Journal of Threatened Taxa

Building evidence for conservation globally

www.threatenedtaxa.org

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

Communication

Comparative phytosociological assessment of three terrestrial ecosystems of Wayanad Wildlife Sanctuary, Kerala, India

M. Vishnu Chandran, S. Gopakumar & Anoopa Mathews

26 April 2020 | Vol. 12 | No. 5 | Pages: 15631–15645
DOI: 10.11609/jott.5754.12.5.15631-15645

For Focus, Scope, Aims, Policies, and Guidelines visit https://threatenedtaxa.org/index.php/JoTT/about/editorialPolicies#custom-0
For Article Submission Guidelines, visit https://threatenedtaxa.org/index.php/JoTT/about/submissions#onlineSubmissions
For Policies against Scientific Misconduct, visit https://threatenedtaxa.org/index.php/JoTT/about/editorialPolicies#custom-2
For reprints, contact <ravi@threatenedtaxa.org>

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 April 2020 | 12(5): 15631–15645
ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)
DOI: https://doi.org/10.11609/jott.4754.12.5.15631-15645
#4754 | Received 10 December 2018 | Final received 06 March 2020 | Finally accepted 01 April 2020
PLATINUM OPEN ACCESS

COMMUNICATION

Comparative phytosociological assessment of three terrestrial ecosystems of Wayanad Wildlife Sanctuary, Kerala, India

M. Vishnu Chandran [1], S. Gopakumar [2] & Anoopa Mathews [3]

[1,2] Department of Natural Resource Management, College of Forestry, Kerala Agricultural University, N.H. 47, Vellanikkara, Thrissur, Kerala 680656, India.
[3] Department of Geology and Environmental Science, Christ College, Irinjalakuda, Thrissur, Kerala 680125, India.
[1] vchandran187@gmail.com (corresponding author), [2] gopan.s@kau.in (corresponding author), [3] anuanoopamathews15@gmail.com

Abstract: Phytosociological studies were conducted in three vegetation types in the WS II area of Wayanad Wildlife Sanctuary. In each vegetation type, 85 quadrats (10 x 10 m) were laid to quantify the vegetation. Natural forest showed comparatively higher species richness than plantation and vayal (swamps/low lying grassland). In natural forest 96 plant species were present while it was 70 and 66 respectively in plantation and vayal. Fabaceae was the dominant family in all the three vegetation types. The natural forest was dominated by *Chromolaena odorata*, followed by *Lantana camara*, *Mimosa pudica*, *Terminalia elliptica*, *Glycosmis pentaphylla*. In the plantations, *Chromolaena odorata*, *Tectona grandis*, *Mimosa pudica* and *Glycosmis pentaphylla* showed dominance. The vayal was dominated by *Arundinella leptochloa*. The second most dominant species in the vayal was *Chromolaena odorata*. Other dominant species were *Kyllinga nemoralis* and *Sporobolus tenuissimus*. Among the three, vayal recorded the highest Simpson Diversity Index. The highest Berger-Parker Dominance Index value in plantation indicates the presence of dominant species. Natural forests recorded highest Margalef Richness Index and the least was in vayal. The highest Pielou's Wiener Equitability Index in vayal indicated all species are evenly distributed.

Keywords: Invasive alien species, phytosociology, Simpson Diversity Index, Wayanad Wildlife Sanctuary, Western Ghats.

Abbreviations: C—Climber | H—Herb | IVI—Important Value Index | NF—Natural Forest | S—Shrub | T—Tree | WS—Wildlife Sanctuary | WS II—Wildlife Sanctuary II.

സംഗ്രഹം: വയനാട് വന്യജീവി സങ്കേതത്തിലെ WS II പ്രദേശത്തെ മൂന്ന് ആവാസ വ്യവസ്ഥകളിൽ ഫൈറ്റോസോഷ്യോളജിക്കൽ പഠനങ്ങൾ നടത്തി. ഈ ഓരോ ആവാസ വ്യവസ്ഥകളിലും, സസ്യങ്ങളെ കണക്കാക്കാൻ വേണ്ടി 85 ക്വാഡ്രറ്റുകൾ (10x10 m) സ്ഥാപിച്ചു. തോട്ടം, വയൽ (ചതുപ്പുകൾ / താഴ്ന്ന പുൽമേടുകൾ) എന്നിവയേക്കാൾ താരതമ്യേന ഉയർന്ന ഇനം സസ്യ സമ്പന്നത പ്രകൃതിദത്ത വനങ്ങളിൽ കാണപ്പെട്ടു. പ്രകൃതിദത്ത വനങ്ങളിൽ 96 ഇനം സസ്യങ്ങളും തോട്ടത്തിലും വയലിലും യഥാക്രമം 70 ഉം 66 ഉം സസ്യ ഇനങ്ങളും കണ്ടെത്തി. മൂന്ന് ആവാസ വ്യവസ്ഥകളിലും ഫാബാസിയായിരുന്നു പ്രധാനപെട്ട സസ്യ കുടുംബം. പ്രകൃതിദത്ത വനത്തിൽ ക്രോമോളീന ഒഡോറാറ്റയും, ലന്താന കമാറ, മിമോസ പുഡിക്ക, ടെർമിനാലിയ എലിപ്റ്റിക്ക, ഗ്ലൈക്കോസ്മിസ് പെന്റാഫില്ല എന്നിവയാണ് മുഖ്യമായും കാണപ്പെട്ടത്. തോട്ടങ്ങളിൽ, ക്രോമോളീന ഒഡോറാറ്റ, ടെക്കേറ്റാണ ഗ്രാൻഡിസ്, മിമോസ പുഡിക്ക, ഗ്ലൈക്കോസ്മിസ് പെന്റാഫില്ല എന്നിവ ആധിപത്യം പ്രകടമാക്കി. വയലിൽ ആധിപത്യം കാണിച്ചത് അരുണ്ടിനെല്ല ലെപ്റ്റോക്ലോവയാണ്. വയലിലെ ഏറ്റവും പ്രബലമായ രണ്ടാമത്തെ സസ്യ ഇനം ക്രോമോളീന ഒഡോറാറ്റയാണ്. കില്ലിംഗ നെമോറലിസ്, സ്പോറോബോളസ് ടെനുസിസിമസ് എന്നിവയായിരുന്നു മറ്റ് പ്രധാന സസ്യ ഇനങ്ങൾ. മൂന്ന് ആവാസ വ്യവസ്ഥകളിൽ വച്ച്, ഏറ്റവും ഉയർന്ന സിംപ്സൺ വൈവിധ്യ സൂചിക രേഖപ്പെടുത്തിയത് വയലിലാണ്. പ്രബലമായ ജീവിവർഗങ്ങളുടെ സാന്നിധ്യം കാരണം തോട്ടത്തിലാണ് ഏറ്റവും ഉയർന്ന ബർഗർ-പാർക്കർ ആധിപത്യ സൂചിക രേഖപ്പെടുത്തിയത്. ഏറ്റവും ഉയർന്ന മാർഗലഫ് സമ്പന്ന സൂചിക രേഖപ്പെടുത്തിയത് പ്രകൃതിദത്ത വനങ്ങളിലാണ്, ഏറ്റവും കുറവ് വയലിലും. വയലിലെ ഉയർന്ന പിയാലോയുടെ വീനർ ഇക്വിറ്റബിലിറ്റി സൂചിക സൂചിപ്പിക്കുന്നത് എല്ലാ ഇനങ്ങളും തുല്യമായി വിതരണം ചെയ്യപ്പെടുന്നു എന്നാണ്.

Editor: K. Ravikumar, Foundation for Revitalisation of Local Health Traditions (FRLHT), Bengaluru, India. **Date of publication:** 26 April 2020 (online & print)

Citation: Chandran, M.V., S. Gopakumar & A. Mathews (2020). Comparative phytosociological assessment of three terrestrial ecosystems of Wayanad Wildlife Sanctuary, Kerala, India. *Journal of Threatened Taxa* 12(5): 15631–15645. https://doi.org/10.11609/jott.4754.12.5.15631-15645

Funding: Kerala Agricultural University, Vellanikkara, Thrissur, Kerala.

Competing interests: The authors declare no competing interests.

For **Author details & Author contribution** see end of this article.

Acknowledgements: The first and second author would like to thank the Kerala Agricultural University for the financial and technical support given for this study. The permission granted by the Kerala state Forest and Wildlife department to undertake this investigation which forms a part of the postgraduate study of the first author is also gratefully acknowledged.

INTRODUCTION

Forests are the principal bio-resources and repositories of natural wealth that support human well-being and ecological sustainability (Sarkar 2016). Phytosociological studies are necessary for protecting the biodiversity and natural plant communities (Rao et al. 2015). These are very essential components for understanding the changes accomplished in the past and future (Hamzaoglu 2006). The environmental safety of a country depends on the health of its forest area (Lloyd & Ghelard 1964) as it is the forest ecosystems which allocate disparate share to the world's biodiversity (Battles et al. 2001). For the conservation of biodiversity, it is crucial to attain forest sustainability (Chaubey et al. 1988). It is proven that long-term sustainability of forest ecosystems is greatly related to plant diversity and their phytosociological attributes. Most of the forests in the world today are under extensive anthropogenic disturbances and require careful management intervention to maintain overall biodiversity and sustainability (Kumar et al. 2006). As plants provide both food and habitat for other organisms (Das et al. 2015), the total forest diversity is a dependent factor of plant diversity. The overall strength of the forest rests on its plant composition, and hence the information on its composition, diversity and ecological aspects is of primary importance in conservation planning and implementation.

Tree species control the growth of other vascular plants as they regulate sunlight availability of the forest floor. Analysis and estimation of tree diversity, through which a combination of physical habitat, vegetation, physiognomy, species composition and community relationship are unlocked, are useful datasets in forest management interventions (Battles et al. 2004). The inherent variation within communities and ecosystems must be documented and used as base-line data to effectively predict the outcome of disturbances, such as regeneration and harvest methods on floristic diversity and richness (Sarkar 2015).

MATERIALS AND METHODS

Study area

The study was carried out in Wayanad Wildlife Sanctuary (WWS), Kerala State located in southern India, between October 2016 and February 2017. WWS is spread over to 344km^2 and comprises two discontinuous land areas of 77.67km^2 (WS-I) and 266.77 km^2 (WS-II) (Figure 1). The larger of these two, WS-II lies within the geographical extremes of 11^{0}35'–11 ^{0}49'N and 76^{0}13'–76^{0}27'E. The other area WS-I lies within 11^{0}50'–11^{0}59'N and 76^{0}02'–76^{0}7'E. The phytosociological study was done in WS-II which has been divided into three forest ranges, namely, Muthanga, Kurichiat, and Sulthan Bathery. The dominant natural vegetation here is characterized by moist and dry deciduous forest (Image 1), teak and eucalyptus plantations (Image 2), and bamboo brakes (Management Plan 2012–2022). Swamps, which are low lying grasslands are spread over 715.79ha. The land area locally known as vayals (Image 3), represent an edaphic climax with its deep clayey soils and are waterlogged during the monsoon, but sustain grasses throughout the year.

The quadrat method was employed for phytosociological analysis of all vegetation. Three ecosystems, viz., natural forest (NF), plantation, and swamps/vayal (low lying grasslands) were compared. In each vegetation type, 85 quadrats (10 × 10 m) were randomly laid to quantify the tree vegetation. Tree species found within each quadrat were photographed. Those plants which could not be immediately identified were recorded by their vernacular names (information from range officer, beat officer, forest guards, and local people). These species were later identified and their scientific names recorded by consulting dendrologists, books, articles, and internet. The other vegetation inside the 10 × 10 m quadrat was further surveyed using 2 × 2 m nested quadrats. In the nested quadrats, for all the species identity, origin (native or alien), growth form (herb, shrub, and climber), and abundance of other vascular plant species were recorded. In order to analyse the diversity of tree vegetation, frequency, relative frequency, density, and relative density were calculated using the following formulae.

$$\text{Density (D)} = \frac{\text{Number of individuals}}{\text{Hectare}}$$

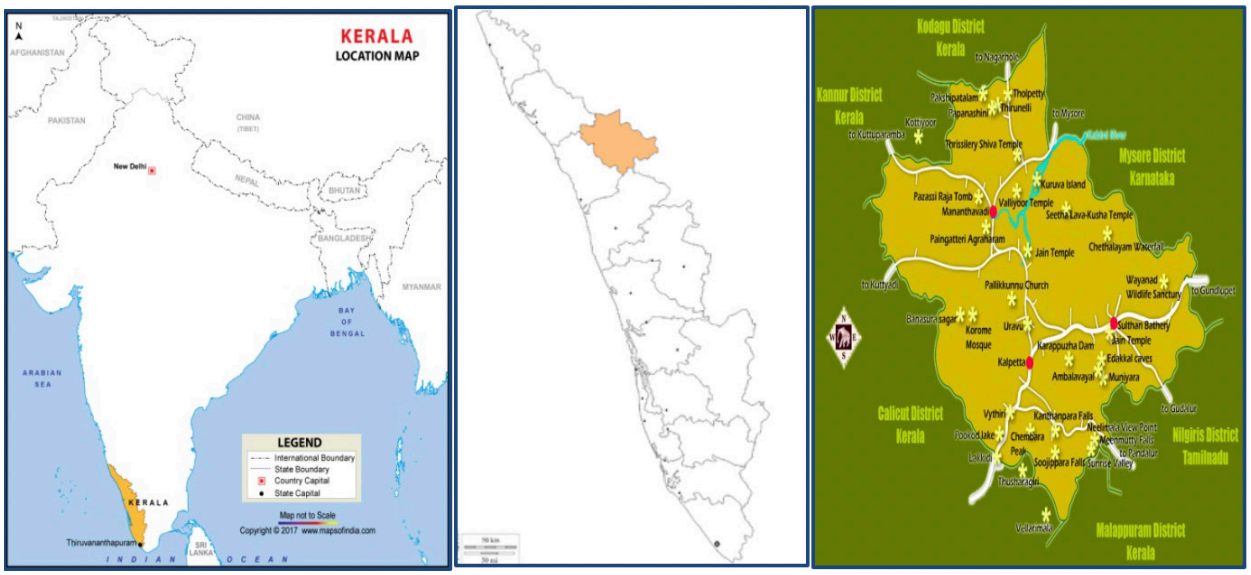
$$\text{Relative Density (RD)} = \frac{\text{Number of individuals of the species}}{\text{Number of individuals of all species}} \times 100$$

$$\text{Abundance (A)} = \frac{\text{Total number of individuals of a species in all quadrats}}{\text{Number of quadrats of occurrence of the species}}$$

$$\text{Frequency (F)} = \frac{\text{Number of quadrats of occurrence of the species}}{\text{Total number of quadrats studied}} \times 100$$

$$\text{Relative frequency (RF)} = \frac{\text{Frequency of individual species}}{\text{Sum of frequency of all species}} \times 100$$

Importance value index (IVI) was calculated by adding relative frequency, relative density and relative



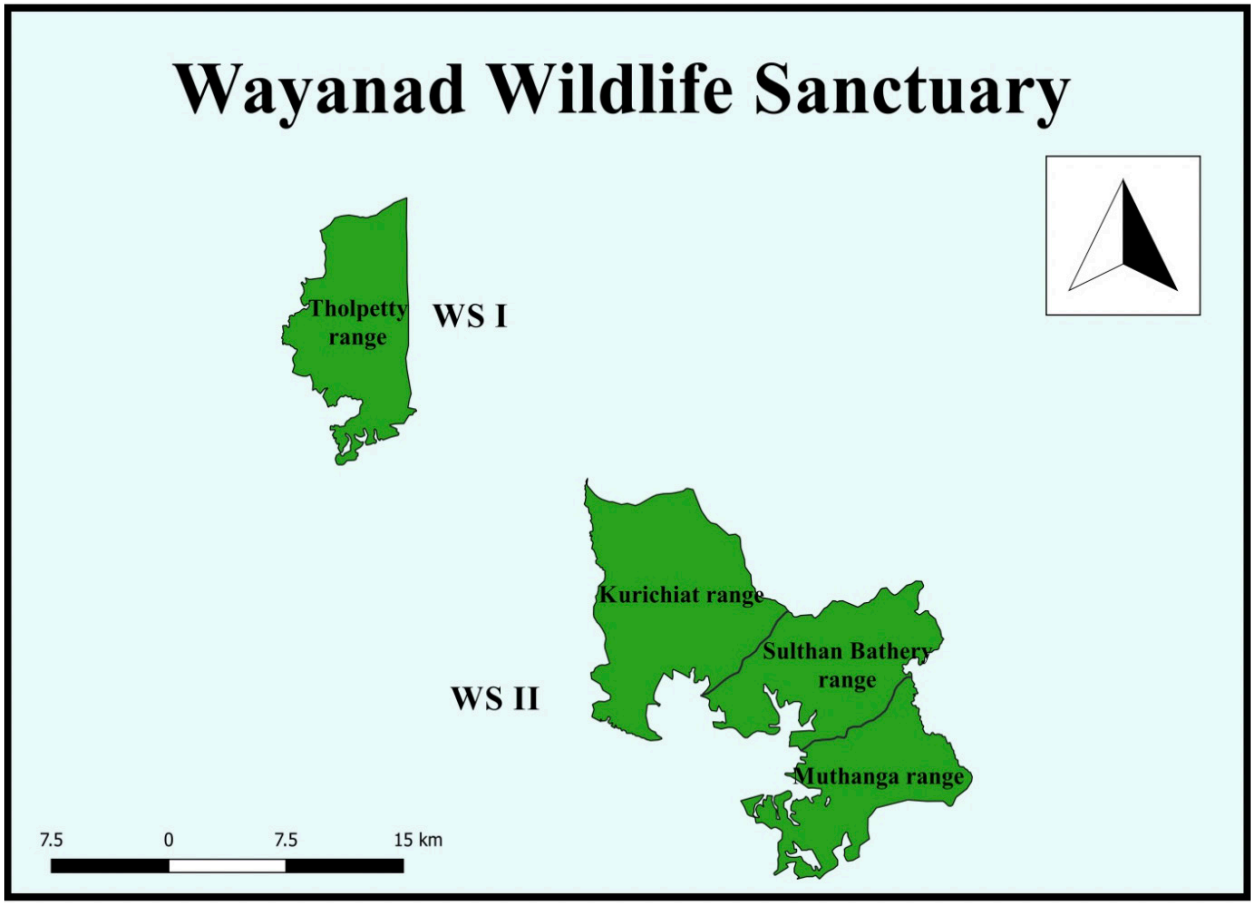


Figure 1. Location map of the study area.

basal area.

Species richness was calculated according to Margalef (1958). Diversity was calculated using Simpson's diversity index (Simpson 1949). The evenness was calculated in terms of Pielou's equitability index (Pielou 1969). Dominance was calculated using Berger-Parker dominance index (Berger & Parker 1970).

Image 1. Natural forest in WS II.

Image 2. Plantation in WS II.

Image 3. Vayal in WS II.

RESULTS AND DISCUSSION

Overall 129 plant species representing 111 genera were recorded from the three ecosystems (Table 2). Of these, 55 were trees, 24 were shrubs, 35 herbs, and 12 climbers (Table 1). Natural forest showed comparatively higher species richness than plantation and vayal. In natural forest there were 96 plant species. Plantation and vayal had 70 and 66 plant species, respectively. The species recorded in natural forest represented 84 genera in 46 families (Table 1). Fabaceae was the dominant family across the three ecosystems (Figure 2). In the natural forest alone, Fabaceae was represented by 12 species. The other dominant families were Poacae, Asteraceae, Caesalpinaceae, Combretaceae, Verbenaceae and Euphorbiaceae.

Among the tree species *Anogeissus latifolia, Butea monosperma, Cassia fistula, Lagerstroemia microcarpa, Lannea coromandelica, Naringi crenulata, Olea dioica, Pterocarpus marsupium, Shorea roxburghii, Syzygium cumini, Tabernamontana alternifolia, Tectona grandis, Terminalia bellirica*, and *T. elliptica* were seen in all the three vegetation types. *Aporosa cardiosperma, Carallia brachiata, Dalbergia lanceolaria, Diospyros melanoxylon, Elaeocarpus variabilis, Gmelina arborea, Hydnocarpus pentandra, Miliusa tomentosa, Pongamia pinnata, Streblus asper*, and *Terminalia paniculata* were observed only in NF. In vayals, the trees, namely, *Careya arborea* and *Trewia nudiflora* were seen. In plantations, only *Ailanthus triphysa, Elaeocarpus tuberculatus, Mallotus tetracoccus*, and *Ziziphus mauritiana* were present.

Biophytum reinwardtii var. *reinwardtii, Crassocephalum crepidioides, Curculigo orchioides,*

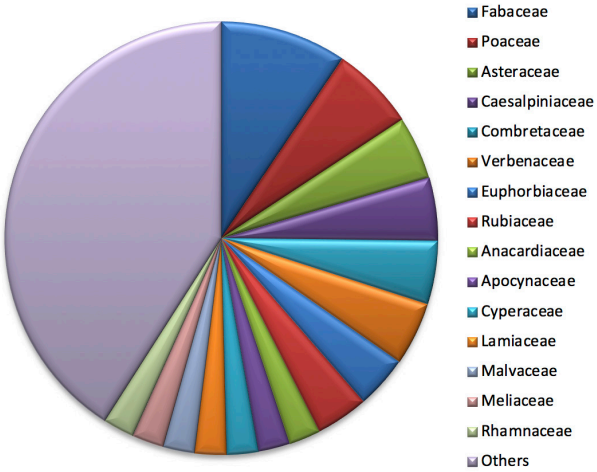


Figure 2. Family wise plant species in Wayanad WS.

Table 1. Vegetation-type-wise distribution of species, genera, and families.

	Herb	Shrub	Tree	Climber	Total no. of plant species	Family	Genus
Natural forest	17	21	46	9	96	46	84
Plantation	15	16	30	6	70	36	59
Vayal	26	10	24	3	66	31	60

Table 2. List of all plant species in the WS II of sanctuary.

	Binomial	Category	Family	NF	Plantation	Vayal
1	*Ageratum conyzoides* L.*	Herb	Asteraceae	+	-	+
2	*Ailanthus triphysa* (Dennst.) Alston	Tree	Simaboubaceae	-	+	-
3	*Annona squamosa* L.*	Tree	Annonaceae	+	-	+
4	*Anogeissus latifolia* Wall	Tree	Combretaceae	+	+	+
5	*Aporosa cardiosperma* (Gaertn.) Merr.	Tree	Euphorbiaceae	+	-	-
6	*Arundinella leptochloa* Hook.f.	Herb	Poaceae	-	-	+
7	*Axonopus compressus* P. Beauv.	Herb	Poaceae	-	-	+
8	*Barleria mysorensis* Heyne	Shrub	Acanthaceae	+	+	-
9	*Bauhinia malabarica* Roxb.	Tree	Caesalpiniaceae	-	-	+
10	*Bauhinia racemosa* Lam.	Tree	Caesalpiniaceae	+	+	-
11	*Biophytum reinwardtii* (Zucc.) Klotzsch	Herb	Oxalidaceae	+	+	+
12	*Butea monosperma* (Lam.) Taub.	Tree	Fabaceae	+	+	+
13	*Caesalpinia mimosoides* Lam.	Climber	Caesalpiniaceae	+	-	-
14	*Calotropis gigantea* (L.) W.T. Aiton	Shrub	Asclepiadaceae	-	-	+
15	*Calycopteris floribunda* (Roxb.) Lam.	Climber	Combretaceae	+	+	-
16	*Canthium coromandelicum* (Burm.f.) Alston	Shrub	Rubiaceae	+	-	-
17	*Carallia brachiata* Lour. Merr.	Tree	Rhizophoraceae	+	-	-
18	*Cardiospermum halicacabum* L.	Climber	Sapindaceae	+	+	-
19	*Careya arborea* Roxb.	Tree	Lecythidaceae	-	-	+
20	*Carmona retusa* (Vahl) Masamune*	Shrub	Boraginaceae	+	+	-
21	*Caryota urens* L.	Tree	Palmae	+	+	-
22	*Cassia fistula* L.	Tree	Caesalpiniaceae	+	+	+
23	*Catunaregam spinosa* (Thunb.) Tirveng.	Shrub	Rubiaceae	+	+	+
24	*Centella asiatica* (L.) Urb.	Herb	Umbelliferae	+	-	-
25	*Chamaecrista absus* (L.) H.S.Irwin & Barneby	Herb	Caesalpiniaceae	+	-	-
26	*Chonemorpha fragrans* (Moon) Alst.	Climber	Apocynaceae	-	-	+
27	*Chromolaena odora* (L.) King & Rob.*	Shrub	Asteraceae	+	+	+
28	*Cinnamomum verum* J.Presl	Tree	Lauraceae	+	+	-
29	*Cipadessa baccifera* Miq.	Shrub	Meliaceae	+	+	-
30	*Clerodendrum infortunatum* L.	Shrub	Verbenaceae	+	-	-
31	*Cosmostigma racemosum* Wight	Climber	Asclepiadaceae	+	-	-
32	*Crassocephalum crepidioides* S.Moore*	Herb	Asteraceae	+	+	+
33	*Curculigo orchioides* Gaertn.	Herb	Hypoxidaceae	+	+	+
34	*Curcuma neilgherrensis* Wight	Herb	Zingiberaceae	+	+	+
35	*Cyclea peltata* (Lam.) Hook.f. & Thoms.	Climber	Menispermaceae	+	+	-
36	*Cyperus pilosus* Vahl	Herb	Cyperaceae	-	-	+
37	*Dalbergia lanceolaria* L.f.	Tree	Fabaceae	+	-	-
38	*Dalbergia latifolia* Roxb.	Tree	Fabaceae	-	+	+

	Binomial	Category	Family	NF	Plantation	Vayal
39	*Dendrocalamus strictus* Nees	Shrub	Graminae	+	+	+
40	*Desmodium gangeticum* Blanco	Herb	Fabaceae	-	+	-
41	*Desmodium heterocarpon* (L.) DC.	Shrub	Fabaceae	+	+	-
42	*Desmodium laxiflorum* DC.	Herb	Fabaceae	+	+	-
43	*Desmodium pulchellum* (L.) Benth.	Shrub	Fabaceae	+	+	-
44	*Desmodium triflorum* (L.) DC.	Herb	Fabaceae	-	-	+
45	*Digitaria ciliaris* (Retz.) Koeler	Herb	Graminae	-	-	+
46	*Diospyros melanoxylon* Roxb.	Tree	Ebenaceae	+	-	-
47	*Elaeagnus kologa* Schltdl.	Climber	Elaeagnaceae	+	-	-
48	*Elaeocarpus tuberculatus* Roxb.	Tree	Elaeocarpaceae	-	+	-
49	*Elaeocarpus variabilis* Zmarzty	Tree	Elaeocarpaceae	+	-	-
50	*Elephantopus scaber* L.	Herb	Asteraceae	+	+	+
51	*Eleutheranthera ruderalis* (Sw.) Sch.Bip.*	Herb	Asteraceae	+	+	+
52	*Eragrostis tenella* (L.) P.Beauv. ex Roem. & Schult.	Herb	Poaceae	-	-	+
53	*Eucalyptus globulus* Labill.*	Tree	Myrtaceae	-	+	+
54	*Flacourtia indica* (Burm.f.) Merr.	Shrub	Flacourtiaceae	+	-	-
55	*Flemingia strobilifera* (L.) W.T.Aiton	Shrub	Fabaceae	-	-	+
56	*Glycosmis pentaphylla* (Retz.) DC.	Shrub	Rutaceae	+	+	+
57	*Gmelina arborea* Roxb.	Tree	Verbenaceae	+	-	-
58	*Gomphrena celosioides* Mart.*	Herb	Amaranthaceae	-	+	-
59	*Grangea maderaspatana* (L.) Poir.	Herb	Asteraceae	-	-	+
60	*Grewia tiliifolia* Vahl.	Tree	Tiliaceae	+	+	-
61	*Haldina cordifolia* (Roxb.) Ridsdale.	Tree	Rubiaceae	+	-	+
62	*Helicteres isora* L.	Shrub	Sterculiaceae	+	+	-
63	*Hemidesmus indicus* (L.) R.Br.	Climber	Periplocaceae	+	+	+
64	*Hydnocarpus pentandra* (Buch.-Ham.) Oken	Tree	Flacourtiaceae	+	-	-
65	*Hyptis suaveolens* (L.) Poit.*	Herb	Lamiaceae	+	+	-
66	*Jansenella griffithiana* (Müll.Hal.) Bor	Herb	Poaceae	-	-	+
67	*Kyllinga nemoralis* (J.R.Forst. & G.Forst.) Dandy	Herb	Cyperaceae	-	-	+
68	*Lagerstroemia microcarpa* Wight.	Tree	Lythraceae	+	+	+
69	*Lagerstroemia speciosa* Pers.	Tree	Lythraceae	+	-	-
70	*Lannea coromandelica* (Houtt.) Merr.	Tree	Anacardiaceae	+	+	+
71	*Lantana camara* L.*	Shrub	Verbenaceae	+	+	+
72	*Lepidagathis incurva* Buch.-Ham. ex D.Don	Herb	Acanthaceae	+	+	+
73	*Leucaena leucocephala* (Lam.) de Wit*	Herb	Mimosaceae	+	-	-
74	*Leucas aspera* Link	Herb	Lamiaceae	+	-	+
75	*Lindernia crustacea* (L.) F.Muell.*	Herb	Scrophulariaceae	+	-	-
76	*Ludwigia peruviana* (L.) H.Hara*	Shrub	Onagraceae	-	-	+
77	*Mallotus tetracoccus* Kurz	Tree	Euphorbiaceae	-	+	-
78	*Mangifera indica* Wall.	Tree	Anacardiaceae	+	-	-
79	*Melastoma malabathricum* L.	Shrub	Melastomataceae	+	-	+
80	*Melia azedarach* L.*	Tree	Meliaceae	+	+	-
81	*Melia dubia* Cav.	Tree	Meliaceae	+	+	-
82	*Mikania micrantha* Kunth*	Climber	Asteraceae	-	+	-
83	*Miliusa tomentosa* (Roxb.) Finet & Gagnep.	Tree	Annonaceae	+	-	-
84	*Mimosa pudica* L.*	Herb	Fabaceae	+	+	+

	Binomial	Category	Family	NF	Plantation	Vayal
85	*Mimusops elengi* Wight	Tree	Sapotacea	+	+	-
86	*Mitracarpus hirtus* DC.*	Herb	Rubiaceae	+	+	+
87	*Naringi crenulata* (Roxb.) Nicolson	Tree	Rutaceae	+	+	+
88	*Olea dioica* Roxb.	Tree	Oleacea	+	+	+
89	*Osbeckia aspera* Blume	Shrub	Melastomataceae	+	-	-
90	*Panicum trypheron* Schult.	Herb	Poaceae	-	-	+
91	*Persea macrantha* (Nees) Kosterm.	Tree	Lauraceae	+	+	-
92	*Phyllanthus emblica* L.	Tree	Euphorbiaceae	+	-	+
93	*Piper nigrum* L.	Climber	Piperaceae	+	-	-
94	*Pogostemon purpurascens* Dalzell	Herb	Lamiaceae	-	+	-
95	*Pongamia pinnata* (L.) Merr.	Tree	Fabaceae	+	-	-
96	*Premna tomentosa* Wild.	Tree	Verbenaceae	+	-	-
97	*Pterocarpus marsupium* Roxb.	Tree	Fabaceae	+	+	+
98	*Rauvolfia serpentina* Jacq.	Shrub	Apocynaceae	+	-	-
99	*Rhynchospora corymbosa* (L.) Britton	Herb	Cyperaceae	-	-	+
100	*Sacciolepis indica* (L.) Chase*	Herb	Poaceae	-	-	+
101	*Schleichera oleosa* (Lour.) Oken	Tree	Sapindaceae	+	+	-
102	*Schrebera swietenioides* Roxb.	Tree	Oleacea	+	-	-
103	*Semecarpus anacardium* Roxb.	Tree	Anacardiaceae	-	+	-
104	*Senna spectabilis* (DC.) H. S. Irwin & Barneby*	Tree	Fabaceae	+	+	+
105	*Senna tora* Roxb.*	Herb	Caesalpiniaceae	+	+	+
106	*Shorea roxburghii* G. Don.	Tree	Dipterocarpaceae	+	+	+
107	*Sida acuta burm.* F.	Shrub	Malvaceae	+	+	+
108	*Sida alnifolia* L.	Shrub	Malvaceae	+	+	+
109	*Sida rhombifolia* L.	Shrub	Malvaceae	-	+	-
110	*Solanum aculeatissimum* Jacq.*	Shrub	Solanaceae	+	+	+
111	*Spathodea campanulata* Buch.-Ham. ex DC.*	Tree	Bignoniaceae	+	-	-
112	*Sporobolus tenuissimus* Kuntze	Herb	Poaceae	-	-	+
113	*Stachytarpheta jamaicensis* (L.) Vahl*	Shrub	Verbenaceae	+	+	-
114	*Streblus asper* Lour.	Tree	Moraceae	+	-	-
115	*Syzygium cumini* (L.) Skeels	Tree	Myrtaceae	+	+	+
116	*Tabernamontana alternifolia* Roxb.	Tree	Apocynaceae	+	+	+
117	*Tamilnadia uliginosa* (Retz.) Tirveng. & Sastre	Tree	Rubiaceae	+	-	+
118	*Tectona grandis* L.f.	Tree	Verbenaceae	+	+	+
119	*Terminalia bellirica* (Gaertn.) Roxb.	Tree	Combretaceae	+	+	+
120	*Terminalia cuneata* Roth	Tree	Combretaceae	+	-	+
121	*Terminalia elliptica* Willd.	Tree	Combretaceae	+	+	+
122	*Terminalia paniculata* Roth	Tree	Combretaceae	+	-	-
123	*Themeda triandra* Forssk.	Herb	Poaceae	-	-	+
124	*Trewia nudiflora* Wight	Tree	Euphorbiaceae	-	-	+
125	*Triumfetta rhomboidea* Jacq.	Shrub	Tiliaceae	+	+	-
126	*Vitex altissima* L.f.	Tree	Verbenaceae	+	-	-
127	*Ziziphus* glabrata B. Heyne ex Roth	Tree	Rhamnaceae	+	-	-
128	*Ziziphus mauritiana* Lam.	Tree	Rhamnaceae	-	+	-
129	*Ziziphus oenoplia* (L.) Mill.	Climber	Rhamnaceae	+	+	+

*indicates non-native species

Curcuma neilgherrensis, Elephantopus scaber, Eleutheranthera ruderalis, Lepidagathis incurva, Mimosa pudica, Mitracarpus hirtus, and *Senna tora* were the herbs seen in all the three vegetation types. *Centella asiatica, Chamaecrista absus*, and *Lindernia crustacea* were the herbs observed only in NF. In plantations, the herbs seen were *Acalypha paniculata, Desmodium gangeticum, Gomphrena celosioides*. *Arundinella leptochloa, Axonopus compressus, Cyperus pilosus, Desmodium trifolium, Digitaria ciliaris, Grangea maderaspatana, Jansenella griffithiana*, and *Kyllinga nemoralis* were observed only in vayal.

Catunaregam spinosa, Dendrocalamus strictus, Glycosmis pentaphylla, Sida acuta, S. alnifolia, and *Solanum aculeatissimum* are the shrubs that could be recorded in all three vegetation types. *Canthium coromandelicum, Carmona retusa, Clerodendrum infortunatum*, *Desmodium heterocarpon, D. pulchellum, Flacourtia indica, Glycosmis pentaphylla, Helicteres isora, Melastoma malabathricum, Osbeckia aspera, Rauvolfia serpentina, Sida acuta, S. alnifolia, Solanum aculeatissimum, Stachyphrynium jamaicensis*, and *Triumfetta rhomboidei* were the shrubs observed in NF. *Canthium coromandelicum, Clerodendrum infortunatum, Flacourtia indica, Osbeckia aspera*, and *Rauvolfia serpentina* were seen only in NF. *Carmona retusa, Catunaregam spinosa, Cipadessa baccifera, Dendrocalamus strictus, Desmodium heterocarpon, D. pulchellum, Glycosmis pentaphylla, Helicteres isora, Sida acuta, S. alnifolia, S. rhombifolia, Solanum aculeatissimum, Stachyphrynium jamaicensis*, and *Triumfetta rhomboidei* were the shrubs seen in plantation. *Calotropis gigantea, Catunaregam spinosa, Dendrocalamus strictus, Flemingia strobilifera, Glycosmis pentaphylla, Ludwigia peruviana, Melastoma malabathricum, Sida acuta, S. alnifolia*, and *Solanum aculeatissimum* were the shrubs commonly seen in vayal. Among these, *Calotropis gigantea* and *Flemingia strobilifera* were only seen in vayal.

Among the 11 climbers, *Hemidesmus indicus* and *Ziziphus oenoplia* were seen in all the vegetation types. *Caesalpinia mimosoides*, *Cosmostigma racemosum, Elaeagnus kologa*, and *Piper nigrum* were seen in NF. In vayal, *Chonemorpha fragrans* was only climber which was seen. No climber could be recorded in the plantation.

The vegetation analysis in NF showed that *Chromolaena odorata* has maximum abundance (81.6) and frequency (61.1) (Table 3). Next to *Chromolaena odorata, Stachytarpheta jamaicensis* (31.3) has maximum abundance. The abundance of *Senna* spectabilis and

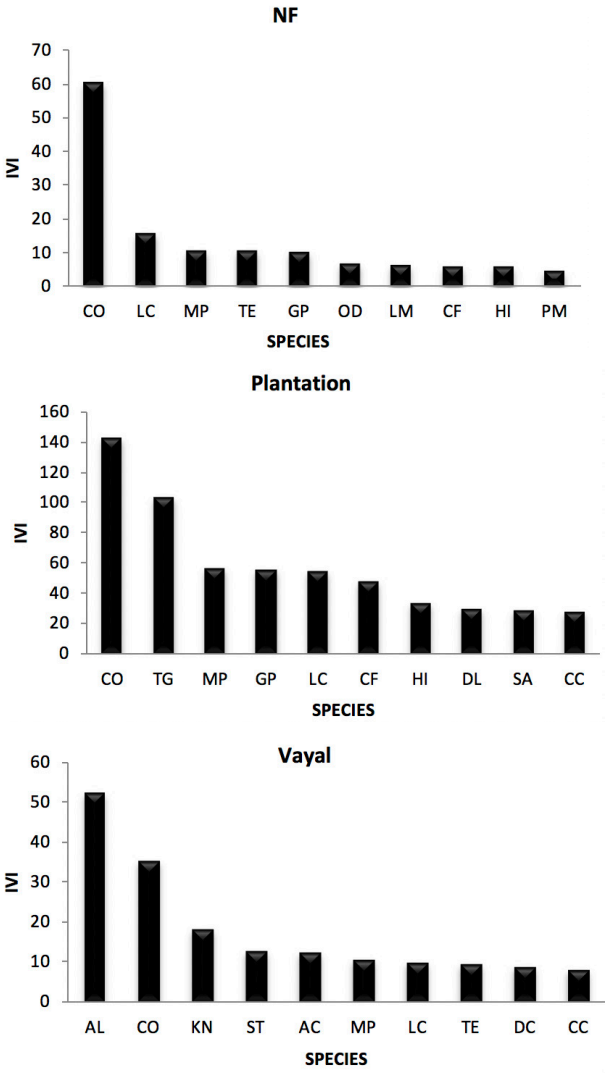


Figure 3. Ten dominant species encountered in each vegetation type: AC—*Axonopus compressus* | AL—*Arundinella leptochloa* | CC—*Crassocephalum crepidioides | CO—*Chromolaena odorata** | CF—*Cassia fistula* | DC—*Digitaria ciliaris* | DL—*Dalbergia latifolia* | TG—*Tectona grandis* | GP—*Glycosmis pentaphylla* | HI—*Helicteres isora* | KN—*Kyllinga nemoralis* | LM—*Lagerstroemia microcarpa* | LC—*Lantana camara** | MP—*Mimosa pudica** | OD—*Olea dioica* | SA—*Sida alnifolia* | ST—*Sporobolus tenuissimus* | TE—*Terminalia elliptica* | PM—*Persea macrantha*.**

*indicates non-native species

Lantana camara were 17.7 and 9.8, respectively. The density of *Lantana camara* was 532.9 stems ha^{-1}. After *Lantana camara*, *Glycosmis pentaphylla* (338.8 stems ha-1) and *Mitracarpus hirtus* (195.2 stems ha-1) were the densely seen plant species in NF. The most densely seen tree species in NF is *S. spectabilis* (188.2 stems ha^{-1}). Among the first ten highly dense plant species in NF, five were IAPS. Maximum frequency in NF was shown by *Chromolaena odorata* (61.1) and *Lantana camara*

Table 3. Phytosociological analysis of vegetation in natural forest.

	Binomial	F	RF	D	RD	A	RBA	IVI
1	*Ageratum conyzoides**	11.76	1.14	61.18	0.60	5.20	1.14	2.88
2	*Annona squamosa**	1.18	0.11	1.18	0.01	1.00	0.11	0.24
3	*Anogeissus latifolia*	9.41	0.91	12.94	0.13	1.38	0.91	1.95
4	*Aporosa cardiosperma*	5.88	0.57	8.24	0.08	1.40	0.57	1.22
5	*Barleria mysorensis*	1.18	0.11	1.18	0.01	1.00	0.11	0.24
6	*Bauhinia racemosa*	1.18	0.11	1.18	0.01	1.00	0.11	0.24
7	*Biophytum reinwardtii*	2.35	0.23	10.59	0.10	4.50	0.23	0.56
8	*Butea monosperma*	9.41	0.91	10.59	0.10	1.13	0.91	1.93
9	*Caesalpinia mimosoides*	1.18	0.11	17.65	0.17	15.0	0.11	0.40
10	*Calycopteris floribunda*	18.82	1.83	37.65	0.37	2.00	1.83	4.02
11	*Canthium coromandelicum*	1.18	0.11	2.35	0.02	2.00	0.11	0.25
12	*Carallia brachiata*	15.29	1.48	37.65	0.37	2.46	1.48	3.33
13	*Cardiospermum halicacabum*	8.24	0.80	10.59	0.10	1.29	0.80	1.70
14	*Carmona retusa**	15.29	1.48	18.82	0.18	1.23	1.48	3.15
15	*Caryota urens*	3.53	0.34	7.06	0.07	2.00	0.34	0.75
16	*Cassia fistula*	28.24	2.74	57.65	0.56	2.04	2.74	6.04
17	*Catunaregam spinosa*	10.59	1.03	11.76	0.11	1.11	1.03	2.17
18	*Centella asiatica*	1.18	0.11	2.35	0.02	2.00	0.11	0.25
19	*Chamaecrista absus*	1.18	0.11	2.35	0.02	2.00	0.11	0.25
20	*Chromolaena odorata**	61.18	5.94	4996.47	48.69	81.6	5.94	60.5
21	*Cinnamomum verum*	11.76	1.14	52.94	0.52	4.50	1.14	2.80
22	*Cipadessa baccifera*	4.71	0.46	8.24	0.08	1.75	0.46	0.99
23	*Clerodendrum infortunatum*	1.18	0.11	2.35	0.02	2.00	0.11	0.25
24	*Cosmostigma racemosum*	1.18	0.11	2.35	0.02	2.00	0.11	0.25
25	*Crassocephalum crepidioides**	8.24	0.80	11.76	0.11	1.43	0.80	1.71
26	*Curculigo orchioides*	3.53	0.34	44.71	0.44	12.6	0.34	1.12
27	*Curcuma neilgherrensis*	17.65	1.71	70.59	0.69	4.00	1.71	4.11
28	*Cyclea peltata*	17.65	1.71	27.06	0.26	1.53	1.71	3.69
29	*Dalbergia lanceolaria*	10.59	1.03	15.29	0.15	1.44	1.03	2.20
30	*Dendrocalamus strictus*	18.82	1.83	58.82	0.57	3.13	1.83	4.23
31	*Desmodium heterocarpon*	2.35	0.23	8.24	0.08	3.50	0.23	0.54
32	*Desmodium laxiflorum*	7.06	0.68	11.76	0.11	1.67	0.68	1.48
33	*Desmodium pulchellum*	5.88	0.57	7.06	0.07	1.20	0.57	1.21
34	*Diospyros melanoxylon*	7.06	0.68	9.41	0.09	1.33	0.68	1.46
35	*Elaeagnus kologa*	2.35	0.23	4.71	0.05	2.00	0.23	0.50
36	*Elaeocarpus variabilis*	1.18	0.11	1.18	0.01	1.00	0.11	0.24
37	*Elephantopus scaber*	14.12	1.37	142.35	1.39	10.1	1.37	4.13
38	*Eleutheranthera ruderalis**	7.06	0.68	31.76	0.31	4.50	0.68	1.68
39	*Flacourtia indica*	11.76	1.14	14.12	0.14	1.20	1.14	2.42
40	*Glycosmis pentaphylla*	36.47	3.54	338.82	3.30	9.29	3.54	10.3
41	*Gmelina arborea*	2.35	0.23	2.35	0.02	1.00	0.23	0.48
42	*Grewia tiliifolia*	14.12	1.37	20.00	0.19	1.42	1.37	2.93
43	*Haldina cordifolia*	5.88	0.57	9.41	0.09	1.60	0.57	1.23

F—Frequency | RF—Relative Frequency | D—Density, RD—Relative density| A—Abundance | RBA—Relative basal area | IVI—Importance Value Index.

	Binomial	F	RF	D	RD	A	RBA	IVI
44	*Helicteres isora*	27.06	2.63	50.59	0.49	1.87	2.63	5.74
45	*Hemidesmus indicus*	1.18	0.11	3.53	0.03	3.00	0.11	0.26
46	*Hydnocarpus pentandra*	5.88	0.57	5.88	0.06	1.00	0.57	1.20
47	*Hyptis suaveolens**	3.53	0.34	24.71	0.24	7.00	0.34	0.93
48	*Lagerstroemia microcarpa*	31.76	3.08	38.82	0.38	1.22	3.08	6.54
49	*Lagerstroemia speciosa*	3.53	0.34	3.53	0.03	1.00	0.34	0.72
50	*Lannea coromandelica*	2.35	0.23	2.35	0.02	1.00	0.23	0.48
51	*Lantana camara**	54.12	5.25	532.94	5.19	9.85	5.25	15.7
52	*Lepidagathis incurva*	15.29	1.48	29.41	0.29	1.92	1.48	3.25
53	*Leucaena leucocephala**	1.18	0.11	1.18	0.01	1.00	0.11	0.24
54	*Leucas aspera*	1.18	0.11	2.35	0.02	2.00	0.11	0.25
55	*Lindernia crustacea**	12.94	1.26	35.29	0.34	2.73	1.26	2.86
56	*Mangifera indica*	4.71	0.46	11.76	0.11	2.50	0.46	1.03
57	*Melastoma malabathricum*	1.18	0.11	1.18	0.01	1.00	0.11	0.24
58	*Melia azedarach**	4.71	0.46	5.88	0.06	1.25	0.46	0.97
59	*Melia dubia*	4.71	0.46	4.71	0.05	1.00	0.46	0.96
60	*Miliusa tomentosa*	1.18	0.11	2.35	0.02	2.00	0.11	0.25
61	*Mimosa pudica**	48.24	4.68	149.41	1.46	3.10	4.68	10.8
62	*Mimusops elengi*	2.35	0.23	2.35	0.02	1.00	0.23	0.48
63	*Mitracarpus hirtus*	9.41	0.91	195.29	1.90	20.7	0.91	3.73
64	*Naringi crenulata*	20.00	1.94	40.00	0.39	2.00	1.94	4.27
65	*Olea dioica*	30.59	2.97	80.00	0.78	2.62	2.97	6.72
66	*Osbeckia aspera*	1.18	0.11	1.18	0.01	1.00	0.11	0.24
67	*Persea macrantha*	22.35	2.17	40.00	0.39	1.79	2.17	4.73
68	*Phyllanthus emblica*	2.35	0.23	2.35	0.02	1.00	0.23	0.48
69	*Piper nigrum*	7.06	0.68	11.76	0.11	1.67	0.68	1.48
70	*Pongamia pinnata*	5.88	0.57	8.24	0.08	1.40	0.57	1.22
71	*Premna mollissima*	1.18	0.11	1.18	0.01	1.00	0.11	0.24
72	*Pterocarpus marsupium*	8.24	0.80	8.24	0.08	1.00	0.80	1.68
73	*Rauvolfia serpentina*	3.53	0.34	5.88	0.06	1.67	0.34	0.74
74	*Schleichera oleosa*	16.47	1.60	22.35	0.22	1.36	1.60	3.41
75	*Schrebera swietenioides*	1.18	0.11	1.18	0.01	1.00	0.11	0.24
76	*Senna spectabilis**	10.59	1.03	188.24	1.83	17.7	1.03	3.89
77	*Senna tora**	3.53	0.34	10.59	0.10	3.00	0.34	0.79
78	*Shorea roxburghii*	15.29	1.48	36.47	0.36	2.38	1.48	3.32
79	*Sida acuta*	3.53	0.34	3.53	0.03	1.00	0.34	0.72
80	*Sida alnifolia*	11.76	1.14	22.35	0.22	1.90	1.14	2.50
81	*Solanum aculeatissimum**	18.82	1.83	29.41	0.29	1.56	1.83	3.94
82	*Spathodea campanulata**	11.76	1.14	18.82	0.18	1.60	1.14	2.47
83	*Stachytarpheta jamaicensis**	3.53	0.34	110.59	1.08	31.3	0.34	1.76
84	*Streblus asper*	7.06	0.68	7.06	0.07	1.00	0.68	1.44
85	*Syzygium cumini*	18.82	1.83	60.00	0.58	3.19	1.83	4.24
86	*Tabernamontana alternifolia*	16.47	1.60	32.94	0.32	2.00	1.60	3.52
87	*Tamilnadia ulginosa*	1.18	0.11	1.18	0.01	1.00	0.11	0.24
88	*Tectona grandis*	20.00	1.94	42.35	0.41	2.12	1.94	4.29

	Binomial	F	RF	D	RD	A	RBA	IVI
89	*Terminalia bellirica*	5.88	0.57	5.88	0.06	1.00	0.57	1.20
90	*Terminalia cuneata*	3.53	0.34	3.53	0.03	1.00	0.34	0.72
91	*Terminalia elliptica*	50.59	4.91	72.94	0.71	1.44	4.91	10.5
92	*Terminalia paniculata*	14.12	1.37	14.12	0.14	1.00	1.37	2.88
93	*Triumfetta rhomboidea*	4.71	0.46	4.71	0.05	1.00	0.46	0.96
94	*Vitex altissima*	4.71	0.46	5.88	0.06	1.25	0.46	0.97
95	*Ziziphus glabrata*	20.00	1.94	20.00	0.19	1.00	1.94	4.08
96	*Ziziphus oenoplia*	5.88	0.57	7.06	0.07	1.20	0.57	1.21
	Total	**1029.41**	**99.89**	**8228.24**	**80.18**	**368.08**	**99.89**	**300.00**

*indicates non-native species

Table 4. Phytosociological analysis of vegetation in plantation.

	Binomial	F	RF	D	RD	A	RBA	IVI
1	*Acalypha paniculata*	1.18	0.13	2.35	0.03	2.00	1.18	1.33
2	*Ailanthus triphysa*	5.88	0.64	7.06	0.09	1.20	5.88	6.61
3	*Anogeissus latifolia*	14.12	1.54	14.1	0.17	1.00	14.12	15.8
4	*Barleria mysorensis*	1.18	0.13	1.18	0.01	1.00	1.18	1.32
5	*Bauhinia racemosa*	1.18	0.13	1.18	0.01	1.00	1.18	1.32
6	*Biophytum reinwardtii*	2.35	0.26	5.88	0.07	2.50	2.35	2.68
7	*Butea monosperma*	2.35	0.26	2.35	0.03	1.00	2.35	2.64
8	*Calycopteris floribunda*	2.35	0.26	4.71	0.06	2.00	2.35	2.67
9	*Cardiospermum halicacabum*	3.53	0.38	3.53	0.04	1.00	3.53	3.96
10	*Carmona retusa**	3.53	0.38	3.53	0.04	1.00	3.53	3.96
11	*Caryota urens*	2.35	0.26	2.35	0.03	1.00	2.35	2.64
12	*Cassia fistula*	42.35	4.62	83.5	1.01	1.97	42.35	47.9
13	*Catunaregam spinosa*	21.18	2.31	31.7	0.38	1.50	21.18	23.8
14	*Chromolaena odorata**	75.29	8.21	4943.53	59.56	65.6	75.29	143.1
15	*Cinnamomum verum*	4.71	0.51	11.76	0.14	2.50	4.71	5.36
16	*Cipadessa baccifera*	11.76	1.28	14.12	0.17	1.20	11.76	13.22
17	*Crassocephalum crepidioides**	24.71	2.69	35.29	0.43	1.43	24.71	27.82
18	*Curculigo orchioides*	10.59	1.15	84.71	1.02	8.00	10.59	12.76
19	*Curcuma neilgherrensis*	15.29	1.67	72.94	0.88	4.77	15.29	17.84
20	*Cyclea peltata*	10.59	1.15	17.65	0.21	1.67	10.59	11.95
21	*Dalbergia latifolia*	27.06	2.95	34.12	0.41	1.26	27.06	30.42
22	*Dendrocalamus strictus*	14.12	1.54	37.65	0.45	2.67	14.12	16.11
23	*Desmodium gangeticum*	1.18	0.13	2.35	0.03	2.00	1.18	1.33
24	*Desmodium heterocarpon*	2.35	0.26	2.35	0.03	1.00	2.35	2.64
25	*Desmodium laxiflorum*	7.06	0.77	7.06	0.09	1.00	7.06	7.91
26	*Desmodium pulchellum*	9.41	1.03	14.12	0.17	1.50	9.41	10.61
27	*Elaeocarpus tuberculatus*	2.35	0.26	16.47	0.20	7.00	2.35	2.81
28	*Elephantopus scaber*	23.53	2.56	101.18	1.22	4.30	23.53	27.31
29	*Eleutheranthera ruderalis**	1.18	0.13	4.71	0.06	4.00	1.18	1.36
30	*Eucalyptus globulus**	12.94	1.41	75.29	0.91	5.82	12.94	15.26
31	*Glycosmis pentaphylla*	44.71	4.87	484.71	5.84	10.8	44.71	55.42

F—Frequency | RF—Relative Frequency | D—Density, RD—Relative density| A—Abundance | RBA—Relative basal area | IVI—Importance Value Index.

	Binomial	F	RF	D	RD	A	RBA	IVI
32	*Gomphrena celosioides**	3.53	0.38	9.41	0.11	2.67	3.53	4.03
33	*Grewia tiliifolia*	10.59	1.15	16.47	0.20	1.56	10.59	11.94
34	*Helicteres isora*	29.41	3.21	67.06	0.81	2.28	29.41	33.42
35	*Hemidesmus indicus*	8.24	0.90	68.24	0.82	8.29	8.24	9.95
36	*Hyptis suaveolens**	1.18	0.13	4.71	0.06	4.00	1.18	1.36
37	*Lagerstroemia microcarpa*	17.65	1.92	20.00	0.24	1.13	17.65	19.81
38	*Lannea coromandelica*	1.18	0.13	1.18	0.01	1.00	1.18	1.32
39	*Lantana camara**	45.88	5.00	322.35	3.88	7.03	45.88	54.77
40	*Lepidagathis incurve*	4.71	0.51	28.24	0.34	6.00	4.71	5.56
41	*Mallotus tetracoccus*	4.71	0.51	9.41	0.11	2.00	4.71	5.33
42	*Melia azedarach**	1.18	0.13	1.18	0.01	1.00	1.18	1.32
43	*Melia dubia*	11.76	1.28	57.65	0.69	4.90	11.76	13.74
44	*Mikania micrantha**	2.35	0.26	11.76	0.14	5.00	2.35	2.75
45	*Mimosa pudica**	49.41	5.38	183.53	2.21	3.71	49.41	57.01
46	*Mimusops elengi*	1.18	0.13	1.18	0.01	1.00	1.18	1.32
47	*Mitracarpus hirtus*	11.76	1.28	147.06	1.77	12.5	11.76	14.82
48	*Naringi crenulata*	2.35	0.26	2.35	0.03	1.00	2.35	2.64
49	*Olea dioica*	16.47	1.79	42.35	0.51	2.57	16.47	18.78
50	*Persea macrantha*	1.18	0.13	4.71	0.06	4.00	1.18	1.36
51	*Pogostemon purpurascens*	3.53	0.38	50.59	0.61	14.3	3.53	4.52
52	*Pterocarpus marsupium*	2.35	0.26	2.35	0.03	1.00	2.35	2.64
53	*Schleichera oleosa*	18.82	2.05	92.94	1.12	4.94	18.82	21.99
54	*Semecarpus anacardium*	18.82	2.05	25.88	0.31	1.38	18.82	21.19
55	*Senna spectabilis**	8.24	0.90	63.53	0.77	7.71	8.24	9.90
56	*Senna tora**	3.53	0.38	38.82	0.47	11.0	3.53	4.38
57	*Shorea roxburghii*	12.94	1.41	17.65	0.21	1.36	12.94	14.56
58	*Sida acuta*	12.94	1.41	14.12	0.17	1.09	12.94	14.52
59	*Sida alnifolia*	25.88	2.82	54.12	0.65	2.09	25.88	29.35
60	*Sida rhombifolia*	8.24	0.90	8.24	0.10	1.00	8.24	9.23
61	*Solanum aculeatissimum**	11.76	1.28	21.18	0.26	1.80	11.76	13.30
62	*Stachytarpheta jamaicensis**	2.35	0.26	90.59	1.09	38.5	2.35	3.70
63	*Syzygium cumini*	8.24	0.90	20.00	0.24	2.43	8.24	9.37
64	*Tabernamontana alternifolia*	23.53	2.56	41.18	0.50	1.75	23.53	26.59
65	*Tectona grandis*	87.06	9.49	564.71	6.80	6.49	87.06	103.3
66	*Terminalia bellirica*	2.35	0.26	2.35	0.03	1.00	2.35	2.64
67	*Terminalia elliptica*	4.71	0.51	14.12	0.17	3.00	4.71	5.39
68	*Triumfetta rhomboidea*	15.29	1.67	23.53	0.28	1.54	15.29	17.24
69	*Ziziphus mauritiana*	5.88	0.64	5.88	0.07	1.00	5.88	6.59
70	*Ziziphus oenoplia*	14.12	1.54	25.88	0.31	1.83	14.12	15.97
	Total	**917.65**	**100.00**	**8300.00**	**100.00**	**321.66**	**100.0**	**300**

*indicates non-native species

Table 5. Phytosociological analysis of vegetation in Vayal.

	Binomial	F	RF	D	RD	A	RBA	IVI
1	*Ageratum conyzoides**	10.59	1.03	768.24	2.39	72.56	1.03	4.46
2	*Annona squamosa**	1.18	0.11	22.35	0.07	19.00	0.11	0.30
3	*Anogeissus latifolia*	11.76	1.15	11.76	0.04	1.00	1.15	2.34
4	*Arundinella leptochloa*	83.53	8.16	11662.3	36.27	139.6	8.16	52.59
5	*Axonopus compressus*	17.65	1.72	2917.65	9.07	165.3	1.72	12.52
6	*Bauhinia malabarica*	1.18	0.11	1.18	0.00	1.00	0.11	0.23
7	*Biophytum reinwardtii*	4.71	0.46	4.71	0.01	1.00	0.46	0.93
8	*Butea monosperma*	2.35	0.23	2.35	0.01	1.00	0.23	0.47
9	*Calotropis gigantea*	3.53	0.34	3.53	0.01	1.00	0.34	0.70
10	*Careya arborea*	4.71	0.46	4.71	0.01	1.00	0.46	0.93
11	*Cassia fistula*	12.94	1.26	20.00	0.06	1.55	1.26	2.59
12	*Catunaregam spinosa*	4.71	0.46	4.71	0.01	1.00	0.46	0.93
13	*Chonemorpha fragrans*	1.18	0.11	1.18	0.00	1.00	0.11	0.23
14	*Crassocephalum crepidioides**	40.00	3.91	80.00	0.25	2.00	3.91	8.06
15	*Curculigo orchioides*	7.06	0.69	11.76	0.04	1.67	0.69	1.42
16	*Curcuma neilgherrensis*	23.53	2.30	49.41	0.15	2.10	2.30	4.75
17	*Cyperus pilosus*	8.24	0.80	195.29	0.61	23.71	0.80	2.22
18	*Dalbergia latifolia*	4.71	0.46	4.71	0.01	1.00	0.46	0.93
19	*Dendrocalamus strictus*	7.06	0.69	11.76	0.04	1.67	0.69	1.42
20	*Desmodium triflorum*	15.29	1.49	712.94	2.22	46.62	1.49	5.21
21	*Digitaria ciliaris*	29.41	2.87	992.94	3.09	33.76	2.87	8.83
22	*Elephantopus scaber*	8.24	0.80	37.65	0.12	4.57	0.80	1.73
23	*Eleutheranthera ruderalis**	4.71	0.46	37.65	0.12	8.00	0.46	1.04
24	*Eragrostis tenella*	21.18	2.07	1052.94	3.27	49.72	2.07	7.41
25	*Eucalyptus globulus**	1.18	0.11	3.53	0.01	3.00	0.11	0.24
26	*Chromolaena odorata**	89.41	8.74	5810.59	18.07	64.99	8.74	35.54
27	*Flemingia strobilifera*	2.35	0.23	7.06	0.02	3.00	0.23	0.48
28	*Glycosmis pentaphylla*	14.12	1.38	148.24	0.46	10.50	1.38	3.22
29	*Grangea maderaspatana*	7.06	0.69	11.76	0.04	1.67	0.69	1.42
30	*Haldina cordifolia*	35.29	3.45	38.82	0.12	1.10	3.45	7.02
31	*Hemidesmus indicus*	3.53	0.34	8.24	0.03	2.33	0.34	0.72
32	*Jansenella griffithiana*	18.82	1.84	203.53	0.63	10.81	1.84	4.31
33	*Kyllinga nemoralis*	24.71	2.41	4289.41	13.34	173.6	2.41	18.17
34	*Lagerstroemia microcarpa*	8.24	0.80	8.24	0.03	1.00	0.80	1.63
35	*Lannea coromandelica*	1.18	0.11	1.18	0.00	1.00	0.11	0.23
36	*Lantana camara**	43.53	4.25	423.53	1.32	9.73	4.25	9.82
37	*Lepidagathis incurve*	1.18	0.11	3.53	0.01	3.00	0.11	0.24
38	*Leucas asper*	8.24	0.80	10.59	0.03	1.29	0.80	1.64
39	*Ludwigia peruviana*	1.18	0.11	7.06	0.02	6.00	0.11	0.25
40	*Melastoma malabathricum*	2.35	0.23	12.94	0.04	5.50	0.23	0.50
41	*Mimosa pudica**	52.94	5.17	172.94	0.54	3.27	5.17	10.88
42	*Mitracarpus hirtus**	18.82	1.84	137.65	0.43	7.31	1.84	4.11
43	*Naringi crenulata*	2.35	0.23	2.35	0.01	1.00	0.23	0.47

F—Frequency | RF—Relative Frequency | D—Density, RD—Relative density| A—Abundance | RBA—Relative basal area | IVI—Importance Value Index.

	Binomial	F	RF	D	RD	A	RBA	IVI
44	*Olea dioica*	7.06	0.69	8.24	0.03	1.17	0.69	1.40
45	*Panicum trypheron*	29.41	2.87	736.47	2.29	25.04	2.87	8.04
46	*Phyllanthus emblica*	4.71	0.46	4.71	0.01	1.00	0.46	0.93
47	*Pterocarpus marsupium*	5.88	0.57	9.41	0.03	1.60	0.57	1.18
48	*Rhynchospora corymbosa*	7.06	0.69	81.18	0.25	11.50	0.69	1.63
49	*Sacciolepis indica**	30.59	2.99	250.59	0.78	8.19	2.99	6.76
50	*Senna spectabilis**	7.06	0.69	84.71	0.26	12.00	0.69	1.64
51	*Senna tora**	21.18	2.07	45.88	0.14	2.17	2.07	4.28
52	*Shorea roxburghii*	3.53	0.34	8.24	0.03	2.33	0.34	0.72
53	*Sida acuta*	10.59	1.03	18.82	0.06	1.78	1.03	2.13
54	*Sida alnifolia*	16.47	1.61	25.88	0.08	1.57	1.61	3.30
55	*Solanum aculeatissimum*	29.41	2.87	54.12	0.17	1.84	2.87	5.92
56	*Sporobolus tenuissimus*	56.47	5.52	632.94	1.97	11.21	5.52	13.00
57	*Syzygium cumini*	18.82	1.84	21.18	0.07	1.13	1.84	3.74
58	*Tabernamontana alternifolia*	2.35	0.23	2.35	0.01	1.00	0.23	0.47
59	*Tamilnadia uliginosa*	18.82	1.84	20.00	0.06	1.06	1.84	3.74
60	*Tectona grandis*	16.47	1.61	41.18	0.13	2.50	1.61	3.35
61	*Terminalia bellirica*	4.71	0.46	4.71	0.01	1.00	0.46	0.93
62	*Terminalia cuneata*	7.06	0.69	7.06	0.02	1.00	0.69	1.40
63	*Terminalia elliptica*	48.24	4.71	74.12	0.23	1.54	4.71	9.66
64	*Themeda triandra*	8.24	0.80	105.88	0.33	12.86	0.80	1.94
65	*Trewia nudiflora*	1.18	0.11	2.35	0.01	2.00	0.11	0.24
66	*Ziziphus oenoplia*	2.35	0.23	3.53	0.01	1.50	0.23	0.47
	Total	**1023.53**	**100.0**	**32156.4**	**100.0**	**997.96**	**100.0**	**300.0**

*indicates non-native species.

Table 6. Diversity attributes of three ecosystems.

Ecosystem	Simpson's diversity index (1-D)	Berger-Parker dominance index	Margalef richness index	Pielou's equitability index
Natural Forest	0.61	0.62	10.76	1.002
Plantation	0.58	0.64	7.85	0.999
Vayal	0.80	0.36	6.46	1.19

(54.1). *Terminalia elliptica* (50.5) was the tree species having the highest frequency, followed by *Lagerstroemia microcarpa* (31.7) and *Olea dioica* (35.8). It is *Annona squamosa* which has the lowest frequency, abundance and density in NF.

In plantation, *Chromolaena odorata* (75.29) was recorded in maximum frequency, followed by *Glycosmis pentaphylla* (44.7), *Lantana camara* (44.5) and *Mimosa pudica* (44.9) (Table 4). After *Chromolaena odorata* (65.6), *Stachytarpheta jamaicensis* (38.5) recorded the second highest abundance. The highest frequency in plantation was for *Tectona grandis* (87.05). It was followed by *Chromolaena odorata* (75.29) and *Mimosa pudica* (49.4). The least frequency was shown by *Barleria mysorensis, Bauhinia racemosa, Lannea coromandelica, Melia azedarach* and *Mimusops elengi. Chromolaena odorata* recorded the highest IVI, followed by *Tectona grandis.*

The most densely seen plant species in vayals was *Arundinella leptochloa* (11,662 stems ha^{-1}) (Table 5). Density of *Chromolaena odorata* in vayal was (58,10.6 stems ha^{-1}). The lowest density in vayal was recorded for *Bauhinia malabarica, Chonemorpha fragrans*, and *Lannea coromandelica*. The most abundantly seen plant species in vayals was *Kyllinga nemoralis* (173.6). It was followed by *Arundinella leptochloa* (165.3) and

Axonopus compressus (139.6). In vayals, *Ageratum conyzoides* (72.56) was more abundantly seen than *Chromolaena odorata*. The highest frequency in vayals was recorded for *Chromolaena odorata* (89.4) and *Arundinella leptochloa* (83.5).

The NF in WS II was dominated by *Chromolaena odorata* (60.56) (Figure 3). The second most dominant species in NF was *Lantana camara* (15.7). Other dominating species were *Mimosa pudica* (10.82), *Terminalia elliptica* (10.53), and *Glycosmis pentaphylla* (10.38). In the WS II plantation also, the dominance of *Chromolaena odorata* (143.06) was evident. The second most dominant species here was *Tectona grandis* (103.35). Other dominating species were *Mimosa pudica* (57.01), and *Glycosmis pentaphylla* (55.42). In vayal, *Arundinella leptochloa* (143.06) had the highest dominance. This was followed by *Chromolaena odorata* (35.54), *K. nemoralis* (18.17) and *Sporobolus tenuissimus* (13.0) in that order.

Among the three ecosystems (Table 6), vayals recorded the highest Simpson's diversity index, with plantations recording the least index value. In the vayal ecosystem, the predominance of many grass species has contributed to the higher index value. Moreover, vayals also recorded the highest Pielou's Wiener equitability index, which means that, in vayals, the plant species present are also more evenly distributed. The highest Berger-Parker dominance index for the plantations indicates the domination by selected species in this ecosystem which is also a reason for its reduced diversity index. The highest Margalef richness index was in natural forest followed by plantation and vayal.

CONCLUSION

The paper assessed the phytosociological characters of the vegetation in three different ecosystems (Natural forest, plantation and vayal) of WS II area of Wayanad WS in Kerala State. The plant species diversity and the structural composition of flora found in these ecosystems were distinctly different. As expected, the highest species richness was found in NF and the least was in vayal. All the three ecosystems had their unique set of representative plant species. *Chromolaena odorata*, which is an invasive alien plant species (IAPS), however, was one of the dominant species in all three ecosystems. Besides the tree species, *Terminalia eliptica* and *Tectona grandis,* WS II of Wayanad WS was also observed to be largely invaded by *Chromolaena odorata, Lantana camara*, and *Mimosa pudica*, which are also invasive in nature.

REFERENCES

Battles, J.J., A.J. Shlinsky, R.H. Barrett, R.C. Heald & B.H. Allen-Diaz (2001). The effects of forest management on plant species diversity in a Sierran conifer forest. *Forest Ecology and Management* 146: 211–222.

Berger, W.H. & F.L. Parker (1970). Diversity of Planktonic Foraminifera in Deep-Sea Sediments. *Science* 168(3937): 1345–1347.

Chaubey, O.P., R. Prasad & G.P. Mishra (1988). Studies of Teak Plantation and mixed natural forest in Madhya Pradesh. *Journal of Tropical Forestry* 4: 22–35.

Das, D., B.K. Pramanik & S.K. Mollay (2015). A Model Classical Ecological report on Vegetation dynamics in Gorumara National Park in West Bengal, India. *International Journal Pharmacy & Biomedical Research* 2(2): 1–14.

GOK [Government of Kerala] (2012). Wayanad Wildlife Sanctuary Management plan [on-line]. Available: http://www.forest.kerala.gov.in/index.php/forest/forestmanagement/management-plans [11 Sept 2012], 230pp.

Hamzaoglu, E. (2006). Phytosociological studies on the steppe communities of East Anatolia. *Ekoloji* 15(61): 29–55.

Kumar, A., G.M. Bruce & S. Ajai (2006). Tree species diversity and distribution patterns in tropical forests of Garo Hills. *Current Science* 91: 1370–1381.

Lloyd, M. & R.J. Ghelard (1964). A table for calculating the equitability component of species diversity. *Journal of Animal Ecology* 33: 217–255.

Margalef, R. (1958). Temporal succession and spatial heterogeneity in phytoplankton, pp. 323–347. In: Buzzati-Traverso (ed.). *Perspectives in Marine Biology.* University California Press, Berkeley. 621 pp.

Pielou, E.C. (1969). *An Introduction to Mathematical Ecology.* Wiley-Interscience, New York, 286pp.

Sarkar, A.K. (2015). Phytosociological studies of tree vegetation of Moraghat forest range, India. *Asian Journal of Biological Life Science* 4(3): 217–220.

Sarkar, A.K. (2016). Ecological Studies of Tree Vegetation of Ramshai Forest Range, Gorumara National Park, India. *Research Journal of Biological Sciences* 5(7): 53–59.

Simpson, E.H. (1949). Measurement of Diversity. *Nature*.163: 688.

Rao, S.D., P.P. Murthy & O.A. Kumar (2015). Plant biodiversity and phytosociological studies on tree species diversity of Khammam District, Telangana State, India. *Journal of Pharmaceutical Sciences and Research* 7(8): 518–522.

Author details: Mr. M. Vishnu Chandran is a postgraduate in tropical forestry from the Department of Natural Resource Management of College of Forestry of Kerala Agricultural University, India and is specializing in the study and management of invasive alien plant species in tropical ecosystems. Dr. S. Gopakumar is a Professor of Forest Management in the Department of Natural Resource Management of College of Forestry of Kerala Agricultural University, India with over 21 years of research and academic experience in tropical forestry. Miss. Anoopa Mathews is an Environmental science postgraduate from Christ College Irinjalakkuda, India. She is an amateur plant taxonomist and an expert in tree and grass systematics.

Author contribution: MVC—conducted the field study, data analyses, drafting the manuscript, provided literatures, photos of specimens, habitats. SG—conceptualized the research idea and peer reviewed the manuscript. AM—identification of the observed plant species.

Journal of Threatened Taxa

www.threatenedtaxa.org

PLATINUM OPEN ACCESS

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

April 2020 | Vol. 12 | No. 5 | Pages: 15535–15674
Date of Publication: 26 April 2020 (Online & Print)
DOI: 10.11609/jott.2020.12.5.15535-15674

Publisher & Host

WILD ZOOREACH Threatened Taxa

Member

FJN