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

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

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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 *Mimosa pudica*, *Glycosmis pentaphylla* showed dominance. The vayal was dominated by *Arundinella leptochloa*. The second most dominant species in the vayal was *Chromolaena odorata*. 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 | WI—Wildlife Sanctuary II.

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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 344km² and comprises two discontinuous land areas of 77.67km² (WS-I) and 266.77 km² (WS-II) (Figure 1). The larger of these two, WS-II lies within the geographical extremes of 11°35’–11°49’N and 76°13’–76°27’E. The other area WS-I lies within 11°50’–11°59’N and 76°02’–76°07’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.

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

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

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

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

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
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).

Figure 1. Location map of the study area.
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 Poaceae, 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, Mililusa 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,
Table 1. Vegetation-type-wise distribution of species, genera, and families.

| Ecosystem          | 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        | Herb     | Asteraceae | +  | -          | +     |
| 2        | Tree     | Simaboubaceae | -  | +          | -     |
| 3        | Tree     | Annonaceae  | +  | -          | +     |
| 4        | Tree     | Combretaceae | +  | +          | +     |
| 5        | Tree     | Euphorbiaceae | +  | -          | -     |
| 6        | Herb     | Poaceae    | -  | -          | +     |
| 7        | Herb     | Poaceae    | -  | -          | +     |
| 8        | Shrub    | Acanthaceae | +  | +          | -     |
| 9        | Tree     | Caesalpiniae | -  | -          | +     |
| 10       | Tree     | Caesalpiniae | +  | +          | -     |
| 11       | Herb     | Oxalidaceae | +  | +          | +     |
| 12       | Tree     | Fabaceae   | +  | +          | +     |
| 13       | Climber  | Caesalpiniae | +  | -          | -     |
| 14       | Shrub    | Asclepiadaceae | -  | -          | +     |
| 15       | Climber  | Combretaceae | +  | +          | -     |
| 16       | Shrub    | Rubiaceae  | +  | -          | -     |
| 17       | Tree     | Rhizophoraceae | +  | -          | -     |
| 18       | Climber  | Sapindaceae | +  | +          | -     |
| 19       | Tree     | Lecythidae | -  | -          | +     |
| 20       | Shrub    | Boraginaceae | +  | -          | +     |
| 21       | Tree     | Palmae     | +  | +          | -     |
| 22       | Tree     | Caesalpiniae | +  | +          | +     |
| 23       | Shrub    | Rubiaceae  | +  | +          | +     |
| 24       | Herb     | Umbellifera | +  | -          | -     |
| 25       | Herb     | Caesalpiniae | +  | -          | -     |
| 26       | Climber  | Apocynaceae | -  | -          | +     |
| 27       | Shrub    | Asteraceae  | +  | +          | +     |
| 28       | Tree     | Lauraceae  | +  | -          | -     |
| 29       | Shrub    | Meliaceae  | +  | +          | -     |
| 30       | Shrub    | Verbenaceae | +  | -          | -     |
| 31       | Climber  | Asclepiadaceae | +  | -          | -     |
| 32       | Herb     | Asteraceae  | +  | +          | +     |
| 33       | Herb     | Hypoxidaceae | +  | -          | +     |
| 34       | Herb     | Zingiberaceae | +  | +          | +     |
| 35       | Climber  | Menisperminaceae | +  | +          | -     |
| 36       | Herb     | Pyrolaceae  | -  | -          | +     |
| 37       | Tree     | Fabaceae   | +  | -          | -     |
| 38       | Tree     | Fabaceae   | -  | +          | +     |
| Binomial | Category | Family | NF  | Plantation | Vayal |
|----------|----------|--------|-----|-------------|-------|
| 39 Dendrocalamus strictus Nees | Shrub | Gramineae | +  | + | + |
| 40 Desmodium gangeticum Blanco | Herb | Fabaceae | -  | + | - |
| 41 Desmodium heterocarpum (L.) DC. | Shrub | Fabaceae | +  | + | - |
| 42 Desmodium laxiflorum DC. | Herb | Fabaceae | +  | + | - |
| 43 Desmodium pulchellum (L.) Benth. | Shrub | Fabaceae | +  | + | - |
| 44 Desmodium triforum (L.) DC. | Herb | Fabaceae | -  | - | + |
| 45 Digitaria ciliaris (Retz.) Koeler | Herb | Gramineae | -  | - | + |
| 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 | Flacourtiaecae | +  | - | - |
| 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 tilifolia 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 Hydrocotylosus patens (Buch.-Ham.) Oken | Tree | Flacourtiaecae | +  | - | - |
| 65 Hymenocallis suaveolens (L.) Poit. | Herb | Lamianae | +  | + | - |
| 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 | Lamianae | +  | - | + |
| 75 Lindernia griffithiana | Herb | Scrophulariaceae | +  | + | + |
| 76 Ludwigia peruviana (L.) H.Hara* | Herb | Scrophulariaceae | +  | - | - |
| 77 Mallotus tetrococcus Kurz | Tree | Euphorbiaceae | -  | + | - |
| 78 Mangifera indica Wall. | Tree | Anacardiaceae | +  | - | - |
| 79 Melastoma malabathricum L. | Shrub | Melastomataceae | +  | - | + |
| 80 Melia azedarach L.* | Tree | Melianae | +  | + | - |
| 81 Melia dubia Cav. | Tree | Melianae | +  | + | - |
| 82 Mikania micrantha Kunth* | Climber | Asteraceae | -  | + | - |
| 83 Milicia tomentosa (Roxb.) Finet & Gagnep. | Tree | Annonaceae | +  | - | - |
| 84 Mimosa pudica L.* | Herb | Fabaceae | +  | + | + |
| Binomial                        | Category | Family            | NF | Plantation | Vayal |
|--------------------------------|----------|-------------------|----|------------|-------|
| Mimusops elengi Wight          | Tree     | Sapotacea         | +  |            |       |
| Mitracarpus hirtus DC.*        | Herb     | Rubiaceae         | +  | +          | +     |
| Naringi crenulata (Roxb.) Nicolson | Tree     | Rutaceae          | +  |            | +     |
| Olea Dioica Roxb.              | Tree     | Oleaceae          | +  |            |       |
| Osbeckia aspera Blume          | Shrub    | Melastomataceae   | +  |            |       |
| Panicum trypberon Schult.      | Herb     | Poaceae           | -  |            | +     |
| Persea macrantha (Nees) Koetem. | Tree     | Lauraceae         | +  |            |       |
| Phyllanthus emblica L.         | Tree     | Euphorbiaceae     | +  |            |       |
| Piper nigrum L.                | Climber  | Piperaceae        | +  |            |       |
| Pogonanthem purpurascens Dalzell | Herb    | Lamiaceae         | -  |            | -     |
| Pongamia pinnata (L.) Merr.    | Tree     | Fabaceae          | +  |            |       |
| Premna tomentosu Wild.         | Tree     | Verbenaceae       | +  |            |       |
| Pterocarpus marsupium Roxb.    | Tree     | Fabaceae          | +  |            |       |
| Rauvelfia serpentina Jacq.     | Shrub    | Apocynaceae       | +  | -          |       |
| Rhynchopora corymbosa (L.) Britton | Herb    | Cyperaceae        | -  |            | +     |
| Sacciolepis indica (L.) Chase* | Herb     | Poaceae           | -  |            | +     |
| Schleichera aloesa (Lour.) Oken | Tree     | Sapindaceae       | +  | -          | -     |
| Schrebera swietenioides Roxb.  | Tree     | Oleaceae          | +  |            |       |
| Semecarpus anacardium Roxb.    | Tree     | Anacardiaceae     | -  |            | +     |
| Senko spectabilis (DC.) H. S. Irwin & Barney* | Tree     | Fabaceae          | +  |            | +     |
| Senna tora Roxb.*              | Herb     | Caesalpinaceae    | +  |            | +     |
| Shorea roxburghi G. Don.       | Tree     | Dipterocarpaeceae | +  |            | +     |
| Sida acuta burm. F.            | Shrub    | Malvaceae         | +  |            |       |
| Sida alyfolia L.               | Shrub    | Malvaceae         | +  |            | +     |
| Sida rhombifolia L.            | Shrub    | Malvaceae         | -  |            |       |
| Solarum aculeatissimum Jacq.*  | Shrub    | Solanaceae        | +  |            | +     |
| Spathodea campanulata Buch.-Ham. ex DC.* | Tree    | Bignoniaceae      | +  |            |       |
| Sporobolus tenusissimus Kunte  | Herb     | Poaceae           | -  |            | -     |
| Stachyapheta jamaicensis (L.) Vahl* | Shrub    | Verbenaceae       | +  |            | +     |
| Streblus asper Lour.           | Tree     | Moraceae          | +  |            | -     |
| Syzygium cumini (L.) Skeels    | Tree     | Myrtaceae         | +  |            | +     |
| Tabernamontana alternifolia Roxb. | Tree     | Apocynaceae       | +  |            | +     |
| Tamalinda uliginosa (Retz.) Tirveng. & Sastre | Tree    | Rubiaceae         | -  |            | +     |
| Tectona grandis L.f.           | Tree     | Verbenaceae       | +  |            | +     |
| Terminalia bellica (Gaertn.) Roxb. | Tree     | Combretaceae      | +  |            | +     |
| Terminalia cuneata Roth        | Tree     | Combretaceae      | +  |            |       |
| Terminalia elliptica Willd.    | Tree     | Combretaceae      | +  |            | +     |
| Terminalia paniculata Roth     | Tree     | Combretaceae      | +  |            |       |
| Themeda triandra Forssk.       | Herb     | Poaceae           | -  |            | +     |
| Trewia nudiflora Wight         | Tree     | Euphorbiaceae     | -  |            | +     |
| Triumfetta rhomboidea Jacq.    | Shrub    | Tiliaceae         | +  |            | -     |
| Vitex altissima L.f.           | Tree     | Verbenaceae       | +  |            | -     |
| Ziziphus gabrata B. Heyne ex Roth | Tree    | Rhamnaceae        | +  |            | -     |
| Ziziphus mauritiana Lam.       | Tree     | Rhamnaceae        | -  |            | +     |
| 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 leptochoa, 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 coromandelicium, Carmona retusa, Clerodendrum infortunatum, Desmodium heterocarpon, D. pulchellum, Flacourtia indica, Glycosmis pentaphylla, Helicteres isora, Melastoma malabathricum, Osbeckia aspera, Rauwolfia serpentina, Sida acuta, S. alnifolia, Solanum aculeatissimum, Stachyphrynium jamaicensis, and Triumfetta rhomboidei were the shrubs observed in NF. Canthium coromandelicium, Clerodendrum infortunatum, Flacourtia indica, Osbeckia aspera, and Rauwolfia 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 are 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 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  |
|-----------------------------------------|-----|-----|------|-----|-----|-----|------|
| Ageratum conyzoides*                    | 11.76 | 1.14 | 61.18 | 0.60 | 5.20 | 1.14 | 2.88 |
| Annona squamosa*                        | 1.18  | 0.11 | 1.18  | 0.01 | 1.00 | 0.11 | 0.24 |
| Anogeissus latifolia                    | 9.41  | 0.91 | 12.94 | 0.13 | 1.38 | 0.91 | 1.95 |
| Aporosa cardiophyllum                   | 5.88  | 0.57 | 8.24  | 0.08 | 1.40 | 0.57 | 1.22 |
| Barleria mysorensis                     | 1.18  | 0.11 | 1.18  | 0.01 | 1.00 | 0.11 | 0.24 |
| Bauhinia racemosa                       | 1.18  | 0.11 | 1.18  | 0.01 | 1.00 | 0.11 | 0.24 |
| Biophytum reinwardti                    | 2.35  | 0.23 | 10.59 | 0.10 | 4.50 | 0.23 | 0.56 |
| Butera monasperma                       | 9.41  | 0.91 | 10.59 | 0.10 | 1.13 | 0.91 | 1.93 |
| Caesalpinia mimosoides                  | 1.18  | 0.11 | 17.65 | 0.17 | 15.0 | 0.11 | 0.40 |
| Calycophyllum floribunda                | 18.82 | 1.83 | 37.65 | 0.37 | 2.00 | 1.83 | 4.02 |
| Campanthium coromandelicum              | 1.18  | 0.11 | 2.35  | 0.02 | 2.00 | 0.11 | 0.25 |
| Canthium coromandelicum                 | 15.29 | 1.48 | 37.65 | 0.37 | 2.46 | 1.48 | 3.33 |
| Cardiospermum halicacabum               | 8.24  | 0.80 | 10.59 | 0.10 | 1.29 | 0.80 | 1.70 |
| Carmona retusa*                         | 15.29 | 1.48 | 18.82 | 0.18 | 1.23 | 1.48 | 3.15 |
| Caryota urens                           | 3.53  | 0.34 | 7.06  | 0.07 | 2.00 | 0.34 | 0.75 |
| Cassia fistula                          | 28.24 | 2.74 | 57.65 | 0.56 | 2.04 | 2.74 | 6.04 |
| Catunaregma spinosa                     | 10.59 | 1.03 | 11.76 | 0.11 | 1.11 | 1.03 | 2.17 |
| Centella asiatica                       | 1.18  | 0.11 | 2.35  | 0.02 | 2.00 | 0.11 | 0.25 |
| Chamaecrista absus                      | 1.18  | 0.11 | 2.35  | 0.02 | 2.00 | 0.11 | 0.25 |
| Chromolaena odorata*                    | 61.18 | 5.94 | 4996.47 | 48.69 | 81.6 | 5.94 | 60.5 |
| Cinnamomum verum                        | 11.76 | 1.14 | 52.94 | 0.52 | 4.50 | 1.14 | 2.80 |
| Cipadessa baccifera                     | 4.71  | 0.46 | 8.24  | 0.08 | 1.75 | 0.46 | 0.99 |
| Clerodendrum infortunatum               | 1.18  | 0.11 | 2.35  | 0.02 | 2.00 | 0.11 | 0.25 |
| Cosmostigma racemosum                   | 1.18  | 0.11 | 2.35  | 0.02 | 2.00 | 0.11 | 0.25 |
| Crassocephalum crepidioides*            | 8.24  | 0.80 | 11.76 | 0.11 | 1.43 | 0.80 | 1.71 |
| Curcuma neilgherrensis                  | 17.65 | 1.71 | 70.59 | 0.69 | 4.00 | 1.71 | 4.11 |
| Cyclistis petiolaris                    | 17.65 | 1.71 | 27.06 | 0.26 | 1.53 | 1.71 | 3.69 |
| Dalbergia lanceolata                    | 10.59 | 1.03 | 15.29 | 0.15 | 1.44 | 1.03 | 2.20 |
| Dendrocalamus strictus                  | 18.82 | 1.83 | 58.82 | 0.57 | 3.13 | 1.83 | 4.23 |
| Desmodium heterocarpus                  | 2.35  | 0.23 | 8.24  | 0.08 | 3.50 | 0.23 | 0.54 |
| Desmodium laxiflorum                   | 7.06  | 0.68 | 11.76 | 0.11 | 1.67 | 0.68 | 1.48 |
| Desmodium pulchellum                    | 5.88  | 0.57 | 7.06  | 0.07 | 1.20 | 0.57 | 1.21 |
| Diospyros melanoxylon                   | 7.06  | 0.68 | 9.41  | 0.09 | 1.33 | 0.68 | 1.46 |
| Elaeagnus kologa                        | 2.35  | 0.23 | 4.71  | 0.05 | 2.00 | 0.23 | 0.50 |
| Elaeocarpus variabilis                  | 1.18  | 0.11 | 1.18  | 0.01 | 1.00 | 0.11 | 0.24 |
| Elaphantopus scaber                     | 14.12 | 1.37 | 142.35 | 1.39 | 10.1 | 1.37 | 4.13 |
| Eleutherothera ruderals*                | 7.06  | 0.68 | 31.76 | 0.31 | 4.50 | 0.68 | 1.68 |
| Flacourtia indica                       | 11.76 | 1.14 | 14.12 | 0.14 | 1.20 | 1.14 | 2.42 |
| Glycosmis pentaphylla                   | 36.47 | 3.54 | 338.82 | 3.30 | 9.29 | 3.54 | 10.3 |
| Gmelina arborea                         | 2.35  | 0.23 | 2.35  | 0.02 | 1.00 | 0.23 | 0.48 |
| Grewia triflora                         | 14.12 | 1.37 | 20.00 | 0.19 | 1.42 | 1.37 | 2.93 |
| Halodina 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 Mella azedarach*              | 4.71  | 0.46  | 5.88  | 0.06 | 1.25  | 0.46 | 0.97 |
| 59 Mella dubia                   | 4.71  | 0.46  | 4.71  | 0.05 | 1.00  | 0.46 | 0.96 |
| 60 Milusia 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 Stachytypheta jamaiicensis*    | 3.53  | 0.34  | 110.59| 1.08 | 31.3  | 0.34 | 1.76 |
| 84 Strelbus 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 Taminadia uliginosa           | 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 |
### Table 4. Phytosociological analysis of vegetation in plantation.

| Binomial                        | F  | RF | D  | RD  | A   | RBA | IVI |
|---------------------------------|----|----|----|-----|-----|-----|-----|
| Acalypha paniculata             | 1.18 | 0.13 | 2.35 | 0.03 | 2.00 | 1.18 | 1.33 |
| Ailanthus triphysa              | 5.88 | 0.64 | 7.06 | 0.09 | 1.20 | 5.88 | 6.61 |
| Anogeissus latifolia            | 14.12 | 1.54 | 14.1 | 0.17 | 1.00 | 14.12 | 15.8 |
| Barleria mysorensis             | 1.18 | 0.13 | 1.18 | 0.01 | 1.00 | 1.18 | 1.32 |
| Boushinia racemosa              | 1.18 | 0.13 | 1.18 | 0.01 | 1.00 | 1.18 | 1.32 |
| Biophytum reinwardtii           | 2.35 | 0.26 | 5.88 | 0.07 | 2.50 | 2.35 | 2.68 |
| Butea monosperma                | 2.35 | 0.26 | 2.35 | 0.03 | 1.00 | 2.35 | 2.64 |
| Calycopteris floribunda        | 2.35 | 0.26 | 4.71 | 0.06 | 2.00 | 2.35 | 2.67 |
| Cordia depressum hollacabum     | 3.53 | 0.38 | 3.53 | 0.04 | 1.00 | 3.53 | 3.96 |
| Carmona retusa *               | 3.53 | 0.38 | 3.53 | 0.04 | 1.00 | 3.53 | 3.96 |
| Caryota urens                  | 2.35 | 0.26 | 2.35 | 0.03 | 1.00 | 2.35 | 2.64 |
| Cassia fistula                 | 42.35 | 4.62 | 83.5 | 1.01 | 1.97 | 42.35 | 47.9 |
| Coturnicola spinosa             | 21.18 | 2.31 | 31.7 | 0.38 | 1.50 | 21.18 | 23.8 |
| Chromolaena odorata *          | 75.29 | 8.21 | 4943.53 | 59.56 | 65.6 | 75.29 | 143.1 |
| Cinnamomum verum               | 4.71 | 0.51 | 11.76 | 0.14 | 2.50 | 4.71 | 5.36 |
| Cipadessa baccifera            | 11.76 | 1.28 | 14.12 | 0.17 | 1.20 | 11.76 | 13.22 |
| Crossocephalum crepidioides *  | 24.71 | 2.69 | 35.29 | 0.43 | 1.43 | 24.71 | 27.82 |
| Curculigo archioides           | 10.59 | 1.15 | 84.71 | 1.02 | 8.00 | 10.59 | 12.76 |
| Curcuma neilgherrensis         | 15.29 | 1.67 | 72.94 | 0.88 | 4.77 | 15.29 | 17.84 |
| Cyclos peltata                 | 10.59 | 1.15 | 17.65 | 0.21 | 1.67 | 10.59 | 11.95 |
| Dalbergia latifolia            | 27.06 | 2.95 | 34.12 | 0.41 | 1.26 | 27.06 | 30.42 |
| Dendrocalamus strictus         | 14.12 | 1.54 | 37.65 | 0.45 | 2.67 | 14.12 | 16.11 |
| Desmodium gangeticum          | 1.18 | 0.13 | 2.35 | 0.03 | 2.00 | 1.18 | 1.33 |
| Desmodium heterocarpfen        | 2.35 | 0.26 | 2.35 | 0.03 | 1.00 | 2.35 | 2.64 |
| Desmodium laxiflorum           | 7.06 | 0.77 | 7.06 | 0.09 | 1.00 | 7.06 | 7.91 |
| Desmodium pulchellum           | 9.41 | 1.03 | 14.12 | 0.17 | 1.50 | 9.41 | 10.61 |
| Elaeocarpus tuberculatus       | 2.35 | 0.26 | 16.47 | 0.20 | 7.00 | 2.35 | 2.81 |
| Elephantopus scaber            | 23.53 | 2.56 | 101.18 | 1.22 | 4.30 | 23.53 | 27.31 |
| Eleutheranthera ruderalis *    | 1.18 | 0.13 | 4.71 | 0.06 | 4.00 | 1.18 | 1.36 |
| Eucalyptus globulus *          | 12.94 | 1.41 | 75.29 | 0.91 | 5.82 | 12.94 | 15.26 |
| Gymnosperm pentaphylla         | 44.71 | 4.87 | 484.71 | 5.84 | 10.8 | 44.71 | 55.42 |

*indicates non-native species

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 bilifolia          | 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 tetrococcus      | 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| 383.53| 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 diosica              | 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 rosulghii          | 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 alinifolia           | 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 Stachyphora 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 Tabernanontana alternifolia| 23.53| 2.56| 41.18| 0.50| 1.75| 23.53| 26.59|
| 65 Tecoma 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 rhotboidea     | 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**| **100.00**| **300**|

*indicates non-native species
Table 5. Phytosociological analysis of vegetation in Vayal.

| Binomial                      | F   | RF  | D    | RD  | A   | RBA | IVI  |
|-------------------------------|-----|-----|------|-----|-----|-----|------|
| Ageratum conyzoides*          | 10.59 | 1.03 | 768.24 | 2.39 | 72.56 | 1.03 | 4.46  |
| Annona squamosa*             | 1.18 | 0.11 | 22.35 | 0.07 | 19.00 | 0.11 | 0.30  |
| Anogeissus latifolia         | 11.76 | 1.15 | 11.76 | 0.04 | 1.00  | 1.15 | 2.34  |
| Arundinella leptochoia       | 83.53 | 8.16 | 11662.3 | 36.27 | 139.6 | 8.16 | 52.59 |
| Axonopus compressus          | 17.65 | 1.72 | 2917.65 | 9.07 | 165.3 | 1.72 | 12.52 |
| Bauhinia malabarica          | 1.18 | 0.11 | 1.18  | 0.00 | 1.00  | 0.11 | 0.23  |
| Biophyllum reinwardthii      | 4.71 | 0.46 | 4.71  | 0.01 | 1.00  | 0.46 | 0.93  |
| Butea monosperma             | 2.35 | 0.23 | 2.35  | 0.01 | 1.00  | 0.23 | 0.47  |
| Calotropis gigantea          | 3.53 | 0.34 | 3.53  | 0.01 | 1.00  | 0.34 | 0.70  |
| Coreya arborea               | 4.71 | 0.46 | 4.71  | 0.01 | 1.00  | 0.46 | 0.93  |
| Cassia fistula               | 12.94 | 1.26 | 20.00 | 0.06 | 1.55  | 1.26 | 2.59  |
| Catanuragam spinosa          | 4.71 | 0.46 | 4.71  | 0.01 | 1.00  | 0.46 | 0.93  |
| Chonemorpha fragrans         | 1.18 | 0.11 | 1.18  | 0.00 | 1.00  | 0.11 | 0.23  |
| Croscosephalum crepidioides* | 40.00 | 3.91 | 80.00 | 0.25 | 2.00  | 3.91 | 8.06  |
| Curcuma neilgherrensis       | 7.06 | 0.69 | 11.76 | 0.04 | 1.67  | 0.69 | 1.42  |
| Cyperus pilosus              | 8.24 | 0.80 | 195.29 | 0.61 | 23.71 | 0.80 | 2.22  |
| Dalbergia latifolia          | 4.71 | 0.46 | 4.71  | 0.01 | 1.00  | 0.46 | 0.93  |
| Dendrocalamus strictus       | 7.06 | 0.69 | 11.76 | 0.04 | 1.67  | 0.69 | 1.42  |
| Desmodium triforum          | 15.29 | 1.49 | 712.94 | 2.22 | 46.62 | 1.49 | 5.21  |
| Digitaria ciliaris           | 29.41 | 2.87 | 992.94 | 3.09 | 33.76 | 2.87 | 8.83  |
| Elephantopus scaber          | 8.24 | 0.80 | 37.65 | 0.12 | 4.57  | 0.80 | 1.73  |
| Eleutheranthera ruderalis*   | 4.71 | 0.46 | 37.65 | 0.12 | 8.00  | 0.46 | 1.04  |
| Eragrostis tenella           | 21.18 | 2.07 | 1052.94 | 3.27 | 49.72 | 2.07 | 7.41  |
| Eucalyptus globulus*         | 1.18 | 0.11 | 3.53  | 0.01 | 3.00  | 0.11 | 0.24  |
| Flemingia strobilifera       | 2.35 | 0.23 | 7.06  | 0.02 | 6.00  | 0.23 | 0.48  |
| Glycosmis pentaphylla        | 14.12 | 1.38 | 148.24 | 0.46 | 10.50 | 1.38 | 3.22  |
| Grangea maderaspatana        | 7.06 | 0.69 | 11.76 | 0.04 | 1.67  | 0.69 | 1.42  |
| Holodina cordifolia          | 35.29 | 3.45 | 38.82 | 0.12 | 1.10  | 3.45 | 7.02  |
| Hemidesmus indicus           | 3.53 | 0.34 | 8.24  | 0.03 | 2.33  | 0.34 | 0.72  |
| Jansenella griffithiana      | 18.82 | 1.84 | 203.53 | 0.63 | 10.81 | 1.84 | 4.31  |
| Kylinga nemoralis           | 24.71 | 2.41 | 4289.41 | 13.34 | 173.6 | 2.41 | 18.17 |
| Lagerstroemia microcarpa     | 8.24 | 0.80 | 8.24  | 0.03 | 1.00  | 0.80 | 1.63  |
| Lannea coromandelica         | 1.18 | 0.11 | 1.18  | 0.00 | 1.00  | 0.11 | 0.23  |
| Lantana camara*              | 43.53 | 4.25 | 423.53 | 1.32 | 9.73  | 4.25 | 9.82  |
| Lepidagathis incurve         | 1.18 | 0.11 | 3.53  | 0.01 | 3.00  | 0.11 | 0.24  |
| Leucas asper                 | 8.24 | 0.80 | 10.59 | 0.03 | 1.29  | 0.80 | 1.64  |
| Ludwigia peruviana           | 1.18 | 0.11 | 7.06  | 0.02 | 6.00  | 0.11 | 0.25  |
| Melastoma malabathricum      | 2.35 | 0.23 | 12.94 | 0.04 | 5.50  | 0.23 | 0.50  |
| Mimosa pudica*               | 52.94 | 5.17 | 172.94 | 0.54 | 3.27  | 5.17 | 10.88 |
| Mitracarpus hirtus*          | 18.82 | 1.84 | 137.65 | 0.43 | 7.31  | 1.84 | 4.11  |
| Naringia 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.
(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 mysoresensis*, *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

### 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                        |
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 leptochoila (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 leptochoila (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 elliptica 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.

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