

COMMUNITY STRUCTURE OF PLANT SPECIES IN OKHLA BIRD SANCTUARY, DELHI, INDIA

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Abstract

*Okhla Bird Sanctuary (OBS) has been well known as the home of migratory birds and most of the studies have been so far focused on bird diversity and aquatic vegetation. The present study was conducted to find out the structure and composition of terrestrial vegetation of sanctuary in two Nature trails. The total number of terrestrial plant species recorded in the study area is 106, of which 48 are trees, 9 shrubs and 49 herbs. The density of tree species were recorded in Nature Trail 1 and Nature Trail 2 had almost similar value with 7.10 and 6.68 stems per ha while density of shrub species found were 5.51 and 6.29 individuals/m². The density of herbaceous species in both the trails enumerated were 50.93 and 46.89 individuals/m², respectively. In terms of importance value index, *Leucaena leucocephala* (IVI- 24.49; SDI- 0.0067) was the dominant tree species in the Nature Trail 1, followed by *Ficus benghalensis* (IVI- 19.90; SDI- 0.0044), *Ficus sp* (IVI- 17.45; SDI- 0.0034) and *Melia azedarach* (IVI- 14.35; SDI- 0.0023). In shrub layer, *Tabernaemontana divaricata* (IVI- 42.04; SDI- 0.0442), followed by *Abutilon indicum* (IVI- 39.98; SDI- 0.0400) and *Lantana camara* (IVI- 35.63; SDI- 0.0317) were the most dominant species in Nature Trail 1. Among the herbaceous species, *Cynodon dactylon* (IVI- 65.9; SDI- 0.1087) was found to dominate the entire stretch of Nature trail 1, followed by *Cannabis sativum* (IVI- 20.8; SDI- 0.0108), *Oxalis corniculata* (IVI- 14.6; SDI- 0.0053) and *Chenopodium album* (IVI- 10.3; SDI- 0.0026). In case of basal area Nature Trail 2 was significantly higher (6.13 m²ha⁻¹) than Nature Trail 1 (6.03 m²ha⁻¹).*

Keywords: *Okhla wildlife sanctuary; Terrestrial vegetation; Community structure; Importance Value Index; Dominance pattern; Species diversity.*

Introduction

The National Capital of Delhi is divided into two main ecological zones, an extension of the Aravalli Hills and the plains. The Yamuna River, where a large number of waterbirds congregate during winter, is the main source of water. Delhi's Northeast and East districts are situated on the banks of River Yamuna and this part is important for migratory water birds, along with the Okhla barrage, which extends to the Okhla Wildlife Sanctuary in Uttar Pradesh, identified as important bird area of the region as Okhla Bird Sanctuary (OBS) [1, 2]. OBS is providing significant ecosystem services in terms of groundwater recharge, erosion control, recreational values, educational values and aesthetic values. It performs important functions of a wetland amidst of metropolitan cities with the presence of 13 globally threatened bird species. It is recognized as an important bird area and a center for conservation education and recreation. The main aim of this study was to know the present status of the terrestrial vegetation by

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combining field observations with other published and unpublished records. Vegetation is the community of plants occurring at a particular site and is an important feature of both natural and man-made habitats [3]. Vegetation cover in general and forest cover in particular are indicators for the quality of the environment. They again stated that a considerable proportion of all ecological work in the past and to a large extent at present has been directed towards the description of vegetation. The methods of vegetation and forest cover classification have progressed in recent years. Structure, composition, and function are the three important attributes of the vegetation communities [4]. These attributes change in response to driving, abiotic and biotic variables. These variables and forest succession are responsible for both local and landscape level variation in forest attributes, thereby producing spatial heterogeneity. Semwal et al. [5] carried out plant diversity assessment on the basis of species richness, tree crown cover and dominance-diversity pattern in different forests of Kedarnath Wildlife Sanctuary (KWLS), Central Himalaya. In general, random distribution pattern (where, Abundance/Frequency ratio ranges between 0.025-0.05) was observed in all three types of forest covered. Another study [6] carried out to find out the impact of coal mining on vegetation in Mehgalya, India. In executing the present study, the different vegetation community characteristics, tree population structure and distribution pattern were analyzed.

Study area

Okhla Bird Sanctuary (OBS) is located at the point where the river Yamuna leaves the territory of Delhi and enters the state of Uttar Pradesh covering a stretch of about 35 km. The geographical extension of OBS lies between 28°32'43.5"N and 28°32'56.3"N latitudes and 77°18'41.7"E and 77°18'56.6"E longitudes (Fig. 1). The total area of the sanctuary is 400 ha, out of which open water comprises around 273 ha, the reed beds and sand beds form 97 ha and bunds and roads comprise of the rest 30 ha area. The sanctuary is a vast alluvial plain with a gentle southeastern slope. The altitude of OBS is about 200m above sea level.

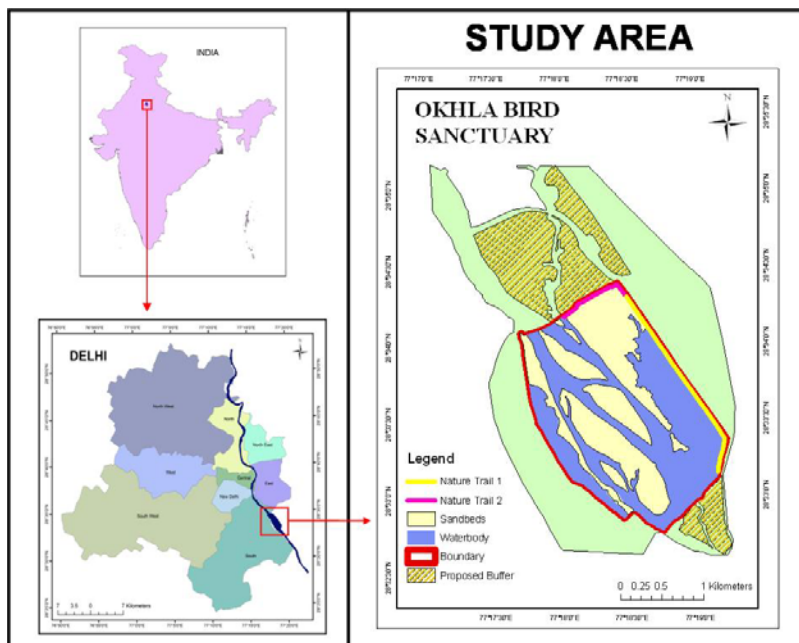


Fig. 1. Location of the Okhla Bird Sanctuary

Methods

To study the terrestrial vegetation, random sampling of vegetation was made using the quadrat method [7]. The terrestrial vegetation was studied in two Nature Trails out of three present in OBS. On Nature Trail 1 (2.56km) which also happens to be the main road of the sanctuary and on Nature Trail 2 (1.00 km), 45 sample plots each for herbs and shrubs species were laid and 30 sample plots were laid for the trees species.

Tree species were analysed in 100m², shrub in 25m², herbs in 1.0m² quadrats randomly in each site. Diameter at breast height (dbh)/ circumference at breast height (cbh) of all trees in each quadrat was measured and recorded individually for different species. The species found in the quadrats were identified [8 - 10]. Quantitative community characteristics such as frequency, density, basal area and important value index (IVI) of each component were determined by prescribed methods [7, 11, 12].

Frequency (%) = 100 x Number of quadrats of occurrence of a species / Total number of quadrats studied

Density = Total number of individuals of a species / Total number of quadrats studied

Basal cover = Density x Average basal area of individuals of a species

Abundance = Number of individuals of a species / Number of quadrats of occurrence of the species

Simpson Dominance Index (1949) = $(n_i/N)^2$

where, n_i = importance value index; N = total importance value of all species

The distribution pattern of the species was studied by using Whitford's index [13].

Whitford's Index = Abundance (A) / Frequency (F)

| | | |
|---------------|--------------|--------------------------------------|
| If A/F ratio: | <0.025 | : Regular distribution |
| | 0.025 – 0.05 | : Random distribution |
| | > 0.05 | : Contagious or clumped distribution |

Shannon- Weaver index of general diversity was calculated by using the formula:

$$H = -\sum (n_i / N) \ln (n_i / N)$$

where, H = Shannon-Weaver index; n_i = Importance Value Index; N = Total Importance Value all species

Result and Discussion

Floristic Composition

In total 106 species were recorded and identified from the study area, of which 48 species were trees, 9 shrubs and 49 herbs. In Nature Trail 1, the number of species, genera and family were found more in case of tree species. The species and genera of shrub species are slightly more in number in Trail 2 and similar pattern was observed in herbaceous species also. Out of a total of 25 herb families, the highest number was of Asteraceae (7 and 9) followed by Malvaceae (3 and 4) in Nature Trail 1 and 2 respectively; in case of trees, the family with highest number of species in both the Nature trails was Fabaceae (5 and 7) followed by Moraceae (5) and Mimosaceae (5) in Nature Trail 1, and Moraceae (5) in Nature Trail 2; Apocynaceae amongst shrubs showed dominance in Nature Trail 2, while rest showed equal

dominance in both the Nature trails (Fig. 2). According to the Management plan of Okhla Bird Sanctuary (2011-2021) in 2010, a total of 186 plant species were recorded and identified. Out of 186 species, 19 were aquatic plant species, 148 were terrestrial species and 21 were amphibious species. Besides, 32 species of trees, 10 species of shrubs, 107 species of herbs, 16 species of grasses, 14 species of sedges and 9 herbaceous climber species were also identified (Tables 1 and 2).

Table 1. Species composition in Okhla Bird Sanctuary

| Species Composition | Nature Trail 1 | Nature Trail 2 |
|----------------------|----------------|----------------|
| Trees | | |
| Species | 37 | 31 |
| Genus | 35 | 29 |
| Family | 19 | 15 |
| Shrubs | | |
| Species | 8 | 9 |
| Genus | 8 | 9 |
| Family | 8 | 8 |
| Herbs | | |
| Species | 30 | 36 |
| Genus | 31 | 38 |
| Family | 21 | 18 |
| Unidentified Species | 8 | 1 |

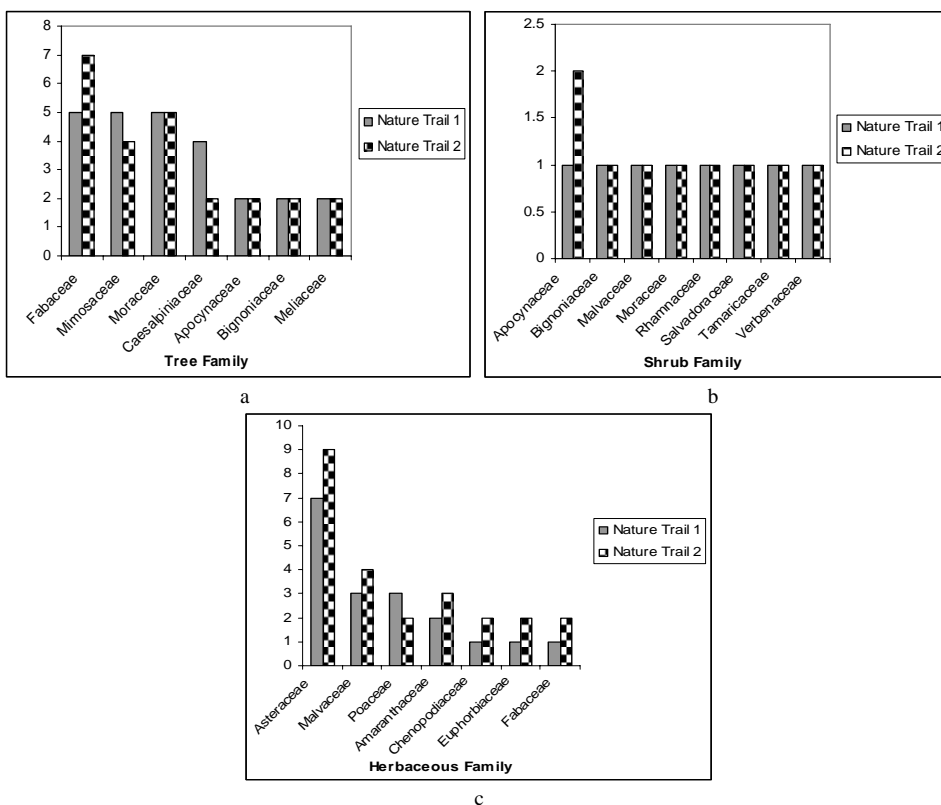


Fig. 2. Distribution of Families:
a – Tree Families, b – Shrub families, c – Herbaceous families

Table 2. Plant species found in Nature Trail 1 and 2 of Okhla Bird Sanctuary

| Trees | | | |
|----------------------------------|-----------------------------------|-----------------------------------|---------------------------------|
| Nature Trail 1 | | Nature Trail 2 | |
| Plant Species | Plant Species | Plant Species | Plant Species |
| <i>Acacia nilotica</i> | <i>Leucaena leucocephala</i> | <i>Acacia nilotica</i> | <i>Ficus virens</i> |
| <i>Albizia procera</i> | <i>Mangifera indica</i> | <i>Aegle marmelos</i> | <i>Holoptelea integrifolia</i> |
| <i>Alstonia scholaris</i> | <i>Melia azedarach</i> | <i>Albizia lebbek</i> | <i>Kigelia pinnata</i> |
| <i>Azadirachta indica</i> | <i>Morus alba</i> | <i>Alstonia scholaris</i> | <i>Leucaena leucocephala</i> |
| <i>Bauhinia sp.</i> | <i>Neolamarckia cadamba</i> | <i>Azadirachta indica</i> | <i>Mangifera indica</i> |
| <i>Bombax ceiba</i> | <i>Parkinsonia aculeate</i> | <i>Bauhinia sp.</i> | <i>Melia azedarach</i> |
| <i>Bougainvillia sp.</i> | <i>Phoenix sp.</i> | <i>Bombax ceiba</i> | <i>Morus alba</i> |
| <i>Butea monosperma</i> | <i>Pithecellobium dulce</i> | <i>Butea monosperma</i> | <i>Murraya paniculata</i> |
| <i>Calliandra haematocephala</i> | <i>Polyalthia longifolia</i> | <i>Dalbergia sissoo</i> | <i>Neolamarckia cadamba</i> |
| <i>Callistemon lanceolatus</i> | <i>Prosopis cineraria</i> | <i>Delonix regia</i> | <i>Parkinsonia aculeata</i> |
| <i>Cassia siamea</i> | <i>Prosopis juliflora</i> | <i>Ehretia laevis</i> | <i>Phoenix sp.</i> |
| <i>Dalbergia sissoo</i> | <i>Psidium guajava</i> | <i>Erythrina sp.</i> | <i>Pithecellobium dulce</i> |
| <i>Delonix regia</i> | <i>Putranjiva roxburghii</i> | <i>Fernandoa adenophyllum</i> | <i>Pongamia glabra</i> |
| <i>Ehretia laevis</i> | <i>Syzygium cumini</i> | <i>Ficus benghalensis</i> | <i>Prosopis juliflora</i> |
| <i>Ficus benghalensis</i> | <i>Tamarindus indica</i> | <i>Ficus racemosa</i> | <i>Thevetia peruviana</i> |
| <i>Ficus carica</i> | <i>Tecoma stans</i> | <i>Ficus religiosa</i> | <i>Zizyphus mauritiana</i> |
| <i>Ficus religiosa</i> | <i>Tectona grandis</i> | | |
| <i>Ficus sp.</i> | <i>Thevetia peruviana</i> | | |
| <i>Grevillea robusta</i> | <i>Zizyphus mauritiana</i> | | |
| <i>Kigelia pinnata</i> | <i>Leucaena leucocephala</i> | | |
| Shrubs | | | |
| Nature Trail 1 | | Nature Trail 2 | |
| Plant Species | Plant Species | Plant Species | Plant Species |
| | <i>Tabernaemontana divaricata</i> | <i>Abutilon indicum</i> | <i>Tamarix dioica</i> |
| <i>Abutilon indicum</i> | <i>divaricata</i> | <i>Ficus palmata</i> | <i>Tecomella undulata</i> |
| <i>Ficus palmata</i> | <i>Tamarix dioica</i> | <i>Lantana camara</i> | <i>Thevetia peruviana</i> |
| <i>Lantana camara</i> | <i>Tecomella undulata</i> | <i>Salvadora oleoides</i> | <i>Zizyphus nummularia</i> |
| <i>Salvadora oleoides</i> | <i>Zizyphus nummularia</i> | <i>Tabernaemontana divaricata</i> | |
| Herbs | | | |
| Nature Trail 1 | | Nature Trail 2 | |
| Plant Species | Plant Species | Plant Species | Plant Species |
| <i>Achyranthus aspera</i> | <i>Gnaphalium purpureum</i> | <i>Achyranthus aspera</i> | <i>Launea nudicaulis</i> |
| <i>Ageratum conyzoides</i> | <i>Ipomea aquatica</i> | <i>Ageratum conyzoides</i> | <i>Malva parviflora</i> |
| <i>Amaranthus tricolor</i> | <i>Launea nudicaulis</i> | <i>Amaranthus tricolor</i> | <i>Malvastrum sp.</i> |
| <i>Anagalis arvensis</i> | <i>Malvastrum sp.</i> | <i>Argemone sp.</i> | <i>Melilotus indica</i> |
| <i>Argemone sp.</i> | <i>Melilotus indica</i> | <i>Arundo donax</i> | <i>Oenanthe javanica</i> |
| <i>Boerhaavia difusa</i> | <i>Oxalis corniculata</i> | <i>Calotropis sp.</i> | <i>Parthenium hysterophorus</i> |
| <i>Calotropis sp.</i> | <i>Parthenium hysterophorus</i> | <i>Centella asiatica</i> | <i>Peristrophe bicalyculata</i> |
| <i>Cannabis sativum</i> | <i>Ranunculus scleratus</i> | <i>Chenopodium album</i> | <i>Polygonum glabrum</i> |
| <i>Cassia tora</i> | <i>Ricinus communis</i> | <i>Cirsium arvense</i> | <i>Ranunculus scleratus</i> |
| <i>Chenopodium album</i> | <i>Sida cordifolia</i> | <i>Commelina kurzii</i> | <i>Ricinus communis</i> |
| <i>Coronopus didymis</i> | <i>Solanum nigrum</i> | <i>Coronopus didymis</i> | <i>Solanum nigrum</i> |
| <i>Cucumis sp.</i> | <i>Tinospora sinensis</i> | <i>Cynodon dactylon</i> | <i>Sonchus arvensis</i> |
| <i>Cynodon dactylon</i> | <i>Tridax procumbens</i> | <i>Datura sp.</i> | <i>Suaeda maritima</i> |
| <i>Datura sp.</i> | <i>Urena lobata</i> | <i>Desmodium triflorum</i> | <i>Tridax procumbens</i> |
| <i>Dicanthium annulatum</i> | <i>Vernonia cineria</i> | <i>Euphorbia hirta</i> | <i>Typha sp.</i> |
| <i>Eleusine indica</i> | | <i>Gnaphalium purpureum</i> | <i>Urena lobata</i> |
| | | <i>Gomphrena celosioides</i> | <i>Vernonia cineria</i> |
| | | <i>Hibiscus micranthus</i> | <i>Youngia japonica</i> |
| | | <i>Ipomea aquatica</i> | |

Density

There was not much variation in the densities of plant species between the two study sites. The tree density on Nature Trail 1 was 7.10 stems per ha while the shrub and herbaceous densities were 5.51 and 50.93 individuals/m² respectively. Whereas on Nature Trail 2 the densities were 6.687 stem per ha for tree species, 6.29 individuals/m² for shrub species and 46.89 individuals/m² for herbaceous species (Fig. 3).

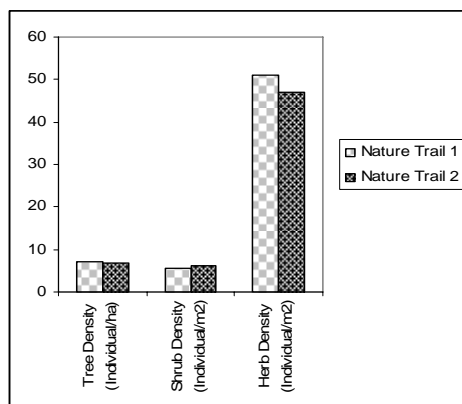


Fig. 3. Densities of plant species between the two sites

Dominance Pattern

In terms of importance value index, *Leucaena leucocephala* (IVI- 24.49; SDI- 0.0067) was the dominant tree species in the Nature Trail 1 which was followed by *Ficus benghalensis* (IVI- 19.90; SDI- 0.0044), *Ficus* sp. (IVI- 17.45; SDI- 0.0034) and *Melia azedarach* (IVI- 14.35; SDI- 0.0023). Whereas the least dominant tree species were *Zizyphus mauritiana* (IVI- 2.33; SDI- 0.0001) and *Ficus carica* (IVI- 2.02; SDI- 0.00). In Nature Trail 2 the most dominant tree species was *Prosopis juliflora* (IVI- 31.34; SDI- 0.01091) followed by *Leucaena leucocephala* (IVI- 27.29; SDI- 0.00827), *Dalbergia sissoo* (IVI- 22.77; SDI- 0.00576) and *Ficus benghalensis* (IVI- 20.72; SDI- 0.00477). *Acacia nilotica* (IVI- 1.78; SDI- 0.00004) and *Ehretia laevis* (IVI- 1.53; SDI- 0.00003) were however the least dominant tree species in Nature Trail 2.

In shrub layer *Tabernaemontana divaricata* (IVI- 42.04; SDI- 0.0442) followed by *Abutilon indicum* (IVI- 39.98; SDI- 0.0400) and *Lantana camara* (IVI- 35.63; SDI- 0.0317) were the most dominant species in Nature Trail 1. The two least dominant shrub species were *Tamarix dioica* (IVI- 11.18; SDI- 0.0031) and *Tecomella undulate* (IVI-10.33; SDI- 0.0027). Similarly in Nature Trail 2 the two almost equally dominant shrub species were *Ficus palmata* (IVI-44.76; SDI- 0.0501) followed by *Tabernaemontana divaricata* (IVI- 44.63; SDI- 0.0498) and *Lantana camara* (IVI-30.07; SDI-0.0226). Whereas the least dominant shrub species were *Tamarix dioica* (IVI- 6.21; SDI- 0.0010) followed by *Salvadora oleiodes* (IVI- 5.82; SDI- 0.0008).

Among herbaceous species *Cynodon dactylon* (IVI-65.9; SDI- 0.1087) highly dominated the entire stretch of Nature Trail 1, which was followed by *Cannabis sativum*(IVI- 20.8; SDI- 0.0108), *Oxalis corniculata* (IVI- 14.6; SDI- 0.0053) and *Chenopodium album* (IVI- 10.3; SDI- 0.0026). Whereas, the least dominating herbaceous species were *Cucumis* sp (IVI- 0.7; SDI - 0.00) and *Malvastrum* sp (IVI- 0.4; SDI- 0.00). In case of Nature Trail 2 the dominance pattern

was *Cynodon dactylon* (IVI- 81.5; SDI- 0.16624) followed by *Parthenium hysterophorus* (IVI- 8.8; SDI- 0.00194) then *Chenopodium album* (IVI- 8.7; SDI- 0.00188) and finally *Achyranthus aspera* (IVI- 7.7; SDI- 0.00149). Whereas the least dominant were *Hibiscus micranthus* (IVI- 0.5; SDI- 0.00001) and *Solanum nigrum* (IVI- 0.4; SDI- 0.00000).

Dominance-diversity curves have been used to interpret the dominance of different species in the community in relation to resource apportionment and niche space [14]. The curves of tree and shrub species (Fig. 4) in both the sites resemble the broken stick (a.k.a. simultaneous breakage model, random niche-boundary model [15]; suggesting that most species are almost equally abundant as resource is partitioned more equitably and no severe dominance is possible, resulting in a less-steep dominance-diversity plot. Typically found in narrowly defined communities of closely related species. The curves of herb species (Fig. 4) in both the sites resemble geometric series (a.k.a. sequential breakage model [16] which occurs when species arrive at an unsaturated habitat at regular intervals of time, occupying fractions of remaining niche hypspace (Table 3).

Table 3. Plant species with highest and lowest Importance Value Index (IVI)

| Plant Species | Nature Trail 1 | | | Nature Trail 2 | | |
|-----------------------------------|----------------|-------|---------|----------------|------|---------|
| | IVI | ni/N | SDI | IVI | ni/N | SDI |
| Trees | | | | | | |
| <i>Prosopis juliflora</i> | - | - | - | 31.34 | 0.10 | 0.01091 |
| <i>Leucaena leucocephala</i> | 24.49 | 0.08 | 0.00666 | 27.29 | 0.09 | 0.00827 |
| <i>Dalbergia sissoo</i> | - | - | - | 22.77 | 0.08 | 0.00576 |
| <i>Ficus benghalensis</i> | 19.90 | 0.07 | 0.00440 | 20.72 | 0.07 | 0.00477 |
| <i>Ficus sp.</i> | 17.45 | 0.06 | 0.00338 | - | - | - |
| <i>Melia azedarach</i> | 14.35 | 0.05 | 0.00229 | - | - | - |
| <i>Zizyphus mauritiana</i> | 2.33 | 0.01 | 0.00006 | - | - | - |
| <i>Ficus carica</i> | 2.02 | 0.01 | 0.00005 | - | - | - |
| <i>Acacia nilotica</i> | - | - | - | 1.78 | 0.01 | 0.00004 |
| <i>Ehretia laevis</i> | - | - | - | 1.53 | 0.01 | 0.00003 |
| Shrubs | | | | | | |
| <i>Ficus palmata</i> | - | - | - | 44.76 | 0.22 | 0.0501 |
| <i>Tabernaemontana divaricata</i> | 42.04 | 0.21 | 0.04418 | 44.63 | 0.22 | 0.0498 |
| <i>Abutilon indicum</i> | 39.98 | 0.20 | 0.03996 | - | - | - |
| <i>Lantana camara</i> | 35.63 | 0.18 | 0.03173 | 30.07 | 0.15 | 0.0226 |
| <i>Tamarix dioica</i> | 11.18 | 0.06 | 0.00312 | 6.21 | 0.03 | 0.0010 |
| <i>Tecomella undulata</i> | 10.33 | 0.05 | 0.00267 | - | - | - |
| <i>Salvadora oleiodes</i> | - | - | - | 5.82 | 0.03 | 0.0008 |
| Herbs | | | | | | |
| <i>Cynodon dactylon</i> | 65.9 | 0.33 | 0.10870 | 81.5 | 0.41 | 0.16624 |
| <i>Cannabis sativum</i> | 20.8 | 0.10 | 0.01078 | - | - | - |
| <i>Oxalis corniculata</i> | 14.6 | 0.07 | 0.00533 | - | - | - |
| <i>Parthenium hysterophorus</i> | - | - | - | 8.8 | 0.04 | 0.00194 |
| <i>Chenopodium album</i> | 10.3 | 0.05 | 0.00264 | 8.7 | 0.04 | 0.00188 |
| <i>Achyranthus aspera</i> | - | - | - | 7.7 | 0.04 | 0.00149 |
| <i>Cucumis sp.</i> | 0.7 | 0.003 | 0.00001 | - | - | - |
| <i>Hibiscus micranthus</i> | - | - | - | 0.5 | 0.00 | 0.00001 |
| <i>Malvastrum sp.</i> | 0.4 | 0.002 | 0.0000 | - | - | - |
| <i>Solanum nigrum</i> | - | - | - | 0.4 | 0.00 | 0.00000 |

SDI: Simpson Dominance Index; IVI: Importance Value Index; '-' Absent

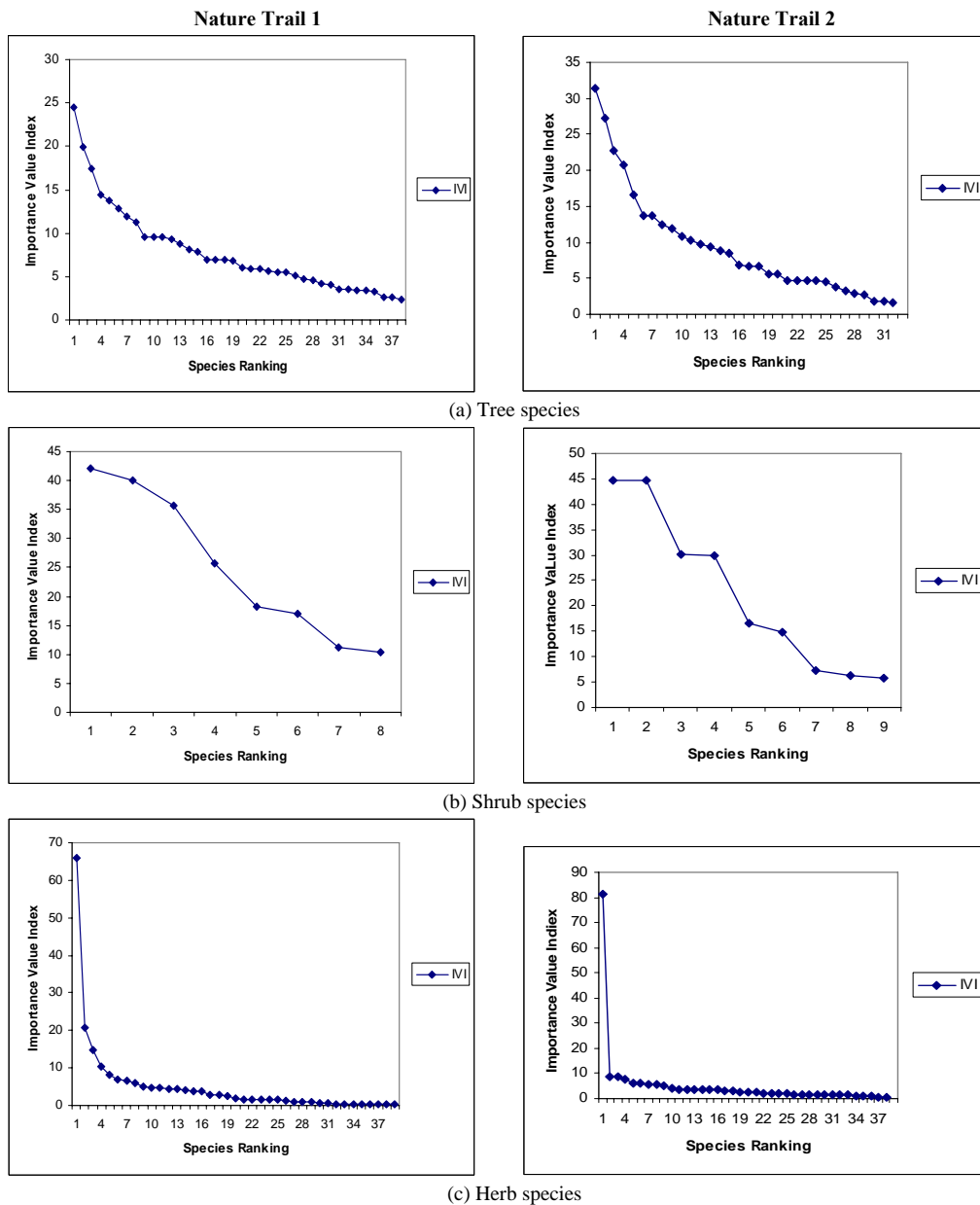


Fig. 4. Dominance-Diversity curves of plant species: left - Nature Trail 1, right - Nature Trail 2, a – tree species, b – shrub species, c – herb species,

Species Diversity

Shannon-Weaver diversity index showed that both the sites were equally diverse in case of shrub and herbaceous species. Diversity of trees was a little less in Nature Trail 2 as compared to Nature Trail 1 (Table 4).

Table 4. Shannon-Weaver species diversity index

| Plant Species | Nature Trail 1 | Nature Trail 2 |
|---------------|----------------|----------------|
| Tree | 3.48 | 3.15 |
| Shrub | 1.96 | 1.97 |
| Herbs | 2.71 | 2.69 |

Density- Diameter Distribution

The trees of girth class (116-135cm) dominated Nature Trail 1. In Nature Trail 2 the trees with medium girth-class (96-115cm) had the maximum individuals (Fig. 5).

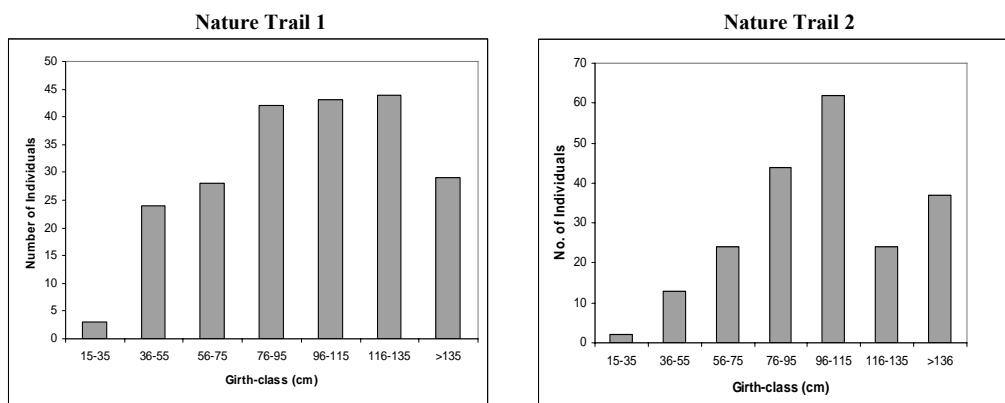


Fig. 5. Density-Diameter distribution of tree species in different girth-classes

Basal Cover

The basal area in Nature Trail 2 was found to be higher (6.13 m²ha⁻¹) than Nature Trail 1 (6.03 m²ha⁻¹). The lower basal area in Nature Trail 1 was recorded in spite of high population density (individuals·ha⁻¹) attributed that the dominant trees found here were similar in sizes.

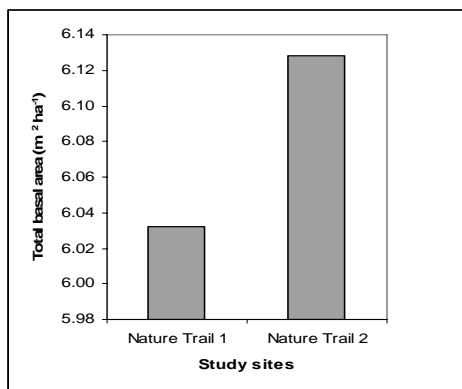


Fig. 6. Basal area in tree species

Distribution Pattern

Plant populations are usually distributed heterogeneously in their habitats and their spatial distribution is often patchy. In ecology the structure of dispersion is classified into three categories, viz., contagious (clumped), random (unpredictable spacing), and uniform (regular). This classification is based on the frequency distribution of individuals in statistical sense, e.g., based on quadrat counts [17]. The distribution of species into clumped, uniform, or random depends on different abiotic and biotic factors. The distribution pattern of a species' population is often related to its reproductive biology and; soil and water conditions are major abiotic factors that play roles in controlling species distribution pattern [18].

Most tree and shrub species showed a contagious distribution pattern both in Nature Trail 1 (94.87 % and 87.50%) and Nature Trail 2 (81.25 % and 66.67%) respectively.

Table 5. Shannon-Weaver species diversity index

| Distribution Pattern | Nature Trail 1 | Nature Trail 2 |
|-----------------------------|-----------------------|-----------------------|
| Tree | | |
| Regular | 0 | 0 |
| Random | 5.13 | 18.75 |
| Contagious or clumped | 94.87 | 81.25 |
| Shrub | | |
| Regular | 0 | 0 |
| Random | 12.50 | 33.33 |
| Contagious or clumped | 87.50 | 66.67 |
| Herbs | | |
| Regular | 0 | 0 |
| Random | 0 | 0 |
| Contagious or clumped | 100 | 100 |

Conclusion

Okhla Bird Sanctuary (OBS) is the largest wetland found within the capital city of India and it has been playing great role for maintaining the environment. It has been hosting migratory birds for years despite experiencing the high rate of urbanization that surrounds the sanctuary. Scientific documentation of the terrestrial plant species found in the sanctuary that attracts the birds and other wildlife is prerequisite as no such studies have carried out considering this aspect so far. The total numbers of 106 terrestrial plant species recorded in the study area can be considered as adequate to accommodate the visiting birds. Though the area of terrestrial vegetation (~20 ha) is comparatively very less in comparison to the total area of the sanctuary (400 ha), the present study will provide significant information about the terrestrial habitat as well. Major weeds that were identified in OBS during the study were *Parthenium hysterophorus*, *Lantana camara*, *Argemone mexicana* and *Cannabis sativa*. For proper management and conservation of the sanctuary it is suggested that these natural vegetation area should not be disturbed in any condition. During the study it was found that out of the three Nature Trails, Nature Trail 3 which is located along the state of Delhi was highly inaccessible and comparatively less managed than the other side which borders the state of Uttar Pradesh. It was also observed that there was no proper fencing at many places along the defined boundary and there was influx of human and cattle from different boundaries. The findings of the study

could be quite useful while formulating the Management Plan of OBS. It is suggested to carry out further research on the biodiversity of the sanctuary and if possible with its economic value.

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