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Full Length Research Paper

Vegetation analysis of Montane forest of Western Ghats with special emphasis on RET species

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The paper provides a synoptic account of the floristic diversity of the montane forest of Western Ghats of India. Present study has revealed the occurrence of 286 species of plants belonging to 85 families. Among them, 88 rare, endangered and threatened (RET) species were recorded justifying the inclusion of the area in the Western Ghats Hotspot. The rapid growth in tourism has created more infrastructure, increased pollution, put unsustainable demands on local environments and generated adverse impacts on biodiversity. Damaging these natural resources is not only detrimental to the biodiversity of the world, but to the tourism industry itself. Good biodiversity management is good business for tourism companies. Through contributing to the conservation of biodiversity, tourism companies can improve the quality of the service or product provided, enhance their reputation, increase recognition, publicise themselves, save on costs and increase their income. Significantly can contribute towards making tourism sustainable and guaranteeing the livelihoods of people who work within or benefit from the tourism industry now and in the future. The Landuse/Land Cover (LULC) changes in the extent of different landuse categories during the period from 1969 to 2010 was carried out. The paper discusses the negative impacts of tourism on phytodiversity which pinpoints the importance for the conservation of grasslands by means of different diversity indices.

Key words: RET species, endemic flora, biodiversity indices.

INTRODUCTION

Life on Earth depends on the components of biological diversity. Biodiversity maintains essential ecosystem functions including primary production and decomposition. Humans are part of biodiversity, but their activities, deficient knowledge and ever-increasing demand on natural resources are among the main causes for the loss of diversity in the living world. Conservation of plant diversity assumes greater importance when the world is facing unprecedented loss of biological diversity. As per an estimate about 60,000 out of 2,87,655 species of plants known in the world are facing the threat of extinction. 11,824 species were evaluated for their threat status as per the revised 1994 IUCN Red List Categories; of these 8321 species are now on the IUCN Red List 2004 (IUCN, 2004). Shola forests are unique montane vegetation occupying temperate habitats in tropical latitude and are communities restricted to valley and depressions especially along the folds of hills.

The montane grasslands and adjacent evergreen tropical forests (locally called the shola forests) form a distinctive vegetation mosaic. The Western Ghats are a mountain range that runs north-south parallel to the western coastline of the Indian peninsula from 8° N to 22° N. The montane grasslands and adjacent forests face several threats largely due to increasing anthropogenic activities (Pramod et al., 1997). Once widespread across the high altitudes of Western Ghats, the grasslands are

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now highly fragmented and restricted to approximately 400 km (Karunakaran et al., 1998). Unlike the adjacent forests (Gadgil and Vartak, 1975; Chandran et al., 1998; Brown et al., 2006), the grasslands have not received much attention from biologists and conservationists. Landscape level analysis of vegetation, especially from the Vagamon grasslands of Kerala are particularly lacking.

Biodiversity hotspots are areas that support natural ecosystems that are largely intact and where native species and communities associated with these ecosystems are well represented. They are also areas with a high diversity of locally endemic species, which are species that are not found or are rarely found outside the hotspot. Emphasis was given mainly on the plants that are endemic (to India) and/or in the rare, endangered and threatened (RET) category according to IUCN (International Union for Conservation of nature and Natural Resources). A rare species is one with small population that is not presently endangered but is at risk, an endangered species is one, which is in danger of extinction throughout all or of a significant portion of its range and a threatened species is one, which is likely to become endangered in foreseeable future (IUCN, 1978; Bryde, 1979; Smith 1980; Nayar and Sastry, 1990).

Study area

Across the world, 25 hotspots have been identified on the basis of species endemism and degree of threat through habitat loss (Myer et. al., 2000). Out of these, two are confined to India sub-continent (that is, Western Ghats / SriLanka and Indo-Burma). The present study site falls within the Western Ghats.

Vagamon (9° 66' and 9° 73´ N latitude and 76° 86´ to 76° 98´ E longitude) has been identified as a biodiversity 'hotspot'. Urban development in the area is generally low; the climate is equitable, ranging from 32°C in summer to 16°C in winter. With an average annual rainfall of about 376 cm, Vagamon receives rain for about 200 days a year. The enchanting hill station dotted with tea gardens will soon be the venue of one of State's foremost eco-tourism projects. The Vagamon hills scattered at a height of about 1,100 m above the mean sea level with delightfully attractive meadows, open forests, waterfalls and valleys offer adventure enthusiasts and nature lover's endless opportunities. Introduction of tourism development activities may result in the deterioration of the ecology of the hills. Extensive developmental activities like road construction in hilly areas will undermine the stability of hill slopes and may cause hazards like landslides. Hence the concept of sustainable development becomes very pertinent for hilly regions, which is influenced to some extent by the climate of the plains; they contain the sources, the catchments and the watersheds of several major river systems, which flow down to the plains; they flourish in natural vegetation and mineral wealth.

The grassland ecosystems has been subjected to particularly intense pressure for the upcoming tourism activities, so current extinction rates of grassland species are expected to remain high or even increase. However, research on these grasslands is scanty and highly dispersed. The main aim of the paper was to consider current processes and future scenarios for grassland biodiversity. It also gives emphasis for the need for conservation of the grasslands and shoal forest.

MATERIALS AND METHODS

Remote sensing techniques are particularly suited for providing reliable, up-to-date and comprehensive data on land-use/land-cover. Apart from the field investigations, SOI Toposheets (1967) (58C/14) and IRS-P 6 LISS III data (Feb. 19, 2004) were used for preparing the land-use map of the area (Figure 2). Different thematic maps were prepared using map info version 5 and 7. The Landuse/Land Cover (LULC) changes in the extent of a,b land use categories during the period from 1967 to 2009 have been carried out.

The study was conducted during the year 2007 to 2010. Plots were laid put by stratified random approach. The plants were identified with the help of Flora of British India (Hooker, 1872-1897), Flora of Presidency of Madras (Gamble and Fischer, 1915-1936), Indian Medicinal Plants (Basu, 1975), Flora of Palghat (Vajravelu, 1990), Flora of Thiruvananthapuram (Mohanan and Henry, 1994), Flowering Plants of Thrissur Forest (Sasidharan and Sivarajan, 1996), 100 Red Listed Medicinal Plants of Conservation Concern in Southern India (Ravikumar and Ved, 2000) and other regional floras. The identification of endemic plants was done by way of standard books such as Endemic Plants of the Indian Region (Ahmedulla and Nayar, 1987), Red Data Book of Indian Plants (Nayar and Sastry, 1987, 1988, 1990), Hot Spots of Endemic Plants of India, Nepal and Bhutan (Nayar, 1996) and Flowering Plants of Kerala (Sasidharan, 2004).

Researchers have applied different indices in order to measure diversity (Krebs, 1998). In most studies about biodiversity, Alpha and Beta diversities have been considered (Pitkanen, 1998). Alpha diversity has been species diversity in a region (Whittaker, 1972) and Beta diversity mentions to the amount of changes of species in environmental gradient length (Whittaker, 1972; Wilson and Shmida, 1984). In the present article, alpha diversity and beta diversity have been studied and important indices of species diversity and evenness were calculated.

For vegetation study, qualitative and quantitative methods were employed. The qualitative method included the collection, identification and verification of plant components using standard flora and herbarium. The entire flora from these plots were counted and identified by following standard keys (Gamble and Fischer, 1915 - 1936). Final identification of materials was done after consulting relevant literature and expert judgment. The nomenclature of each species has been brought up to date as per rules given in the International Code of Botanical Nomenclature (1988).

For analyzing the vegetation quantitatively, quadrate method was employed. The size of the quadrate was determined by the species area curve method. Quadrates of different sizes such as 10 x 10 m for trees, 5 x 5 m for shrubs and climbers and 1 x 1 m for herbs and grasses were laid. The forest dominant communities such as the trees were given importance. The plant components were taxonomically identified, counted and measured. Girth at breast

Table 1. List of RET species.

Species	Vernacular name	Family	Distribution	Status
Actinodaphne campanulata Hook. f.		Lauraceae	Endemic to the Western Ghats	Endangered (IUCN, 2000).
Actinodaphne malabarica Balakr.	Kambilivirinji	Lauraceae	Endemic to Southern Western Ghats	Rare (Nayar, 1997)
Aeschynanthus perrottetii A. DC.		Gesneriaceae	Endemic to Western Ghats	
Allophylus concanicus Radlk.		Sapindaceae	Endemic to Western Ghats	Rare (Nayar and Sastry, 1988)
Amomum pterocarpum Thw.	Peralam	Zingiberaceae	Endemic to Western Ghats	Rare (Nayar, 1997)
Anaphalis lawii (Hook. f.) Gamble		Asteraceae	Endemic to Peninsular India	
Anaphyllum wightii Schott	Keerikizhangu	Araceae	Endemic to Southern Western Ghats	Threatened (Nayar, 1997)
Andrographis explicata (Clarke) Gamble		Acanthaceae	Endemic to Western Ghats	Rare (Nayar, 1997)
Arthraxon lanceolatus (Roxb.) Hochst.		Poaceae		Threatened
Artocarpus hirsutus Lam.	Angili	Moraceae	Endemic to Southern Western Ghats	Endangered
Asystasia gangetica (L.) Anders.	Upputhali	Acanthaceae	Endemic to Peninsular India, Sri Lanka, Arabia and Africa	
Begonia albo-coccinea Hook.		Begoniaceae	Endemic to Southern Western Ghats	Vulnerable (Nayar, 1997)
Begonia trichocarpa Dalz.		Begoniaceae	Endemic to Western Ghats	Vulnerable (Nayar, 1997)
Belosynapsis vivipara (Dalz.)		Commelinaceae	Endemic to Western Ghats	Vulnerable (Nayar, 1997)
Bentinckia condapanna Berry and Roxb.	Kantha-kamugu	Araceae	Endemic to Southern Western Ghats	Vulnerable (IUCN, 2000).
Boesenbergia pulcherrima (Wall.) O. Ktze.		Zingiberaceae	Endemic to Southern Western Ghats	Threatened (Nayar, 1997)
Calamus delessertianus Becc.	Chooral	Arecaceae	Endemic to Western Ghats	
Ceropegia maculata Bedd.		Asclepiadaceae		Possibly extinct
Christisonia tubulosa (Wight) Benth. ex Hook. f.		Orobanchaceae	Endemic to Southern Western Ghats	
Cinnamomum malabatrum (Burm. f.) Blume	Vayana	Lauraceae	Endemis to Southern Western Ghats	
Cinnamomum sulphuratum Nees	Kattu karuva	Lauraceae	Endemic to Western Ghats	
Crinum defixum Ker-Gawl.	Veluthapolathali	Amaryllidaceae	Endemic to India and Sri Lanka	
Crotalaria barbata Grah. Ex Wight and Arn.		Fabaceae	Endemic to Southern Western Ghats	Rare (Nayar, 1997)
Crotalaria grahamiana Wight and Arn.		Fabaceae	Endemic to Southern Western Ghats	Rare (Ahmedullah and Nayar, 1987)
Crotalaria obtecta Grah. ex Wight and Arn.		Fabaceae	Endemic to Southern Western Ghats	Rare
Cullenia exarillata Robyns	Kurunguplavu	Bombacaceae	Endemic to Southern Western Ghats	
Cyclea fissicalyx Dunn		Menispermaceae	Endemic to Southern Western Ghats	Rare and Threatened (Ahmedullah and Nayar, 1987)
Cymbopogon flexuosus (Nees ex Steud). Wats.	Chukkunari pullu	Poaceae	Endemic to India and South East Asia	
Cynanchum alatum Wight and Arn.		Asclepiadaceae	Endemic to Southern Western Ghats	Rare (Nayar, 1997)
Debregeasia ceylanica Hook. f.		Urticaceae		Threatened
Dendrobium haemoglossum Thw.		Orchidaceae		Threatened
Desmos viridiflorus (Bedd.) Safford		Annonaceae	Endemic to Southern Western Ghats	Endangered (Nayar, 1997)
Dictyospermum montanum Wight		Commelinaceae	Endemic to Peninsular India	

Table 1. Continued

Dictyospermum ovalifolium Wight		Commelinaceae	Endemic to Western Ghats	Rare (Nayar and Sastry, 1987)
Didymocarpus fischeri Gamble		Gesneriaceae	Endemic to Southern Western Ghats	Vulnerable (Nayar, 1997)
Ensete superbum (Roxb.) Cheesman.	Kalluvazha	Musaceae	Endemic to Peninsular India	
Exacum bicolor Roxb.		Gentianaceae	Endemic to Peninsular India	
Exacum courtallense Arn.		Gentianaceae	Endemic to Southern Western Ghats	Rare (Nayar, 1997)
Flueggea leucopyrus Willd.	Amboorippachila	Euphorbiaceae	Endemic to India, Sri Lanka and Myanmar	
Globba marantina L.		Zingiberaceae	Endemic to Peninsular India	
Glochidion bourdillonii Gamble		Euphorbiaceae	Endemic to Peninsular India	Vulnerable (IUCN, 2000).
Glycosmis macrocarpa Wight		Rutaceae	Endemic to South India and Sri Lanka	Rare (Nayar, 1997)
Goniothalamus wightii Hook. f.and Thoms.		Annonaceae	Endemic to Southern Western Ghats	
Grewia hirsuta Vahl.		Tiliaceae	Endemic to India, Sri Lanka and Bangladesh	Common
Hedyotis swertioides Hook. f.		Rubiaceae	Endemic to Southern Western Ghats	Rare (Nayar, 1997)
Hoya retusa Dalz.		Asclepiadaceae	Endemic to Western Ghats	Threatened
Impatiens acaulis Arn.		Balsaminaceae		Threatened (Nayar, 1997)
Impatiens cordata Wight.		Balsaminaceae	Endemic to Southern Western Ghats	
Impatiens herbicola Hook. f.		Balsaminaceae		Vulnerable (Nayar, 1997)
Impatiens parasitica Bedd.		Balsaminaceae	Endemic to Southern Western Ghats	
Litsea floribunda (Blume) Gamble	Pattuthali	Lauraceae	Endemic to Western Ghats	
Mallotus philippensis (Lam.) Meull. Arg.		Euphorbiaceae	Endemic to Peninsular India	
Medinilla beddomei Clarke		Marantaceae	Endemic to Southern Western Ghats	
Memecylon lawsonii Gamble		Melastomataceae	Endemic to Southern Western Ghats	Vulnerable (IUCN, 2000).
Mussaenda belilla Buch.-Ham.	Vellila	Rubiaceae	Endemic to Western Ghats	
Myristica malabarica Lamk.	Panampalaka	Myristicaceae	Endemic to Western Ghats	Vulnerable (IUCN, 2000).
Nothopegia racemosa (Dalz.) Ramam.	Naicheru	Anacardiaceae	Endemic to Western Ghats	
Ochlandra scriptoria (Dennst.) Fischer	Eera	Poaceae	Endemic to Western Ghats	
Ochlandra travancorica (Bedd.) Benth. ex Gamble	Eetta	Poaceae	Endemic to Western Ghats	
Osbeckia aspera (L.) Blume		Melastomataceae	Endemic to Southern Western Ghats	Possibly extinct (Nayar, 1997)
Pecteilis gigantea (Smith) Rafin.		Orchidaceae		Threatened
Peucedanum anamallayense Clarke		Apiaceae	Endemic to Southern Western Ghats	Endangered (Nayar, 1997)
Phaeanthus malabaricus Bedd.		Annonaceae	Endemic to Southern Western Ghats	Lower risk: near threatened (IUCN, 2000)
Phoenix sylvestris (L.) Roxb.		Arecaceae	Endemic to India, Sri Lanka, Himalaya and Myanmar	
Piper mullesua Buch.-Ham. ex D. zdon	Kattukurumulaku	Piperaceae	Endemic to Peninsular and north east India	
Premna glaberrima Wight		Verbenaceae	Endemic to Southern Western Ghats	Rare (Nayar, 1997)
Pterocarpus santalinus L. f.	Raktha Chandanam	Fabaceae	Endemic to India, Sri Lanka and Pakistan	
Pterospermum reticulatum Wight. and Arn.	Malyuram	Sterculiaceae	Endemic to Southern Western Ghats	Vulnerable (IUCN, 2000).

Table 1. Continued.

Rauvolfia micrantha Hook. f.		Apocynaceae	Endemic to Southern Western Ghats	Endangered (Nayar, 1997)
Rubus ellipticus Smith.		Rosaceae	Endemic to India, Sri Lanka and Myanmar	
Semecarpus auriculata Bedd.	Vellacheru	Anacardiaceae	Endemic to Southern Western Ghats	Lower risk: near threatened (IUCN, 2000)
Smithia venkobarowii Gamble		Fabaceae	Endemic to Southern Western Ghats	Possibly extinct (Nayar, 1997)
Solanum anguivi Lam.	Neelavazhutina	Solanaceae	Endemic to Peninsular India	
Sonerila sahyadrica Giri and Nayar		Melastomataceae	Endemic to Southern Western Ghats	Rare (Nayar, 1997)
Strobilanthes ciliatus Nees	Karimkurinji	Acanthaceae	Endemic to Peninsular India	
Syzygium cumini (L.) Skeels		Myrtaceae	Endemic to Southern Western Ghats	
Syzygium mundagam (Bourd.) Chitra	Kattuchampa	Myrtaceae	Endemic to Southern Western Ghats	Rare
Tabernaemontana heyneana Wall.	Kundalappala	Apocynaceae	Endemic to Southern Western Ghats	Lower risk: near threatened (IUCN, 2000)
Terminalia paniculata Roth.	Maruthu	Combretaceae	Endemic to Peninsular India	
Thunbergia mysorensis (Wight) Anders.		Acanthaceae	Endemic to Western Ghats	
Torenia bicolor Dalz.	Kakkapoovu	Scrophulariaceae	Endemic to Western Ghats	
Vanasushava pedata (Wight) Mukh. and Const.		Apiaceae	Endemic to Southern Western Ghats	Rare (Nayar, 1997)
Vanda tessellata (Roxb.) Hook. ex D. Don	Arathamaravazha	Euphorbiaceae	Endemic to India, Myanmar, China and Sri Lanka	
Vernonia multibracteata Gamble		Asteraceae	Endemic to Southern Western Ghats	Possibly extinct (Nayar, 1997)
Wrightia tinctoria (Roxb.)	Vetttupala	Apocynaceae	Endemic to India, Myanmar and Timor	
Xanthophyllum arnottianum Wight.	Maddaka	Xanthophyllaceae	Endemic to Western Ghats	
Xanthophyllum flavescens non Roxb.	Mottal	Xanthophyllaceae	Endemic to Western Ghats	
Xanthophyllum flavescens non Roxb.	Mottal	Xanthophyllaceae	Endemic to Western Ghats	

height (GBH), total height as well as the bole height were measured. For each vegetation type, the structural attributes and Importance value index (IVI) were computed as described in Muller-Dombois and Ellenberg (1978) and explained below. Importance value index is a statistical quantity, which gives the overall dominance of a species in the entire community. The importance value index (IVI) for the tree species was determined as the sum of the relative density, relative frequency and relative dominance (Curtis, 1959). These characters were analyzed by following the methods of Curtis and McIntosh (1950) and Misra (1968) (Table 1). Alpha and beta diversities for different species were computed.

Sum of basal cover of individual plants of a species will yield total stand basal cover of that species. Basal area = $(GBH)^2 / 4\pi$; where, GBH = 2 πr. Absolute value which is the simplest beta diversity is the total number of species that are unique between communities (Meffe et al., 2002). The Sorensen index is a very simple measure of beta diversity, ranging from a value of 0 where there is no species overlap between the communities, to a value of 1 when exactly the same species are found in both communities (Sorensen, 1948 in Looman and Campbell, 1960). The number of species per sample is a measure of richness. The more species present in a sample, the 'richer' the sample. Menhinick's richness index is the ratio of the number of taxa to the square root of sample size. Simpson's Index It measures the probability that two individuals randomly selected from a sample will belong to the same species. The tree species diversity was determined by using Shannon-Wiener information function (H´) (Shannon and Wiener, 1963). Berger-Parker dominance is simply the number of individuals in the dominant taxon relative to *n,* It is simply a measure of the numerical importance of the most abundant species. The Gini coefficient is a measure of the inequality of a distribution, a value of 0 expressing total equality and a value of 1 maximal inequality. The Gini coefficient can range from 0 to 1.

RESULTS

The total land use of the study area of Vagamon was 104.3 km^2. The various landuse patterns were classified as (i) open scrub, (ii) tea cultivation, (iii) flood plain, (iv) Kurishumala

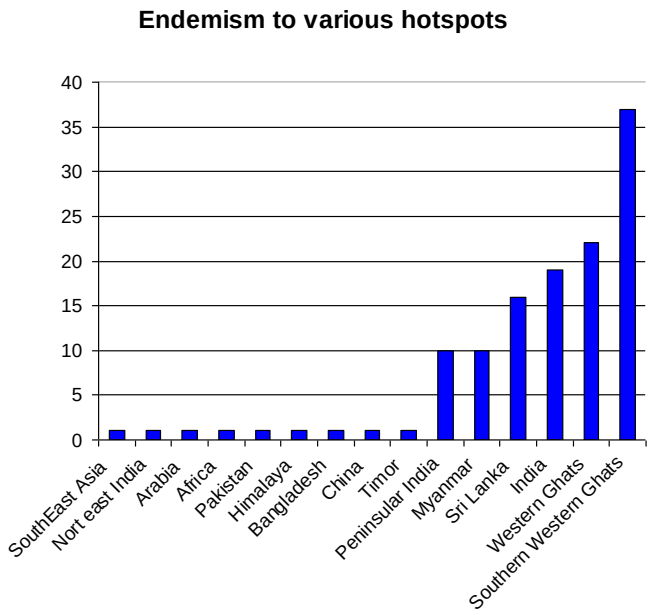

Figure 1. Endemism to various hotspots.

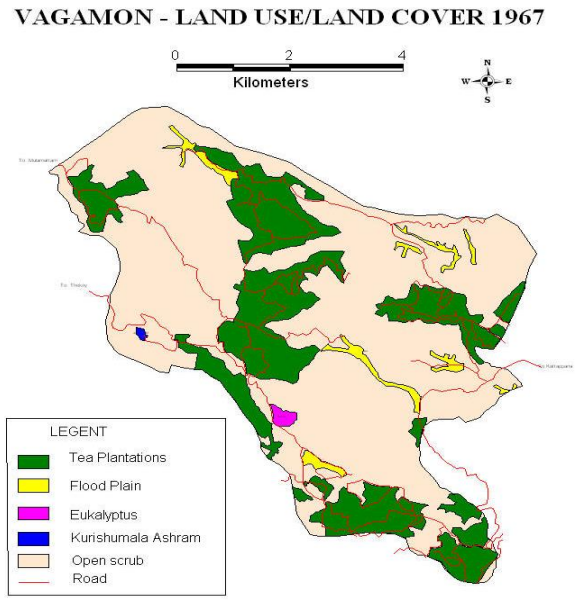

Figure 2a. Landuse/land cover of Vagamon, 1967 (Map 1).

Ashramam, (v) green meadows, (vi) built up land, (vii) mixed crop with settlement, (viii) pine forest and (ix) eucalyptus.Majority of the land area consists of open scrub with the land area 76.48 km^2 in 1967 to 1969, which reduced to 71.49 km^2 in 2009. The cultivation of tea in the area commenced at the time of British rule. The tea plantation area in 1967 to 1969 was 25.02 km^2; but in 2009 it increased to 26.9 km^2. The flood plain area in 1967 to 1969 was 2.39 km^2; it was reduced to 2.08 km^2 in 2009 (Map 2). The land area of Kurishumala Ashramam was 0.08 km^2 and the area of green meadows in was 0.33 km^2. The built up land, mixed crop with settlement, pine forest and eucalyptus are the additional land use patterns after 1967 (Map 1). The built up land comprises an area of 2.187 km^2; the mixed crop with settlement 0.18 km^2; the pine forest covers 0.51 km^2 and eucalyptus area ranges up to 0.55 km^2.

Present study has revealed the occurrence of 286 species of plants belonging to 85 families. Among them, 88 endemic species were recorded justifying the inclusion of the area in the Western Ghats Hotspot (Table 1, 4). The most abundant species are from the families such as Asteraceae (19 spp.), Euphorbiaceae (14 spp.). Fabaceae (15 spp.) Rubiaceae (nine spp.), Orchidaceae (eight spp.) Araceae (nine spp.) Acanthaceae (9 spp.) and Poaceae (14 spp.). The quadrate analysis in 22 sites of the study area shows there are eight species of trees identified with *Memecylon* and *Cinnamomum* with great frequency of occurrence and *Syzygium cumini* with lesser frequency of occurrence. The percentage of Sorensen's similarity index is 100%, this shows the true grassland nature of the study area. Whittaker's Index is calculated as 1 and the total number of Common Species is

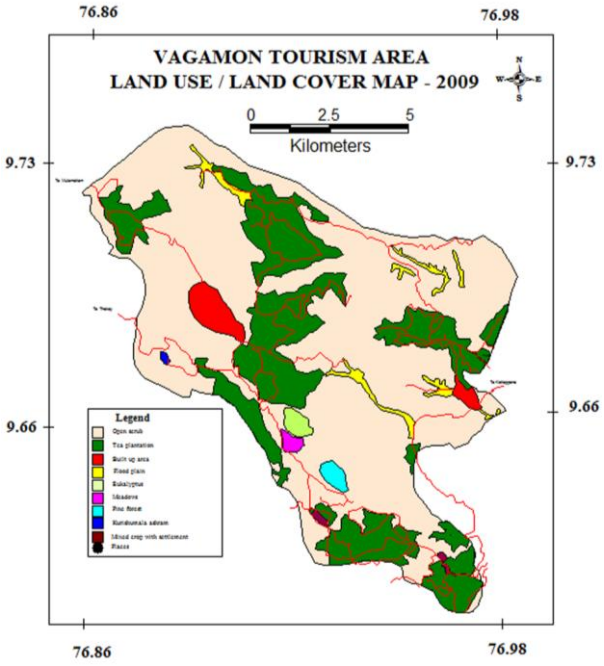

Figure 2b. Landuse/land cover of Vagamon, 2009.

calculated eight. Equitability is the evenness with which the individuals are spread out among the species in a community, the observed value in the study area is 0.7. 88 endemic species recorded as part of this study belong to 43 families (Table 3). Flora has been categorized according to IUCN (2004) (Table 2 and Figure 1).

Table 2. Categorization of plants according to IUCN (2004)

S/N	Category	Number
1	Endangered	5
2	Lower risk: near threatened	3
3	Possibly extinct	4
4	Rare	17
5	Threatened	8
6	Vulnerable	10

The quadrate analysis of the study area consists of 10 x 10, 5 x 5 and 1 x 1 m quadrates for the identification of trees, herbs, shrubs and seedlings and the grasses, respectively. Eight species of trees were identified. *Memecylon* and *Cinnamomum* had the highest frequency of occurrence followed by *Syzygium cumini* with lesser frequency of occurrence. High abundance is shown by *Maesa indica* and high relative density is shown by *S. cumini* and less by *M. indica*. High relative frequency is shown by *S. cumini* (12.6) *M. indica* (6.3), *Symplocos cochinchinensis* (6.3), *Olea dioica* (6.3), *Litsea* (6.3) and the tree belonging to Rubiacea (6.3). The high relative basal area is observed for *S. cumini* and it also shows high important value index (IVI).

The analysis of herbs, shrubs and seedlings and grasses show that high percentage is shown by *M. indica, C. odorata, Urena lobata*, and *Lantana camara*. The grass species with high percentage frequency include *Axonopus compresses, Justicia* spp*., Mimosa pudica* and *Ischaemum* sp. The density of the species *Pteridium aquilium*, *L. camara* and *M. pudica* is high compared to other observed species. *Pteridium aquilium, Symplocos* spp., *M. pudica* and *Ageratum conyzoides* also show high abundance. *Glochidion zeylanicum, Meliosma simplicifolia, Ficus hispida*, *Schefflera* spp. *Albizia, Desmodium triflorum, Ixora, Citrus, Flueggea, Cyclea, Pandanus, Plectranthus, Cymbopogon flexuosus, Desmodium heterophyllum, Alternanthera sessilis, Andrographis explicate, Vernonia cinerea* and *Chromolaena odorata* show high relative density. The relative frequency of herbs, shrubs, seedlings and grasses shows that *Vernonia, Clidemia hirta, G. zeylanicum, Meliosma simplicifolia, Cissampelos pareira, Solanum nguivi, Asclepias curassavica, Ficus hispida, Sida acuta, Triumfetta rhomboidea Pteris, Leucas ciliate, Smithia, Schefflera* sp., *Vernonia arborea, Xanthophyllum arnottianum, Albizia, D. triflorum, Andrographis, Anaphalis lawii, Blumea, Phoenix sylvestris, Psidium guajava, Jasminum* sps*, Osbeckia* spp., *Memecylon, Asparagus, Ixora, Citrus, Litsea, Flueggea, Cyclea, Pandanus, Plectranthus, Rauvolfia, Cymbopogon flexuosus, Desmodium heterophyllum, D. triflorum,Themeda sraes* and *Sporobulus* sp. are the relatively high frequency ones. *Smilax zeylanica,*

Table 3. Number of families.

S. No.	Family	Number of occurrence
1	Acanthaceae	4
2	Amaryllidaceae	1
3	Anacardiaceae	2
4	Annonaceae	3
5	Apiaceae	2
6	Apocynaceae	3
7	Araceae	2
8	Arecaceae	2
9	Asclepiadaceae	3
10	Asteraceae	2
11	Balsaminaceae	4
12	Begoniaceae	2
13	Bombacaceae	1
14	Combretaceae	1
15	Commelinaceae	3
16	Euphorbiaceae	4
17	Fabaceae	5
18	Gentianaceae	2
19	Gesneriaceae	2
20	Lauraceae	5
21	Marantaceae	1
22	Melastomataceae	3
23	Menispermaceae	1
24	Moraceae	1
25	Musaceae	1
26	Myristicaceae	1
27	Myrtaceae	2
28	Orchidaceae	2
29	Orobanchaceae	1
30	Piperaceae	1
31	Poaceae	4
32	Rosaceae	1
33	Rubiaceae	2
34	Rutaceae	1
35	Sapindaceae	1
36	Scrophulariaceae	1
37	Solanaceae	1
38	Sterculiaceae	1
39	Tiliaceae	1
40	Urticaceae	1
41	Verbenaceae	1
42	Xanthophyllaceae	3
43	Zingiberaceae	3

Vernonia, C. hirta, G. zeylanicum, Meliosma simplicifolia, *Crotalaria, Cissampelos pareira, Solanum anguivi,Asclepias curassavica, Ficus hispida, Albizia, D. triflorum, Ixora, Citrus, Flueggea, Cyclea, Pandanus* and *Plectranthus* show high important value index (IVI).

Table 4. Quantitative analysis of floristic diversity of Vagamon.

S/N	Species	Frequency (%)	Density	Abundance	Relative density	Relative frequency	Relative basal area	IVI
Trees								
1	*Maesa indica*	40	6.6	16.5	0.28	6.3	0	6.58
2	*Symplocos cochinchinensis*	40	1.2	3	1.57	6.3	1.9	9.77
3	*Syzygium cumini*	20	0.2	1	9.42	12.6	4.5	26.52
4	*Olea dioica*	40	1	2.5	1.88	6.3	1.17	9.35
5	*Litsea*	40	0.6	1.5	3.14	6.3	2.21	11.65
6	*Cinnamomum*	60	0.6	1	3.14	4.2	2.2	9.54
7	*Memecylon*	80	0.8	1	2.35	3.1	1.77	7.22
8	*Rubiaceae tree*	40	0.4	1	4.71	6.3	3.21	14.22
Herbs, shrubs and seedlings								
1	*Maesa indica*	80	6.6	8.25	0.28	3.1	0	3.38
2	*Chromolaena odorata*	80	6.2	7.75	0.3	3.1	0	3.4
3	*Cinnamomum malabatrum*	40	1	2.5	1.88	6.3	0	8.18
4	*Pteridium aquilium*	40	47.8	119.5	0.39	6.3	0	6.69
5	*Stachytarpheta jamaicensis*	40	4	10	0.47	6.3	0	6.77
6	*Urena lobata*	80	1	1.25	1.88	3.1	0	4.98
7	*Actinodaphne malabarica*	40	1	2.5	1.88	6.3	0	8.18
8	*Mikania micrantha*	40	0.8	2	2.35	6.3	0	8.65
9	*Olea dioica*	40	1	2.5	1.88	6.3	0	8.18
10	*Symplocos*	40	12.6	31.5	0.59	6.3	0	6.89
11	*Smilax zeylanica*	40	0.6	1.5	3.1	6.3	0	9.4
12	*Cymbopogon flexuosus*	40	2.2	10.5	0.85	6.3	0	6.88
13	*Lantana camara*	80	24.8	31	0.75	3.1	0	3.85
14	*Vernonia*	20	1.4	7	1.34	12.6	0	13.94
15	*Clidemia hirta*	20	3	15	0.62	12.6	0	13.22
16	*Rubus ellipticus*	40	1.4	3.5	1.34	6.3	0	7.64
17	*Lobelia nicotianifolia*	40	2.4	6	0.31	6.3	0	6.61
18	*Glochidion zeylanicum*	20	0.2	1	9.42	12.6	0	22.02
19	*Meliosma simplicifolia*	20	0.2	1	9.42	12.6	0	22.02
20	*Crotalaria*	20	1.4	7	1.34	12.6	0	13.94
21	*Cissampelos pareira*	20	0.4	2	4.71	12.6	0	17.31
22	*Solanum anguivi*	20	0.6	3	3.14	12.6	0	15.74
23	*Asclepias curassavica*	20	0.4	2	4.71	12.6	0	17.31
24	*Ficus hispida*	20	0.2	1	9.42	12.6	0	22.02
25	*Sida acuta*	20	0.4	2	4.71	12.6	0	17.31
26	*Triumfetta rhomboidea*	20	0.6	3	3.14	12.6	0	15.74
27	*Pteris*	20	0.8	4	2.35	12.6	0	14.95
29	*Leucas ciliate*	20	0.6	3	3.14	12.6	0	15.74
30	*Smithia*	20	0.4	2	4.71	12.6	0	17.31
31	*Schefflera sp.*	20	0.2	1	9.42	12.6	0	22.02
32	*Vernonia arborea*	20	0.4	2	4.71	12.6	0	17.31
33	*Xanthophyllum arnottianum*	20	0.4	2	4.71	12.6	0	17.31
34	*Albizia*	20	0.2	1	9.42	12.6	0	22.02
35	*Desmodium triflorum*	20	0.2	1	9.42	12.6	0	22.02
36	*Andrographis*	20	0.4	2	4.71	12.6	0	17.31
37	*Anaphalis lawii*	20	0.4	2	4.71	12.6	0	17.31
38	*Blumea*	20	0.8	4	3.14	12.6	0	15.74
39	*Phoenix sylvestris*	20	1.6	8	1.17	12.6	0	13.77

Table 4. Continued.

40	*Psidium guajava*	20	1.4	7	1.34	12.6	0	13.94
41	*Jasminum* spp.	20	0.8	4	2.35	12.6	0	14.95
42	*Osbeckia*	20	1.2	6	1.57	12.6	0	14.17
43	*Memecylon*	20	0.8	4	2.35	12.6	0	14.95
44	*Asparagus*	20	0.4	2	4.71	12.6	0	17.31
45	*Ixora*	20	0.2	1	9.42	12.6	0	22.02
46	*Citrus*	20	0.2	1	9.42	12.6	0	22.02
47	*Litsea*	20	0.4	2	4.71	12.6	0	17.31
49	*Flueggea*	20	0.2	1	9.42	12.6	0	22.02
50	*Cyclea*	20	0.2	1	9.42	12.6	0	22.02
51	*Pandanus*	20	0.2	1	9.42	12.6	0	22.02
52	*Plectranthus*	20	0.2	1	9.42	12.6	0	22.02
53	*Rauvolfia*	20	0.4	2	4.71	12.6	0	17.31
Grasses								
1	*Axonopus compresses*	60						
2	*Cymbopogon flexuosus*	20	0.2	1	9.42	12.6	0	
3	*Urena lobata*	40	0.8	2	2.35	6.3	0	
4	*Desmodium heterophyllum*	20	0.2	1	9.42	12.6	0	
5	*Desmodium triflorum*	20	0.4	2	4.71	12.6	0	
6	*Justicia*	60	3.8	6.3	4.94	4.2	0	
7	*Mimosa pudica*	60	22.4	37.3	8.41	4.2	0	
8	*Themeda sraes*	20	0.4	2	4.71	1.26	0	
9	*Ischaemum sp.*	60				4.2	0	
10	Unknown grass	20				12.6	0	
11	*Sporobulus sp.*	40	1.4	3.5	13.4	6.3	0	
12	*Unknown grass*			1			0	
13	*Andrographis explicate*	20	0.2	1	9.42	12.6	0	
14	*Alternanthera sessilis*	20	0.2	9	9.42	12.6	0	
15	*Ageratum conyzoides*	20	1.8	16	1.04	12.6	0	
16	*Bidens pilosa*	20	3.2	2	5.88	12.6	0	
17	*Emilia sonchifolia*	20	0.4	1	4.71	12.6	0	
18	*Vernonia cinerea*	20	0.2		9.42	12.6	0	
19	*Mikania micrantha*						0	
20	*Elephantopus scaber*	40	7.8	4.75	2.45	6.3	0	
21	*Leucas ciliate*	40	0.8	2	2.35	6.3	0	
22	*Stachytarpheta*	40	0.4	1	4.71	6.3	0	
23	*Chromolaena odorata*	20	0.2	1	9.42	12.6	0	

DISCUSSION

Species diversity is generated by species interaction such as competition and niche diversification (Pianka, 1966; Bada, 1984) which is both greatly manifested in the tropics due to high humidity and temperature (Ojo and Ola-Adams, 1996). There are 57 tree species identified in the Vagamon area.

Simpson's diversity index

Simpson's Diversity Index is a measure of diversity which takes into account the number of species present, as well as the relative abundance of each species. As species richness and evenness increase, so does diversity. The value of Simpson's index ranges between 0 and 1. With this index, 1 represents infinite diversity and 0, no diversity (Simpson, 1949). The Simpsons index of the Vagamon area is calculated as 0.36 and the Dominance Index (D = 1 - Simpson) of Vagamon is 0.65 which shows moderate biodiversity in the area even though it is grassland.

Shannon index

Shannon index (entropy) is a diversity index, taking into

account the number of individuals as well as number of taxa. It varies from 0 for communities with only a single taxon to high values for communities with many taxa, each with few individuals.

H = -sum((n i /n)ln(n i /n)). Shannon-Wiener Index (log) is calculated as 2.09, Shannon-Wiener Index (ln) as 1.45 and the percentage of Shannon-Wiener Index (adjusted)* is 69.81%.

Menhinick's richness index

Menhinick's richness index is the ratio of the number of taxa to the square root of sample size. Menhinick Index of Vagamon is calculated as 1.06.

Margalef's richness index

Margale''s richness index is calculated by (S-1)/ln(n); where, S is the number of taxa, and n is the number of individuals. Margalef richness index for trees, grasses, herbs and shrubs are found to be 1.731, 3.539 and 7.975 respectively (Table 5, 6, 7)

Berger-Parker dominance

Berger-Parker dominance is simply the number of individuals in the dominant taxon relative to n. It is a simple measure of the numerical importance of the most abundant species. d = N max / N; where, N max is the number of individuals in the most abundant species, and N is the total number of individuals in the sample. The reciprocal of the index, 1/d, is often used, so that an increase in the value of the index accompanies an increase in diversity and a reduction in dominance. Berger-Parker dominance index of Vagamon is 0.58 and Inverted Berger-Parker dominance index is calculated as 1.73. It may also be expressed as its reciprocal, which has the advantage that low values indicate a low-diversity community and vice versa.

Absolute Beta value

Absolute beta value of Vagamon is calculated as 7.

Sorensen index

The Sorensen index is a very simple measure of beta diversity, ranging from a value of 0 where there is no species overlap between the communities, to a value of 1 when exactly the same species are found in both communities (Sorensen, 1948).

Sorensen's similarity index

Sorensen's similarity index is 1 and Sorensen's similarity index (%) is 100%, this shows the true grassland nature of Vagamon.

Whittaker's Index

Whittaker's Index is calculated as 1 and the total number of common species is calculated as 8.

Evenness

Equitability is the evenness with which the individuals are spread out among the species in a community, the observed value in the study area is 0.7.

Renyi entropy

The Rényi entropies are important in ecology and statistics as indices of diversity. The Rényi entropy, a generalization of Shannon entropy, is one of a family of functionals for quantifying the diversity, uncertainty or randomness of a system, the observed values of the study area shows higher diversity.

Gini index

The Gini coefficient is a measure of the inequality of a distribution; a value of 0 expressing total equality and a value of 1 indicate maximal inequality. The Gini coefficient can range from 0 to 1; it is sometimes multiplied by 100 to range between 0 and 100. A low Gini coefficient indicates a more equal distribution, with 0 corresponding to complete equality, the Gini coefficient in the Vagamon area is calculated as 2.23, which indicates higher equality of floral diversity in the grassland.

Total number of tree species identified in Vagamon is 56, with Simpson Index of 0.36, Shannon-Wiener Index (log):2.09 and Shannon-Wiener Index (adjusted) is 69.81%. The total number of herbs and shrubs identified in the Vagamon area by quantitative methods are 679 and the total species 53, the Simpson Index is 0.17, Dominance Index (D = 1 - Simpson) is calculated as 0.83. The index values consist of Shannon-Wiener index (log) 3.633, Menhinick index is 2.03, Sorensen's similarity index 1 and the adjusted Shannon-Wiener Index is the percent of the maximum possible diversity. The maximum is the log 2 ('total number of species'): 5.73 or ln('total number of species'): 3.97, depending on which formula is used. Total number of grasses is 501, Simpson index (∑(n i (n i -1)/(N(N-1)))): 0.17 and the dominance index (D = 1 - Simpson): 0.83. The different indexes clearly show that the area is rich in floristic diversity especially the patched shola in the hill valleys.

Many mountain ecosystems are host to higher species richness and levels of endemism than adjacent lowlands.

Table 5. Similarity index of trees of Vagamon.

Total number of tree species:	57	Total number of species:	8
Average population size:	7.125	Decimal accuracy:	4
Total Number of Regions:	1	Total number of region sets:	6
Alpha biodiversity			
Simpson Index ($\sum(n_i(n_i-1)/(N(N-1)))$):	0.3546	Alternate simpson index ($\sum((n/N))^2$):	0.366
Dominance Index (D = 1 - Simpson):	0.6454	Alternate dominance index (D = 1 - Simpson):	0.634
Reciprocal Simpson Index (1 / D):	2.82	Alternate Reciprocal Simpson Index (1 / D):	2.733
Shannon-Wiener Index (log):	2.094	Berger-Parker Dominance Index:	0.5789
Shannon-Wiener index (ln):	1.452	Inverted Berger-Parker dominance index:	1.727
Shannon-Wiener index (adjusted)*:	69.81%	Margalef richness index:	1.731
Menhinick index:	1.06	Rényi entropy/hill numbers (0,1,2,∞):	8, 4.283 2.733, ≈1.728
Buzas and Gibson's index:	0.5338	Gini coefficient:	2.234
Equitability index:	0.6981	ln() of Hill numbers (0,1,2,∞):	2.079, 1.455 1.005, ≈0.5471
Beta biodiversity			
Absolute beta value ($(S_0-c)-(S_1-c)...$):	7	Whittaker's index (S/alpha):	1
Sørensen's similarity index:	1	Alternate Whittaker's index (S/alpha-1):	0
Sørensen's similarity index (%):	100%	Number of common species:	8

Table 6. Similarity index of grasses of Vagamon.

Total number of organisms:	501	Total Number of Species:	23
Average population size:	21.78	Decimal Accuracy:	4
Total number of regions:	1	Total Number of Region Sets:	1
Alpha biodiversity			
Simpson index ($\sum(n_i(n_i-1)/(N(N-1)))$):	0.1656	Alternate Simpson index ($\sum((n/N))^2$):	0.1672
Dominance index (D = 1 - Simpson):	0.8344	Alternate dominance index (D = 1 - Simpson):	0.8328
Reciprocal Simpson index (1 / D):	6.04	Alternate reciprocal Simpson index (1 / D):	5.98
Shannon-Wiener index (log):	3.051	Berger-Parker dominance index:	0.2615
Shannon-Wiener index (ln):	2.115	Inverted Berger-Parker dominance index:	3.824
Shannon-Wiener index (adjusted)*:	67.44%	Margalef richness index:	3.539
Menhinick index:	1.028	Rényi entropy/hill numbers (0,1,2,∞):	23, 8.332 5.98, ≈∞
Buzas and Gibson's index:	0.3603	Gini Coeffificient:	5.031
Equitability index:	0.6744	ln() of hill numbers (0,1,2,∞):	3.135, 2.12 1.788, ≈-INF
Beta biodiversity			
absolute beta value ($(S_0-c)-(S_1-c)...$):	22	Whittaker's index (S/alpha):	1
Sørensen's similarity index:	1	Alternate Whittaker's index (S/alpha-1):	0
Sørensen's similarity index (%):	100%	Number of common species:	23

Mountains at lower altitudes can support exceptional biodiversity, due to compression of a wide range of ecosystems into a relatively short distance. Endemism levels are often high, particularly on mountains at medium elevations in the tropics and warmer temperate zones. The environment of a region is negatively influenced by the increase of tourism, whereas the growth of tourism depends on the quality and characteristics of the environment (Bushell, 2002). Vagamon, a highland area coming under Western Ghats

Table 7. Similarity index of Herbs and shrubs of Vagamon.

Total number of organisms:	679	Total number of species:	53
Average population size:	12.81	Decimal accuracy:	4
Total number of regions:	1	Total number of region sets:	1
Alpha biodiversity			
Simpson index ($\sum(n_i(n_i-1)/(N(N-1)))$):	0.1723	Alternate Simpson index ($\sum((n/N))^2$):	0.1735
Dominance index (D = 1 - Simpson):	0.8277	Alternate dominance index (D = 1 - Simpson):	0.8265
Reciprocal Simpson index (1 / D):	5.805	Alternate reciprocal Simpson index (1 / D):	5.765
Shannon-Wiener index (log):	3.633	Berger-Parker dominance index:	0.352
Shannon-Wiener index (ln):	2.518	Inverted Berger-Parker dominance index:	2.841
Shannon-Wiener index (adjusted)*:	63.42%	Margalef Richness index:	7.975
Menhinick index:	2.034	Rényi Entropy/Hill numbers (0,1,2,∞):	53, 10 5.765, ≈∞
Buzas and Gibson's index:	0.234	Gini coeffificient:	9.395
Equitability index:	0.6342	ln() of hill numbers (0,1,2,∞):	3.97, 2.532 1.752, ≈-INF
Beta biodiversity			
Absolute beta value ($(S_0-c)-(S_1-c)$...):	52	Whittaker's index (S/alpha):	1
Sørensen's similarity index:	1	Alternate Whittaker's index (S/alpha-1):	0
Sørensen's similarity index (%):	100%	Number of common species:	53

is a biodiversity rich area with good number of endemic species includes flora and fauna; unsustainable tourism development in the area leads the disappearance of endemic species and results biodiversity loss.

REFERENCES

Ahmedulla M, Nayar MP (1987). Endemic Plants of the Indian Region. Botanical Survey of India, Kolkata.

Bada SO (1984). Growth patterns in an untreated tropical rainforest ecosystem. PhD thesis, University of Ibadan, Nigeria.

Basu BD (1975). Indian Medicinal Plants. International book Distributors, Dehradun, India. Vol. 1-4.

Brown N, Bhagwat S, Watkinson S (2006). Macrofungal diversity in fragmented and disturbed forests of the Western Ghats of India. J. Appl. Ecol. 43:11-17.

Bryde MB (1979). Information needed to use the Endangered Species Act for Plant Conservation, (Geographical Data Organization, Rare plant conservation, New York).

Bushell R (2002). Healthy Tourism: a new approach to achieve sustainable outcomes. Proceedings of Tourism Development, Community and Conservation: Shaping Ecotourism for the Third Millennium International. Conference. Jhansi, India. Feb, 2002.

Chandran MDS, Gadgil M, Hughes JD (1998). Sacred groves of Western Ghats of India. In: P. S. Ramakrishnan, K. G. Saxena and U. M. Chandrashekara (eds.). Conserving the Sacred for Biodiversity and Management. Science Publishers, Inc. New Hampshire. pp. 211-232.

Curtis JT, McIntosh RP (1950). The interrelations of certain analytic and synthetic phytosociological characters. Ecology 31:434-455.

Curtis JT (1959). The Vegetation of Wisconsin, An Ordination of Plant Communities. University Wisconsin Press, Madison. Wisconsin.

Gadgil M, Vartak VD (1975). Sacred groves of India – A plea for continued conservation. J. Bombay Nat. Hist. Society 72:314-320.

JS, Fisher CEC (1936). Flora of the presidency of Madras. London. (Reprinted 1957), Calcutta.

Hooker JD (1897). The flora of British India London: L. Reeve and Co., 7:4.

IUCN (1978). Plant Red Data Book, (Royal Botanic Garden, Kew, England).

IUCN (2000). Plant Red Data Book, (Royal Botanic Garden, Kew, England).

IUCN Red List of Threatened Species (2004). A Global Species Assessment, The IUCN Species Survival Commission.

Karunakaran PV, Rawat GS, Uniya VK (1998). Ecology and Conservation of the Grasslands of Eravikulam National Park, Western Ghats. Wildlife Institute of India, Dehra Dun, India.

Krebs JC (1998). Ecological Methodology. Addison Wesley Longman Inc., ISBN: 13: 978-0321021731, 620 pp.

Looman J, Campbell JB (1960). Adaptation of Sorensen's K (1948) for estimating unit affinities in prairie vegetation. Ecology 41(3):409-416.

Meffe GK, Nielsen LA, Knight RL, Schenborn DA (2002). Ecosystem management: Adaptive, community-based conservation. Washington, D. C., U.S.A: Island Press.

Myer N, Russell A, Mittermelert C, Mittermelert G, Gustavo AB, Da Fonseca, Kents J (2000). Biodiversity hotspots for conservation priorities. Nature 24:853-858.

Misra R (1968). Ecology Work Book. Oxford and IBH Publishing Company, Calcutta.

Mohanan M, Henry AN (1994). Flora of Thiruvananthapuram, Kerala. Botanical Survey of India. Calcutta.

Mueller-Dombois D, Ellenberg H (1978). Aims and Methods of Vegetation Ecology. John Wiley and Sons, New York.

Nayar MP, Sastry ARK (1987, 1988, 1990). Red Data Book of Indian Plants, eds. 1-3. Botanical Survey of India, Howrah (Calcutta), India.

Nayar MP, Sastry ARK (1990). Red Data Book of Indian Plants, eds. 1-3. Botanical Survey of India, Howrah (Calcutta), India.

Ojo LO, Ola-Adams BA (1996). Measurement of tree diversity in the Nigerian rain forest. Biodivers. Conserv. 5:1253-1270.

Pianka ER (1966). Latitudinal gradients in species diversity: a review of concepts. Am. Nat. 100:33-46.

Pitkanen S (1998). The use of diversity indices to assess the diversity of vegetation in managed boreal forests. For. Ecol. Manag. 112:121-137.

Pramod P, Daniels RJR, Joshi NV, Gadgil M (1997). Evaluating bird communities of Western Ghats to plan for a biodiversity friendly development. Curr. Sci. 73:156-162.

Ravikumar K, Ved DK (2000). Illustrated Field Guide to 100 Red-Listed

Medicinal Plants of Conservation Concern in Southern India, FRLHT, Bangalore.
Sasidharan N, Sivarajan V (1996). Flowering Plants of Thrissur Forest. Sci. Pub., Jodhpur.
Sasidharan N (2004). Flowering plants of Kerala Kerala Forest Research Institute, Peechi, Thrissur.
Shannon CE, Weiner W (1963). The Mathematical theory of communication. University of Illinois Press. Urhana 117.
Simpson EM (1949). Measurement of diversity. Nature 163:688.
Smith EV (1980). Laws and information needs for listing plants. Rhodora 82:193.
Sorenson T (1948). A method of establishing groups of equal amplitude in plant sociology based on similarity of species content. Detkong Danske Vidensk Selk Boil. Skr. Copenhagen) 5:1-34.
Stafleu FA, Cowan RS (1988). International Code of Botanical Nomenclature (Saint Louis Code).
Vajravelu E (1990). Flora of Palghat District, including Silent Valley national park, Kerala (Calcutta: Botanical Survey of India) pp. 245-260.
Whittaker RH (1972). Evolution and measurement of species diversity. Taxon 21:213-251.
Wilson MV, Shamida A (1984). Measuring beta diversity with presence – absence data. J. Ecol. 72:1055-1064.