sirsi	Wet Evergreen-Dense

82	BSP52	Uttara Kannada	Sirsi	Wet Evergreen-Disturbed
83	BSP51	Uttara Kannada	Sirsi	Wet Evergreen-Disturbed
84	BSP54	Uttara Kannada	Honnavar	Wet Evergreen-Disturbed
85	BSPNK1	Uttara Kannada	Yellapur	Primary moist deciduous-Disturbed
86	BSPNK2	Uttara Kannada	Yellapur	Secondary moist deciduous-Dense
87	BSPNK3	Uttara Kannada	Yellapur	Dry deciduous-Woodland
88	BSPNK4	Uttara Kannada	Honnavar	Wet Evergreen-Disturbed
89	BSPNK6	Uttara Kannada	Karwar	Wet Evergreen-Dense
90	BSPNK7	Uttara Kannada	Karwar	Wet Evergreen-Dense
91	BSPNK8	Uttara Kannada	Karwar	Wet Evergreen-Dense
92	BSPNK1	Uttara Kannada	Honnavar	Wet Evergreen-Disturbed
93	BSPNK5	Uttara Kannada	Karwar	Secondary moist deciduous-Scrub woodland
94	BSPNK9	Uttara Kannada	Sirsi	Wet Evergreen-Disturbed
95	BSPsmgKanabur	Shimoga	Koppa	Primary moist deciduous-Woodland
96	BSPsmg6	Shimoga	Sagar	Primary moist deciduous-Disturbed-Woodland
97	BSPsmg1	Shimoga	Chikkamagalur	Primary moist deciduous-Woodland
98	BSPsmg7	Shimoga	Sagar	Wet Evergreen-Disturbed
99	BSPsmg8	Shimoga	Sagar	Wet Evergreen-Disturbed
100	BSPsmg9	Shimoga	Chikkamagalur	Dry deciduous-Scrub woodland-Dense thickets
101	BSPsmgMandagadde	Shimoga	Shimoga	Primary moist deciduous-Woodland
102	BSPsmgMarakutaka	Shimoga	Sagar	Wet Evergreen-Woodland
104	BSPsmgKodachadri	Shimoga	Shimoga	Wet Evergreen-Dense

Annexe 4

List of species encountered in BSPs according to major forest types

-Hab=Habitat
- Trees with potential height

E=Emergent(>40 m)
1=Canopy (24-40 m)
2=2nd Strata (16-24 m)
3=3rd Strata (8-16 m)
4=4th Strata (<8 m)
- sh=shrub
- h=herb
- c=climber
- L=liana

-Phe=Phenology
- eg=Evergreen
- de=Deciduous

-Eco=Ecology
- s=Secondary Evergreen Species
- p=Primary Evergreen Speceis
- o=in openings
- Ex=Exotic

End=Endemic
wg=Endemic to the Western Ghats

-WEG=Wet Evergreen
-SEG=Semi Evergreen
-KEG=Kan Evergreen
-SGD=Secondary Moist Deciduous
-PMD=Primary Moist Deciduous
-DS=Dry Deciduous

Family	Species	Hab	Phe	Eco	End	WEG	KEG	SEG	SMD	PMD	DD
ACANTHACEAE	*Andrographis* sp.	h	eg	s							X
ACANTHACEAE	*Justisia* sp.	c	eg	s		X	X	X	X		X
ACANTHACEAE	*Nilgirianthus barbatus* (Nees) Brem.	4	eg	s					X		
ACANTHACEAE	*Strobilanthes* sp	sh	eg	s		X	X		X	X	
ACANTHACEAE	*Thunbergia mysorensis* (Wt.) Anders.	L	eg	p	wg	X					
ADIANTACEAE	*Adiantum* sp.	h	eg	p		X	X			X	
ALANGIACEAE	*Alangium salvifolium* (L.f.) Wang var. hexapetalum	L	eg	s		X	X	X	X	X	
AMARYLLIDACEAE	*Curculigo orchiodes* Gaertn.	h	eg	s		X	X	X	X	X	X
ANACARDIACEAE	*Buchanania lanzan* Spreng.	4	de			X		X	X	X	X
ANACARDIACEAE	*Holigarna arnottiana* J. Hk.	2	eg	s	wg	X	X	X	X		
ANACARDIACEAE	*Holigarna grahamii* (Wt.) Kurz	1	eg	s	wg	X	X	X	X		
ANACARDIACEAE	*Holigarna nigra* Bourd.	1	eg	p	wg	X			X		
ANACARDIACEAE	*Lannea coromandelica* (Houtt.) Merr.	2	de	s		X	X	X	X	X	X
ANACARDIACEAE	*Mangifera indica* L.	1	eg	p		X	X	X	X	X	
ANACARDIACEAE	*Nothopegia beddomei* Gamble	3	eg	p		X					
ANACARDIACEAE	*Nothopegia racemosa* (Dalz.) Ramam.	3	eg	p		X	X	X	X		
ANACARDIACEAE	*Semecarpus anacardium* L.	2	de						X	X	X
ANACARDIACEAE	*Spondias pinnata* (L.f.) Kurz	1	eg	p		X		X	X	X	
ANCISTROCLADACEAE	*Ancistrocladus heyneanus* Wall.	L	eg	p		X		X			
ANNONACEAE	*Annona reticulata* L.	4	eg	ex						X	
ANNONACEAE	*Artabotrys zeylanicus* J.Hk. & Thoms	L	eg	p		X					
ANNONACEAE	*Cyathocalyx zeylanicus* Champ. ex J. Hk. & Th.	3	eg	p		X					
ANNONACEAE	*Desmos lawii* (J. Hk. & Th.) Safford.	L	eg	s		X	X	X			
ANNONACEAE	*Goniothalamus cardiopetalus* (Dalz.) J. Hk. & Thoms.	4	eg	p	wg	X					
ANNONACEAE	*Meiogyne pannosa* (Dalz.) Sinclair	3	eg	p	wg	X					
ANNONACEAE	*Miliusa eriocarpa* Dunn.	4	eg	p				X	X		
ANNONACEAE	*Miliusa tomentosa* (Roxb.) Sinclair	2	de			X					
ANNONACEAE	*Mitrephora grandiflora* Bedd.	4	eg	p	wg	X					
ANNONACEAE	*Orophea erythrocarpa* Bedd.	4	eg	p	wg	X					
ANNONACEAE	*Orophea zeylanica* J. Hk. & Thoms.	4	eg	p				X			
ANNONACEAE	*Polyalthia cerasoides* (Roxb.) Bedd.	4	eg	s				X	X	X	X
ANNONACEAE	*Polyalthia fragrans* (Dalz.) Bedd.	1	eg	p	wg	X		X			
ANNONACEAE	*Sageraea laurifolia* (Grah.) Blatt. & Mc. Cann.	3	eg	p	wg	X					
ANNONACEAE	*Uvaria narum* (Dunal) Wt. & Arn.	L	eg	s		X	X		X		
APOCYNACEAE	*Alstonia scholaris* (L.) R. Br.	1	eg	s		X	X	X	X	X	
APOCYNACEAE	*Carissa carandas* L.	L	eg	s		X		X	X		
APOCYNACEAE	*Carissa inermis* Vahl.	L	eg	p		X		X	X	X	X
APOCYNACEAE	*Holarrhena antidysenterica* Wall.	4	eg	s			X	X	X	X	X
APOCYNACEAE	*Ichnocarpus frutescens* (L.)R.Br	c	eg	s				X	X		
APOCYNACEAE	*Parsonia albiflavescens* (Dennst.) Mabberley	L	eg	s		X					
APOCYNACEAE	*Tabernaemontana heyneana* Wall.	3	de		wg	X	X	X	X	X	X
APOCYNACEAE	*Wrightia arborea* (Dennist.) Mabberley	4	de						X		X
APOCYNACEAE	*Wrightia tinctoria* (Roxb.) R.Br	4	de						X	X	X
ARACEAE	*Arisaema* sp.	h	eg	p			X		X		
ARACEAE	*Corypha umbraculifera* Linn.	2	eg	p		X					
ARACEAE	*Pothos scandens* L.	c	eg	p		X	X	X			
ARALIACEAE	*Schefflera capitata* (Wt. & Arn.) Harms	3	eg	p	wg	X					
ARALIACEAE	*Schefflera venulosa* (Wt. & Arn.) Harms	st	eg	s		X	X	X			
ARECACEAE	*Arenga wightii* Griff.	4	eg	p	wg	X					
ARECACEAE	*Calamus* sp.	c	eg	p		X		X			
ARECACEAE	*Caryota urens* L.	3	eg	p		X	X	X	X	X	
ARECACEAE	*Phoenix sylvestris* (L.) Roxb	4	eg	s					X		
ARECACEAE	*Pinanga dicksonii* (Roxb.) Blume	4	eg	p	wg	X					
ASCLEPIADACEAE	*Hemidesmus indicus* (L.) R.Br.	c	eg	s					X	X	X
ASTERACEAE	*Eclipta* sp.	h	eg	s						X	
ASTERACEAE	*Elephantopus scaber* L.	h	eg	s					X		
ASTERACEAE	*Eupatorium glandulosum* Kunth.	h	de			X	X	X	X	X	X
BIGNONIACEAE	*Dolichandrone atrovirens* Sprague	4	de					X	X		X
BIGNONIACEAE	*Dolichandrone falcata* Seem.	4	de								X
BIGNONIACEAE	*Pajanelia longifolia* (Willd.) Schum.	E	eg	p		X					
BIGNONIACEAE	*Radermachera xylocarpa* K. Schum.	4	de					X	X	X	
BIGNONIACEAE	*Stereospermum colais* (Buch.-Ham. ex Dillw.) Mabb.	1	eg	s		X	X	X	X	X	X
BOMBACACEAE	*Bombax ceiba* L.	1	de			X		X	X	X	X
BORAGINACEAE	*Carmona retusa* (Vahl) Masam.	sh	eg	s							X
BORAGINACEAE	*Cordia dichotoma* Forst.	4	de					X		X	
BORAGINACEAE	*Cordia macleodii* (Griff.) Hook.	4	de					X	X	X	X
BORAGINACEAE	*Cordia wallichii* G. Don	4	de							X	
BORAGINACEAE	*Ehretia laevis* Roxb.	4	eg	s				X			
BURSERACEAE	*Boswellia serrata* Roxb.	3	de								X
BURSERACEAE	*Canarium strictum* Roxb.	2	eg	p		X		X			X

BURSERACEAE	*Garuga pinnata* Roxb.	2	eg	s						X	X
CAPPARIDACEAE	*Capparis heyneana* Wall.	c	eg	s		X					
CAPPARIDACEAE	*Capparis rheedii* DC.	L	eg	p	wg			X			
CELASTRACEAE	*Cassine glauca* (Rottl.) Kuntze	2	eg	s		X	X		X		X
CELASTRACEAE	*Celastrus paniculatus* Willd.	L	eg	s		X		X	X		X
CELASTRACEAE	*Euonymus indicus* Heyne ex Wall.	4	eg	p	wg	X					
CELASTRACEAE	*Lophopetalum wightianum* Arn.	E	eg	p		X		X			
CELASTRACEAE	*Maytenus emarginata* (Willd.) Ding Hou	4	eg	s		X				X	X
CELASTRACEAE	*Maytenus rothiana* (Walp.) Ramam.	4	eg	p	wg	X		X			
CELASTRACEAE	*Microtropis stocksii* Gamble	4	eg	p	wg	X					
CELASTRACEAE	*Microtropis wallichiana* Wt.	4	eg	p		X					
CLUSIACEAE	*Calophyllum apetalum* Willd.	1	eg	p	wg	X					
CLUSIACEAE	*Calophyllum polyanthum* Wall. ex Chioisy	1	eg	p		X					
CLUSIACEAE	*Garcinia gummi-gutta* (L.) Robson	3	eg	p	wg	X	X	X	X		
CLUSIACEAE	*Garcinia indica* (Thouras) Choisy	3	eg	p	wg	X		X	X		
CLUSIACEAE	*Garcinia morella* (Gaertn.) Merr.	3	eg	p		X		X			
CLUSIACEAE	*Garcinia pictorius* (Roxb.) D'Arcy	3	eg	p		X					
CLUSIACEAE	*Garcinia talbotii* Raiz. & Sant.	2	eg	p	wg	X		X			
CLUSIACEAE	*Mammea suriga* (Buch.-Ham. ex Roxb.) Kosterm.	3	eg	p	wg	X		X	X		
CLUSIACEAE	*Mesua ferrea* L.	1	eg	p		X					
CLUSIACEAE	*Poeciloneuron indicum* Bedd.	1	eg	p	wg	X					
COMBRETACEAE	*Anogeissus latifolia* (Roxb.ex DC) Wall ex Guill. & Perr.	2	de	s					X	X	X
COMBRETACEAE	*Calycopteris floribunda* Lam.	L	de			X	X	X	X	X	X
COMBRETACEAE	*Combretum latifolium* Blume	L	eg	s		X		X			
COMBRETACEAE	*Terminalia bellirica* (Gaertn.) Roxb.	1	de			X	X	X	X	X	X
COMBRETACEAE	*Terminalia chebula* Retz.	3	de					X	X		X
COMBRETACEAE	*Terminalia paniculata* Roth.	2	de			X	X	X	X	X	X
COMBRETACEAE	*Terminalia tomentosa* (Roxb.ex DC.) Wt. & Arn.	1	de			X		X	X	X	X
CONNARACEAE	*Abrus precatorius* L.	c	de					X			
CONNARACEAE	*Connarus ritchiei* J. Hk.	L	eg	p				X			
CONNARACEAE	*Connarus wightii* Hook.	L	eg	s		X		X	X	X	
CONVOLVULACEAE	*Ipomea sp.*	L	eg	s			X	X	X	X	X
CONVOLVULACEAE	*Neuropeltis malbarica* Oost.	L	eg	p	wg	X		X			
CORNACEAE	*Mastixia arborea* (Wt.) Bedd. var. arborea	3	eg	p	wg	X					
DATISCACEAE	*Tetrameles nudiflora* R. Br.	1	de			X	X	X		X	
DICHAPETALACEAE	*Dichapetalum gelonioides* (Roxb.) Engl.	4	eg	p		X		X	X		
DILLENIACEAE	*Dillenia pentagyna* Roxb.	2	de			X	X	X	X	X	X
DIPTEROCARPACEAE	*Dipterocarpus indicus* Bedd.	E	eg	p	wg	X					
DIPTEROCARPACEAE	*Hopea canarensis* Hole	2	eg	p	wg	X					
DIPTEROCARPACEAE	*Hopea parviflora* Bedd.	1	eg	p	wg	X					
DIPTEROCARPACEAE	*Hopea ponga* (Dennst.) Mabb.	2	eg	p	wg	X		X			
DIPTEROCARPACEAE	*Shorea roxburghii* Roxb.	2	de						X	X	
DIPTEROCARPACEAE	*Vateria indica* L.	E	eg	p	wg	X	X		X		
EBENACEAE	*Diospyros angustifolia* (Miq.) Kosterm.	3	eg	p	wg	X		X			
EBENACEAE	*Diospyros assimilis* Bedd.	1	eg	p	wg	X					
EBENACEAE	*Diospyros buxifolia* (Bl.) Hiern	1	eg	s		X		X			
EBENACEAE	*Diospyros candolleana* Wt.	2	eg	p	wg	X		X			
EBENACEAE	*Diospyros crumenata* Thw.	3	eg	p		X	X				
EBENACEAE	*Diospyros ghatensis* Ramesh & De Franceschi	1	eg	p	wg	X					
EBENACEAE	*Diospyros malabarica* (Desr.) Kostel.	3	eg	p			X	X	X		
EBENACEAE	*Diospyros melanoxylon* Roxb.	3	de			X	X		X	X	X
EBENACEAE	*Diospyros montana* Roxb.	3	de			X	X	X	X	X	X
EBENACEAE	*Diospyros oocarpa* Thw.	2	eg	p		X	X	X			
EBENACEAE	*Diospyros paniculata* Dalz.	3	eg	p	wg	X		X			
EBENACEAE	*Diospyros pyrrhocarpoides* Ramesh & De Franceschi	3	eg	p		X					
EBENACEAE	*Diospyros saldanhae* Kosterm.	3	eg	p	wg	X		X			
EBENACEAE	*Diospyros sylvatica* Roxb.	1	eg	p		X	X	X	X		
ELAEAGNACEAE	*Elaeagnus kologa* Schlecht.	L	eg	s		X	X	X	X	X	
ELAEOCARPACEAE	*Elaeocarpus munronii* (Wt.) Mast.	3	eg	p	wg	X					
ELAEOCARPACEAE	*Elaeocarpus serratus* L.	2	eg	s		X	X	X	X		
ELAEOCARPACEAE	*Elaeocarpus tectorius* (Lour.) Poir.	2	eg	p		X				X	
ELAEOCARPACEAE	*Elaeocarpus tuberculatus* Roxb.	1	eg	p		X					
EUPHORBIACEAE	*Agrostistachys indica* Dalz.	4	eg	p		X					
EUPHORBIACEAE	*Antidesma menasu* Miq. ex Tul.	4	eg	s		X				X	
EUPHORBIACEAE	*Aporosa lindleyana* Baill.	3	eg	s		X	X	X	X	X	X
EUPHORBIACEAE	*Bischofia javanica* Blume	1	eg	p		X		X		X	
EUPHORBIACEAE	*Blachia denudata* Benth.	4	eg	p	wg	X					
EUPHORBIACEAE	*Breynia rhamnoides* M. Arg.	sh	eg	s		X	X	X	X	X	X
EUPHORBIACEAE	*Bridelia crenulata* Roxb.	3	de					X	X	X	X
EUPHORBIACEAE	*Bridelia scandens* (Roxb.) Willd.	L	de			X	X	X	X	X	X
EUPHORBIACEAE	*Cleidion spiciflorum* (Burm. f.) Merr.	3	eg	p		X					
EUPHORBIACEAE	*Cleistanthus malabaricus* M. Arg.	4	eg	p	wg	X					
EUPHORBIACEAE	*Croton gibsonianus* Nimmo	4	eg	s				X			
EUPHORBIACEAE	*Dimorphocalyx lawianus* J. Hk.	4	eg	p	wg	X					
EUPHORBIACEAE	*Drypetes confertiflorus* (J. Hk.) Pax & Hoffm.	2	eg	p	wg	X	X				
EUPHORBIACEAE	*Drypetes oblongifolia* (Bedd.) Airy Shaw	3	eg	p	wg		X				
EUPHORBIACEAE	*Drypetes venusta* (Wt.) Pax & Hoffm.	2	eg	p	wg	X					
EUPHORBIACEAE	*Emblica officinalis* Gaertn.	4	de	s		X	X	X	X	X	X
EUPHORBIACEAE	*Epiprinus mallotiformis* (M. Arg.) Croizat.	2	eg	s		X					
EUPHORBIACEAE	*Fahrenheitia zeylanica* (Thw.) Airy Shaw	2	eg	p		X					
EUPHORBIACEAE	*Givotia rottleriformis* Griff.	3	de								X
EUPHORBIACEAE	*Glochidion ellipticum* Wt. var. ellipticum	3	eg	p	wg	X					
EUPHORBIACEAE	*Glochidion malabaricum* Bedd.	3	eg	s	wg	X	X	X	X	X	X
EUPHORBIACEAE	*Glochidion velutinum* Wt.	3	de	s						X	
EUPHORBIACEAE	*Macaranga peltata* (Roxb.) M. Arg.	3	eg	s		X	X	X	X	X	
EUPHORBIACEAE	*Mallotus philippensis* M. Arg.	3	eg	s		X	X	X	X	X	X
EUPHORBIACEAE	*Mallotus stenanthus* M. Arg.	4	eg	p	wg	X					
EUPHORBIACEAE	*Margaritaria indica* (Dalz.) Airy shaw	2	de	p		X	X	X		X	
EUPHORBIACEAE	*Sapium insigne* Benth.	4	de	s					X		
EUPHORBIACEAE	*Securinega leucopyrus* (Willd.) Mueller	4	de	s						X	X
EUPHORBIACEAE	*Trewia nudiflora* L.	3	eg	s		X		X		X	X
EUPHORBIACEAE	*Trewia polycarpa* Benth.	3	eg	p		X					
FABACEAE (Caesalpinioideae)	*Acrocarpus fraxinifolius* Wt.	E	eg	s		X		X		X	

FABACEAE (Caesalpinioideae)	*Bauhinia foveolata* Dalz.	1	de	s	wg			X		X	
FABACEAE (Caesalpinioideae)	*Bauhinia malabarica* Roxb	3	eg	s				X	X	X	X
FABACEAE (Caesalpinioideae)	*Bauhinia phoenicea* Wt. & Arn.	L	eg	s					X		
FABACEAE (Caesalpinioideae)	*Bauhinia racemosa* Lam	4	de					X	X	X	X
FABACEAE (Caesalpinioideae)	*Caesalpinia crista* L.	L	eg	s		X					
FABACEAE (Caesalpinioideae)	*Cassia fistula* L.	4	de			X	X	X	X	X	X
FABACEAE (Caesalpinioideae)	*Cassia glauca* Lam.	4	de							X	X
FABACEAE (Caesalpinioideae)	*Cassia siamea* Lam.	3	de	ex				X	X	X	
FABACEAE (Caesalpinioideae)	*Cassia tora* L.	h	eg	s					X	X	X
FABACEAE (Caesalpinioideae)	*Humboldtia brunonis* Wall.	4	eg	p	wg	X					
FABACEAE (Caesalpinioideae)	*Moullava spicata* Dalz.	L	eg	s	wg	X	X	X	X	X	X
FABACEAE (Caesalpinioideae)	*Saraca asoca* (Roxb.) De Wilde	4	eg	p		X	X				
FABACEAE (Caesalpinioideae)	*Tamarindus indica* L.	2	eg	s					X		X
FABACEAE (Faboideae)	*Butea monosperma* (Lam.) Taub.	4	de						X	X	X
FABACEAE (Faboideae)	*Butea parviflora* Roxb.	L	eg	s					X	X	
FABACEAE (Faboideae)	*Dalbergia horrida* (Dennst.) Mabberley	L	de			X	X	X	X	X	X
FABACEAE (Faboideae)	*Dalbergia latifolia* Roxb.	2	de			X		X	X	X	X
FABACEAE (Faboideae)	*Dalbergia paniculata* Roxb.	2	de							X	X
FABACEAE (Faboideae)	*Derris scandens* (Roxb.) Benth.	L	eg	s		X	X	X		X	
FABACEAE (Faboideae)	*Desmodium pulchellum* (L.) Benth.	sh	de	s					X	X	X
FABACEAE (Faboideae)	*Erythrina stricta* Roxb.	3	eg	s		X		X		X	
FABACEAE (Faboideae)	*Flemingia macrophylla* (Willd.) Merr.	sh	de						X		X
FABACEAE (Faboideae)	*Kunstleria keralense* C.N. Mohanan & N.C. Nair	L	eg	p	wg	X					
FABACEAE (Faboideae)	*Ougeinia oojeinensis* (Roxb.) Hochr.	2	de							X	
FABACEAE (Faboideae)	*Pongamia pinnata* (L.) Pierre	3	eg	s							X
FABACEAE (Faboideae)	*Pterocarpus marsupium* Roxb.	2	de			X	X	X	X	X	X
FABACEAE (Mimosoideae)	*Acacia auriculiformis* A. Cunn. ex Benth	3	eg	ex		X					
FABACEAE (Mimosoideae)	*Acacia caesia* (L.) Willd.	L	eg	s		X					
FABACEAE (Mimosoideae)	*Acacia catechu* Willd.	4	de						X		X
FABACEAE (Mimosoideae)	*Acacia chundra* (Rottl.) Willd.	4	de								X
FABACEAE (Mimosoideae)	*Acacia leucophloea* Willd	3	de								X
FABACEAE (Mimosoideae)	*Acacia pennata* Willd.	L	eg	s		X			X	X	X
FABACEAE (Mimosoideae)	*Acacia sinuata* (Lour.)Merr.	L	de			X			X	X	X
FABACEAE (Mimosoideae)	*Acacia torta* Craib	sh	eg	s		X		X			
FABACEAE (Mimosoideae)	*Albizia amara* Boiv.	3	de						X	X	X
FABACEAE (Mimosoideae)	*Albizia chinensis* (Osb.) Merrill	2	de			X					
FABACEAE (Mimosoideae)	*Albizia lebbeck* (L.) Willd.	2	de			X			X	X	
FABACEAE (Mimosoideae)	*Albizia odoratissima* (L. f.) Benth.	3	de					X	X	X	X
FABACEAE (Mimosoideae)	*Albizia procera* (Roxb.) Benth.	3	de	s		X		X	X		
FABACEAE (Mimosoideae)	*Archidendron monadelphum* (Roxb.) Nielson	3	eg	s		X					
FABACEAE (Mimosoideae)	*Entada pursaetha* DC	L	eg	s		X	X	X			
FABACEAE (Mimosoideae)	*Mimosa pudica* L.	h	eg	s					X	X	X
FABACEAE (Mimosoideae)	*Prosopis cineraria* (L.) Druce	4	eg	s							X
FABACEAE (Mimosoideae)	*Xylia xylocarpa* (Roxb.) Taub.	2	de			X	X	X	X	X	X
FLACOURTIACEAE	*Casearia championii* Thwaites	4	eg	p	wg	X					
FLACOURTIACEAE	*Casearia ovata* (Lam.) Willd.	2	eg	p		X	X	X	X	X	
FLACOURTIACEAE	*Casearia rubens* Dalz.	3	eg	p	wg	X	X		X		
FLACOURTIACEAE	*Casearia tomentosa* Roxb.	4	de			X		X	X	X	X
FLACOURTIACEAE	*Casearia wynadensis* Bedd.	4	eg	p	wg	X					
FLACOURTIACEAE	*Flacourtia indica* (Burm. f) Merr.	4	eg	s				X	X	X	X
FLACOURTIACEAE	*Flacourtia montana* Grah.	4	eg	s	wg	X	X	X	X	X	
FLACOURTIACEAE	*Homalium zeylanicum* (Gardner) Benth.	2	eg	p		X					
FLACOURTIACEAE	*Hydnocarpus pentandra* (Buch-Ham.) Oken	3	eg	s	wg	X	X	X		X	
FLACOURTIACEAE	*Scolopia crenata* (Wt. & Arn.) Clos.	3	eg	s		X					
GNETACEAE	*Gnetum ula* Brongn.	L	eg	p		X	X	X	X		
HIPPOCRATEACEAE	*Hippocratea grahami* L.	L	eg	s		X		X			
HIPPOCRATEACEAE	*Salacia macrosperma* Wight	L	eg	p	wg	X		X			
ICACINACEAE	*Apodytes dimidiata* E. Meyer ex Arn. var. acutifolia	1	eg	p		X					
ICACINACEAE	*Gomphandra coriacea* Wt.	4	eg	p		X					
ICACINACEAE	*Gomphandra tetrandra* (Wall. ex Roxb.) Sleumer	4	eg	p		X					
ICACINACEAE	*Nothapodytes foetida* (Wt.) Sleumer	4	eg	s		X	X	X		X	
ICACINACEAE	*Sarcostigma kleinii* W. & A.	L	eg	p				X			
LAMIACEAE	*Colebrookea oppositifolia* J.E. Smith	sh	eg	o							
LAURACEAE	*Actinodaphne angustifolia* (Blume) Nees	3	eg	p	wg	X	X	X	X	X	
LAURACEAE	*Actinodaphne bourdillonii* Gamble	3	eg	p	wg	X					
LAURACEAE	*Actinodaphne malabarica* Balak.	3	eg	p	wg	X	X	X	X		
LAURACEAE	*Actinodaphne tadulingami* Gamble	3	eg	p	wg	X					
LAURACEAE	*Alseodaphne semecarpifolia* Nees	4	eg	s		X	X	X	X	X	
LAURACEAE	*Beilschmiedia dalzellii* (Meissn.) Kosterm.	2	eg	p	wg	X	X	X		X	
LAURACEAE	*Beilschmiedia wightii* (Nees) Benth. ex J. Hk.	2	eg	p	wg	X					
LAURACEAE	*Cinnamomum keralaense* Kosterm.	2	eg	p	wg	X					
LAURACEAE	*Cinnamomum malabathrum* (Burm. f.) Blume	3	eg	p	wg	X	X	X	X	X	
LAURACEAE	*Cinnamomum verum* J.S. Presl	3	eg	p		X	X	X	X		
LAURACEAE	*Cryptocarya bourdillonii* Gamble	2	eg	p	wg	X		X			
LAURACEAE	*Cryptocarya neilgherrensis* Meissn.	3	eg	p		X					
LAURACEAE	*Litsea floribunda* Gamble	3	eg	p	wg	X					
LAURACEAE	*Litsea ghatica* Saldanha	4	eg	p	wg	X					
LAURACEAE	*Litsea insignis* Gamble	3	eg	p		X					
LAURACEAE	*Litsea laevigata* (Nees) Gamble	3	eg	p	wg	X	X	X			
LAURACEAE	*Litsea mysorensis* Gamble	4	eg	p	wg	X		X			
LAURACEAE	*Litsea oleoides* (Meissn.) J. Hk.	1	eg	p		X					
LAURACEAE	*Litsea stocksii* (Meissn) J. Hk. var. stocksii	3	eg	p	wg	X					
LAURACEAE	*Litsea stocksii* (Meissn.) J. Hk. var. glabrescens	3	eg	p	wg	X					
LAURACEAE	*Neolitsea scrobiculata* Gamble	3	eg	p				X			
LAURACEAE	*Neolitsea zeylanica* (Nees) Merr.	2	eg	p		X		X			

LAURACEAE	*Persea macrantha* (Nees) Kosterm.	1	eg	p		X	X	X			
LECYTHIDACEAE	*Careya arborea* Roxb.	3	de	s		X		X	X	X	X
LEEACEAE	*Leea indica* (Burm.f.) Merr.	4	eg	s		X	X	X	X	X	X
LILIACEAE	*Asparagus racemosus* Willd.	c	eg	s		X		X		X	
LILIACEAE	*Gloriosa superba* L.	c	eg	s						X	
LOGANIACEAE	*Fagraea ceilanica* Thunb.	xxx	eg	s		X					
LOGANIACEAE	*Strychnos nux-vomica* L.	3	eg	s		X		X	X	X	
LOGANIACEAE	*Strychnos potatorum* L.	4	eg	s					X		X
LOGANIACEAE	*Strychnos wallichiana* Steud. ex DC.	L	eg	p		X					
LYTHRACEAE	*Lagerstroemia microcarpa* Wight	2	de			X	X	X	X	X	X
LYTHRACEAE	*Lagerstroemia parviflora* Roxb.	2	de			X	X	X	X	X	X
LYTHRACEAE	*Lagerstroemia reginae* Roxb.	2	de			X		X			
MAGNOLIACEAE	*Michelia champaca* L.	1	eg	p		X	X				
MALPIGHIACEAE	*Hiptage benghalensis* (L.) Kurz	L	eg	s			X				
MALVACEAE	*Kydia calycina* Roxb.	2	de			X		X		X	
MELASTOMATACEAE	*Melastoma malabathricum* L.	sh	eg	s	wg	X					
MELASTOMATACEAE	*Memecylon amplexicaule* Roxb.	4	eg	p		X					
MELASTOMATACEAE	*Memecylon malabaricum* (Cl.) Cogn.	4	eg	p	wg	X					
MELASTOMATACEAE	*Memecylon talbotianum* Brand.	4	eg	p	wg	X		X			
MELASTOMATACEAE	*Memecylon umbellatum* N. Burman	3	eg	p		X	X	X			
MELASTOMATACEAE	*Memecylon wightii* Thw.	4	eg	p		X	X				
MELIACEAE	*Aglaia barberi* Gamble	2	eg	p	wg	X	X	X	X		
MELIACEAE	*Aglaia elaegnoidea* (Juss.)Benth. var. eleagnoidea	3	eg	p		X	X	X			
MELIACEAE	*Aglaia jainii* Viswa. & Ramachan.	1	eg	p	wg	X	X	X			
MELIACEAE	*Aglaia lawii* (Wt.) Saldanha	2	eg	p	wg	X	X				
MELIACEAE	*Aphanamixis polystachya* (Wall.) Parker	2	eg	p		X		X			
MELIACEAE	*Azadirachta indica* A. Juss.	3	eg	s							X
MELIACEAE	*Chloroxylon swietenia* DC.	4	de								X
MELIACEAE	*Chukrasia tabularis* A. Juss.	2	de					X			
MELIACEAE	*Cipadessa baccifera* (Roth.) Miq.	sh	eg	s			X			X	
MELIACEAE	*Dysoxylum binectariferum* J. Hk. ex Bedd.	2	eg	p		X					
MELIACEAE	*Dysoxylum malabaricum* Bedd. ex Hiern.	1	eg	p	wg	X	X	X			
MELIACEAE	*Melia dubia* Cav.	1	de			X	X			X	
MELIACEAE	*Reinwardtiodendron anamallayanum* (Bedd.) Saldanha.	2	eg	p	wg	X					
MELIACEAE	*Soymida febrifuga* A. Juss.	4	de								X
MELIACEAE	*Swietenia mahagoni* (L.) Jacq.	1	eg	ex				X			
MELIACEAE	*Toona ciliata* Roemer	2	eg	s		X	X	X	X	X	
MELIACEAE	*Trichilia connaroides* (Wt. & Arn.) Benth.	2	eg	s		X	X	X			
MELIACEAE	*Walsura trifolia* A. Juss.	3	eg	s		X					
MENISPERMACEAE	*Cocculus hirsutus* (L.) Diels	c	eg	s						X	
MENISPERMACEAE	*Cyclea peltata* (Lam.) J.Hk. & Thoms	c	eg	s		X			X	X	X
MENISPERMACEAE	*Diploclisia glaucescens* (Bl.) Diels	L	eg	s		X	X	X	X		
MORACEAE	*Antiaris toxicaria* Lesch.	1	eg	p		X					
MORACEAE	*Artocarpus gomezianus* Wall ex Trecul var. zeylanicus	1	de			X	X	X	X	X	
MORACEAE	*Artocarpus heterophyllus* Lam.	2	eg	s		X	X	X	X		
MORACEAE	*Artocarpus hirsutus* Lam.	1	eg	s	wg	X	X	X	X		
MORACEAE	*Ficus amplissima* J. E. Sm.	3	eg	s		X		X	X		
MORACEAE	*Ficus arnottiana* Miq.	3	de						X		
MORACEAE	*Ficus beddomei* King	1	eg	p	wg	X					
MORACEAE	*Ficus benghalensis* L.	2	eg	s					X	X	X
MORACEAE	*Ficus callosa* Willd.	2	eg	p		X	X	X			
MORACEAE	*Ficus drupacea* Thunb. var. pubescens	2	eg	s		X	X		X	X	X
MORACEAE	*Ficus exasperata* Vahl.	3	eg	s		X		X	X	X	
MORACEAE	*Ficus gibbosa* Bl.	4	eg	s					X		
MORACEAE	*Ficus hispida* L. f.	4	eg	s		X				X	
MORACEAE	*Ficus microcarpa* L. f.	2	eg	s		X		X	X		
MORACEAE	*Ficus nervosa* Roth	1	eg	p		X		X	X	X	
MORACEAE	*Ficus racemosa* L.	3	eg	s		X		X	X	X	X
MORACEAE	*Ficus religiosa* L.	3	de	s		X			X	X	
MORACEAE	*Ficus talbotii* Heyne ex Roth	2	eg	p			X				
MORACEAE	*Ficus tsjahela* N. Burman	2	de			X		X	X		
MORACEAE	*Ficus virens* Ait.	1	eg	s		X	X	X	X		
MORACEAE	*Streblus asper* Lour.	4	eg	s			X	X	X	X	X
MYRISTICACEAE	*Knema attenuata* (J. Hk. & Thw.) Warb.	2	eg	p	wg	X	X	X	X		
MYRISTICACEAE	*Myristica dactyloides* Gaertn.	2	eg	p		X					
MYRISTICACEAE	*Myristica malabarica* Lam.	1	eg	p	wg	X			X		
MYRSINACEAE	*Ardisia pauciflora* Heyne	4	eg	p		X					
MYRSINACEAE	*Ardisia solanacea* Roxb.	4	eg	s		X	X	X	X		
MYRSINACEAE	*Embelia ribes* N.Burman	L	eg	s			X	X	X	X	X
MYRSINACEAE	*Maesa indica* (Roxb.) DC.	4	eg	s		X		X			
MYRSINACEAE	*Rapanea wightiana* Mez. var. sessilis	4	eg	p		X					
MYRTACEAE	*Eucalyptus globulus* Labill.	2	eg	ex						X	
MYRTACEAE	*Eugenia macrosepala* Duthie	3	eg	s		X		X			
MYRTACEAE	*Eugenia thwaitesii* Duthie	3	eg	p		X	X				
MYRTACEAE	*Syzygium caryophyllatum* Gaertn.	4	eg	s		X		X	X		
MYRTACEAE	*Syzygium cumini* (L.) Skeels	1	eg	s		X	X	X	X	X	X
MYRTACEAE	*Syzygium densiflorum* Wall. ex Wt. & Arn.	3	eg	p	wg	X					
MYRTACEAE	*Syzygium gardneri* Thw.	1	eg	p		X	X				
MYRTACEAE	*Syzygium hemisphericum* (Walp.) Alston	3	eg	p		X	X	X			
MYRTACEAE	*Syzygium laetum* (Buch.-Ham.) Gandhi	3	eg	p	wg	X		X			
MYRTACEAE	*Syzygium rubicundum* Wt. & Arn.	4	eg	p		X					
MYRTACEAE	*Syzygium* sp.	4	eg	p		X					
OCHNACEAE	*Gomphia serrata* (Gaertn.) Kanis	4	eg	s				X			
OLACACEAE	*Olax imbricata* Roxb.	L	eg	s		X		X		X	
OLACACEAE	*Strombosia ceylanica* Gardn.	1	eg	p		X					
OLEACEAE	*Chionanthus malabaricus* (Wall. ex G. Don) Bedd.	4	eg	s		X	X	X	X	X	X
OLEACEAE	*Jasminum arborescens* Roxb.	c	eg	s		X			X		
OLEACEAE	*Jasminum malabaricum* Wight	L	eg	s		X		X	X		X
OLEACEAE	*Ligustrum perrottetii* A. DC.	4	eg	s		X					
OLEACEAE	*Olea dioica* Roxb.	2	eg	s		X	X	X	X	X	
OSMUNDACEA	*Osmunda* sp.	h	eg	p		X					
OXALIDACEAE	*Oxalis corniculata* L.	h	eg	s						X	
PANDANACEAE	*Pandanus thwaitesii* Mart.	4	eg	s		X					
PIPERACEAE	*Peperomia portulacoides* (Lam.) A. Dietr.	h	eg	s		X				X	

Annexe 4

PIPERACEAE	*Piper hymenophyllum* Miq.	c	eg	p	wg	X		X	X	X	
PIPERACEAE	*Piper* sp.	c	eg	p		X	X				
PITTOSPORACEAE	*Pittosporum dasycaulon* Miq.	3	eg	p	wg						
POACEAE	*Bambusa arundinacea* (Retz.) Willd.	4	de	s					X	X	X
POLGONACEAE	*Polygonum chinense* L.	h	eg	s		X					
PROTEACEAE	*Grevillea robusta* R. Br.	2	eg	ex		X					
PTERIDACEAE	*Pteris quadriaurita* Retz.	h	eg	o		X					
RANUNCULACEAE	*Clematis gouriana* Roxb.	c	de	o					X		X
RHAMNACEAE	*Scutia myrtina* Kurz.	L	eg	s		X					
RHAMNACEAE	*Ventilago maderaspatana* Gaertn.	L	eg	s		X	X	X	X	X	X
RHAMNACEAE	*Ziziphus glaberrima* Sant.	L	eg	s				X	X	X	X
RHAMNACEAE	*Ziziphus nummularia* Wt.	sh	eg	s							X
RHAMNACEAE	*Ziziphus oenoplia* (L.) Mill.	L	eg	s		X	X	X	X	X	X
RHAMNACEAE	*Ziziphus rugosa* Lam.	4	eg	s		X	X	X	X	X	X
RHAMNACEAE	*Ziziphus xylopyrus* (Retz.) Willd.	4	eg	s					X	X	
RHIZOPHORACEAE	*Carallia brachiata* (Lour.) Merr.	2	eg	p		X		X	X	X	
ROSACEAE	*Prunus ceylanica* (Wt.) Miq.	2	eg	p		X					
RUBIACEAE	*Canthium angustifolium* Roxb.	L	eg	p		X	X	X	X		X
RUBIACEAE	*Canthium dicoccum* (Gaertn.) Teissm. var. dicoccum	3	eg	s		X	X	X	X	X	
RUBIACEAE	*Canthium parviflorum* Lamk.	4	eg	s						X	X
RUBIACEAE	*Catunaregam dumetorum* (Retz.)Tirven.	4	de			X	X	X	X	X	X
RUBIACEAE	*Chasalia ophioxyloides* (Wall.) Craib	h	eg	p				X			
RUBIACEAE	*Gardenia gummifera* L.f.	4	eg	s					X		
RUBIACEAE	*Gardenia latifolia* Aiton	4	eg	s					X		X
RUBIACEAE	*Gardenia resinifera* Roth.	4	eg	s				X			
RUBIACEAE	*Haldina cordifolia* (Roxb.) Ridsdale	1	de				X	X	X	X	X
RUBIACEAE	*Hymenodictyon orixense* (Roxb.) Mabberly	2	de	s		X				X	
RUBIACEAE	*Ixora arborea* Roxb. ex Smith	4	eg	s		X					X
RUBIACEAE	*Ixora brachiata* Roxb. ex DC.	3	eg	s	wg	X	X	X	X	X	X
RUBIACEAE	*Ixora coccinia* L.	sh	eg	s		X		X	X		
RUBIACEAE	*Ixora nigricans* Br. ex Wt. & Arn.	4	eg	p		X	X	X			
RUBIACEAE	*Ixora polyantha* Wt.	sh	eg	p	wg	X		X			
RUBIACEAE	*Lasianthus acuminatus* Wt.	sh	eg	p	wg	X					
RUBIACEAE	*Meyna laxiflora* Robyns	4	eg	s		X	X	X	X	X	X
RUBIACEAE	*Mitragyna parvifolia* (Roxb.) Korth.	2	de	s		X		X	X	X	X
RUBIACEAE	*Mussaenda frondosa* Linn.	L	eg	s		X	X	X	X		
RUBIACEAE	*Neolamarkia cadamba* (Roxb.) Bosser	1	eg	p		X					
RUBIACEAE	*Pavetta indica* L.	4	eg	s		X					
RUBIACEAE	*Pavetta tomentosa* Roxb. ex J.E. Smith	4	de					X	X		X
RUBIACEAE	*Psychotria dalzellii* J. Hk.	4	eg	p	wg	X		X	X		
RUBIACEAE	*Psychotria flavida* Talbot	4	eg	p		X		X			
RUBIACEAE	*Psychotria nigra* (Gaertn.) Alston	4	eg	p	wg	X		X			
RUBIACEAE	*Psychotria octosulcata* Talbot	sh	eg	p	wg	X					
RUBIACEAE	*Psychotria truncata* Wall.	4	eg	p	wg	X					
RUBIACEAE	*Randia rugulosa* (Thw.)J.Hk.	L	eg	p		X			X		
RUBIACEAE	*Tamilnadia uliginosa* (Retz.) Tirven.	4	eg	s						X	
RUBIACEAE	*Tarenna asiatica* (L.) Kuntze ex K. Schum. var. rigida	sh	eg	s							X
RUBIACEAE	*Tricalysia apiocarpa* (Dalz.) Gamble	3	eg	p	wg	X					
RUBIACEAE	*Wendlandia thyrsoidea* (Schultes) Steud.	4	eg	s		X			X		
RUTACEAE	*Aegle marmelos* L.	3	de						X		
RUTACEAE	*Atalantia wightii* Tanaka	4	eg	p	wg	X		X	X	X	
RUTACEAE	*Clausena dentata* (Willd.) R. & S.	4	eg	s		X	X		X		
RUTACEAE	*Clausena indica* Oliver	4	eg	s		X	X	X	X		
RUTACEAE	*Euodia lunu-ankenda* (Gaertn.) Merr.	3	eg	s		X	X	X	X	X	
RUTACEAE	*Glycosmis macrocarpa* Wt.	3	eg	p	wg	X		X			
RUTACEAE	*Glycosmis pentaphylla* Corr.	4	eg	s		X	X	X		X	
RUTACEAE	*Luvunga sarmentosa* (Blume) Kurz	L	eg	p		X					
RUTACEAE	*Murraya koenigii* (L.) Spreng.	4	eg	s			X	X	X	X	
RUTACEAE	*Naringi crenulata* (Roxb.) Nicolson	4	eg	s					X		X
RUTACEAE	*Paramignya monophylla* Wight	L	eg	p		X	X	X	X	X	
RUTACEAE	*Toddalia asiatica* (L.) Lam.	L	eg	s		X	X	X	X	X	
RUTACEAE	*Vepris bilocularis* (Wt. & Arn.) Engl.	3	eg	p	wg	X		X			
RUTACEAE	*Zanthoxylum ovalifolium* Wt.	L	eg	s		X		X			
RUTACEAE	*Zanthoxylum rhetsa* (Roxb.) DC.	3	de			X		X	X	X	
SANTALACEAE	*Osyris quadripartita* Salz. ex Decne.	4	eg	s				X			
SANTALACEAE	*Santalum album* L.	4	eg	s					X	X	X
SANTALACEAE	*Scleropyrum pentandrum* (Denn.) Mabb.	4	eg	s		X					
SAPINDACEAE	*Allophylus cobbe* (L.) Raeusch	4	eg	s			X	X	X	X	
SAPINDACEAE	*Dimocarpus longan* Lour.	1	eg	s		X	X	X	X		
SAPINDACEAE	*Dodonaea viscosa* (L.)Jacq	sh	eg	s							X
SAPINDACEAE	*Harpullia arborea* (Blanco) Radlk.	3	eg	p		X	X	X	X		
SAPINDACEAE	*Lepisanthes decipiens* Radlk.	4	eg	p		X		X	X		
SAPINDACEAE	*Sapindus laurifolia* Vahl	3	de			X		X	X	X	
SAPINDACEAE	*Schleichera oleosa* (Lour.) Oken	2	de			X	X	X	X	X	X
SAPOTACEAE	*Chrysophyllum lanceolatum* (Blume) DC.	1	eg	p		X	X				
SAPOTACEAE	*Isonandra lanceolata* Wt.	4	eg	p		X					
SAPOTACEAE	*Madhuca longifolia* (Koen.) Macbride var. latifolia	2	de			X	X		X	X	X
SAPOTACEAE	*Madhuca neriifolia* (Moon.) Lam.	3	eg	p		X					
SAPOTACEAE	*Mimusops elengi* L.	1	eg	p		X	X	X	X	X	
SAPOTACEAE	*Palaquium ellipticum* (Dalz.) Baillon	1	eg	p	wg	X					
SAPOTACEAE	*Xantolis tomentosa* (Roxb.) Raf.	2	eg	p		X	X	X	X	X	X
SELAGINELACEAE	*Selaginela* sp.	h	eg	p						X	
SIMARUBACEAE	*Ailanthus excelsa* Roxb.	3	de	ex		X					X
SIMARUBACEAE	*Ailanthus triphysa* (Dennst.) Alston	1	de			X	X	X	X		
SMILACACEAE	*Smilax zeylancia* L.	c	eg	s		X	X	X	X	X	X
SOLANACEAE	*Solanum torvum* Sw.	sh	eg	s						X	
STAPHYLACEAE	*Turpinia malabarica* Gamble	3	eg	p	wg	X					
STERCULIACEAE	*Helicteres isora* L.	4	de							X	
STERCULIACEAE	*Pterospermum diversifolium* Blume	2	eg	s		X		X			
STERCULIACEAE	*Pterospermum reticulatum* Wt. & Arn.	2	eg	s	wg	X	X	X	X		
STERCULIACEAE	*Sterculia colorata* R. Br.	3	de						X		
STERCULIACEAE	*Sterculia guttata* Roxb.	2	de			X	X	X	X	X	
STERCULIACEAE	*Sterculia urens* Roxb.	3	de						X		X
SYMPLOCACEAE	*Symplocos cochinchinensis* (Lour.) Moore var. laurina	4	eg	s		X		X			

SYMPLOCACEAE	*Symplocos macrocarpa* Wt. ex Cl. var. kanarana	3	eg	p	wg	X					
SYMPLOCACEAE	*Symplocos macrophylla* Wall. ex A. DC. var. rosea	3	eg	p	wg	X					
SYMPLOCACEAE	*Symplocos racemosa* Roxb.	3	eg	p		X	X	X	X		
THEACEAE	*Eurya japonica* Thunb.	4	eg	s		X					
THEACEAE	*Gordonia obtusa* Wall. ex Wt. & Arn.	3	eg	p	wg	X					
THYMELAEACEAE	*Gnidia glauca* (Fresen.) Gilg	4	de			X		X	X		
TILIACEAE	*Grewia hirsuta* Vahl.	sh	eg	s							X
TILIACEAE	*Grewia laevigata* Vahl	L	eg	s			X				
TILIACEAE	*Grewia micrococos* L.	4	eg	s		X	X	X	X	X	X
TILIACEAE	*Grewia tiliaefolia* Vahl	2	de			X	X	X	X	X	X
TILIACEAE	*Grewia umbellifera* Bedd.	L	eg	s		X	X	X			X
ULMACEAE	*Aphananthe cuspidata* (Blume) Planch.	2	eg	p		X	X				
ULMACEAE	*Celtis philippensis* Blanco var. philippensis	4	eg	p		X	X	X	X		
ULMACEAE	*Celtis tetrandra* Roxb.	2	eg	s						X	
ULMACEAE	*Holoptelea integrifolia* (Roxb.) Planch.	3	de						X		
ULMACEAE	*Trema orientalis* (L.) Blume	3	eg	s					X	X	
URTICACEAE	*Boehmeria glomerulifera* Miq.	sh	eg	s		X					
URTICACEAE	*Debregeasia longifolia* (N. Burman) Wedd.	4	eg	s		X		X			
VERBENACEAE	*Callicarpa tomentosa* (L.) Murr.	4	eg	s		X	X	X	X	X	
VERBENACEAE	*Clerodendron viscosum* Vent.	4	eg	s		X	X	X	X	X	X
VERBENACEAE	*Gmelina arborea* Roxb.	3	de					X	X	X	X
VERBENACEAE	*Gmelina asiatica* L.	4	de								X
VERBENACEAE	*Lantana camara* L. var. aculeata	4	de				X	X		X	X
VERBENACEAE	*Premna coriacea* Cl.	L	eg	s		X					
VERBENACEAE	*Tectona grandis* L.f.	2	de	s		X		X	X	X	X
VERBENACEAE	*Vitex altissima* L. f.	2	de	s		X	X	X	X	X	
VITACEAE	*Cayratia japonica* (Thunb.) Gagnep.	c	eg	s		X	X	X	X	X	
VITACEAE	*Cissus gigantea* Bedel	c	eg	s						X	
VITACEAE	*Cissus repanda* Vahl.	L	eg	s			X	X			
VITACEAE	*Cissus* sp.	c	eg	s		X					
VITACEAE	*Vitaceae* xxxx	L	eg	s			X		X		
ZINGIBERACEAE	*Curcuma neilgherrensis* Wt.	h	eg	s		X	X	X	X	X	X
ZINGIBERACEAE	*Globba bulbifera* Roxb.	h	eg	s		X			X		
(unidentified)	Unidentifed Ho 3	L	eg	?		X					
(unidentified)	Unidentified Ha 1	L	eg	?						X	
(unidentified)	Unidentified Ha 2	3	de	?						X	
(unidentified)	Unidentified Ha 3	2	de	?						X	
(unidentified)	Unidentified Ho 1	L	eg	?		X					
(unidentified)	Unidentified Ho 2	L	eg	?		X					
(unidentified)	Unidentified Ho 6	L	eg	?		X		X			
(unidentified)	Unidentified Ho 7	L	eg	?				X			
(unidentified)	Unidentified Ho 9	L	eg	?		X					
(unidentified)	Unidentified Ka 1	4	eg	?				X			
(unidentified)	Unidentified Ka 3	L	eg	?				X			
(unidentified)	Unidentified Ka 5	L	eg	?				X			
(unidentified)	Unidentified Ka 6	L	eg	?				X			
(unidentified)	Unidentified Kal 2	L	eg	?		X					
(unidentified)	Unidentified Kal 3	L	eg	?		X					
(unidentified)	Unidentified Kop 1	L	eg	?		X					
(unidentified)	Unidentified Sag 2	L	eg	?		X					
(unidentified)	Unidentified Sh 1	L	eg	?		X					
(unidentified)	Unidentified Sh 2	L	eg	?		X					
(unidentified)	Unidentified Sh 3	L	eg	?		X					
(unidentified)	Unidentified Sh 4	L	eg	?		X					
(unidentified)	Unidentified Sh 5	L	eg	?					X		
(unidentified)	unidentified Sh 6	4	eg	?			X				
(unidentified)	Unidentified Si 1	L	eg	?					X		
(unidentified)	Unidentified Si 4	L	eg	?					X		
(unidentified)	Unidentified Ye 1	4	eg	?				X			
(unidentified)	Unidentified Ye 4	3	de								X
(unidentified)	Unidentified Ye 5	4	eg	?				X			
(unidentified)	Unknown dead	xx	eg	?		X					

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