Structure and Composition of Vegetation along an altitudinal gradient in Outer Seraj Region of Kullu District of Himachal Pradesh, India

**ABSTRACT**

Phytosociological characteristics of tree species along an altitudinal gradient in Anni block of Outer Seraj area of Kullu district wasdocumented and analyzedduring the period 2022 and 2024.The vegetation composition of plant species in three elevation ranges has been determined using a variety of phytosociological and diversity indices. A total of 101 species (33 trees, 28 shrub species and 40 herb species) belonging to 90 genera and 46 families were recorded in the study area and dominant families were Rosaceae (12 spp.), Fabaceae (11 spp.), Pinaceae and Asteraceae (5 spp. each), Sapindaceae, Lamiaceaeand Solanaceae (4 spp. each), Polygonaceae and Urticaceae (3 spp. each).Significant variations in species composition and phytosociological traits were observed among the three elevation zones. As perstudied diversity indices, the medium altitudinal zone (Zone II) showed the highest species diversity and richness for shrubs, whereas the lower altitudinal zone (Zone I) showed the highest species richness for trees and shrubs. The value of Shannon diversity index was recorded between 0.70 to 2.80 for trees, 0.66 to 1.90 for shrubs and 0.52 to 1.65 for herbs. The concentration of dominance values recorded for the study site was 0.13-0.65 for trees, 0.17-0.54 for shrubs and 0.21-0.99 for herbs. Species richness ranged from 1.65 to 5.71 for herbs, 1.63 to 7.68 for shrubs and 3.42 to 11.39 for trees. Most of the recorded species exhibited contagious distribution across all zones except one species *(Thymus linearis)* that exhibited random distribution. This study provides crucial baseline information on phytosociological diversity of plant species in Outer Seraj area of Kullu district and conservation of biodiversity in the Outer Seraj region.

**Keywords:** Phytosociological characteristics, Outer Seraj,vegetation composition, altitudinal zone, diversity indices, conservation

**1. INTRODUCTION**

The study of species composition and the complex sociocultural relationships between species in communities are both included in vegetation ecology(Mueller-Dombois&Ellenberg, 1974).Phytosociology is a quantitative field that focuses on how plant communities work and deepens our understanding of the complex interactions between plants and their surroundings(Braun & Blanquet, 1932). Assessing the condition of natural resources and creating efficient management and conservation plans require an understanding of the floristic composition, species diversity, and community structure of a given area(Lata et al., 2024). The primary goal of the quantitative research, called phytosociology, is to describe vegetation, clarify or predict its patterns, and classify it into useful categories(Ilorkar& Khatri, 2003).Phytosociology, often called the Braun-Blanquet approach, is a vegetation science that effectively examines and categorizes plant communities. The data recording in phytosociology aims to detail all plant taxa, noting their presence in vertical strata and quantifying their cover-abundance within a specific plot representing a vegetation stand(Dengler et al., 2008). These studies are essential for understanding how different plant species are interconnected with each other and with their environment and the processes that modify these communities (Concenço et al., 2017).

The vegetation in the Himalayan forests covers a wide spectrum, transitioning from tropical dry deciduous forests in the foothills to moist temperate forests approaching the timberline.Altitudinal variations are crucial in determining species distribution and patterns of species richness at any given site(Gupta et al., 2018). Diversity of species is crucial to the biodiversity of forests as trees provide habitats and resources for other associated species. They have a major impact on the environmental and structural complexity of forests(Bhat et al., 2020). The variety of tree species found in forests varies and is greatly impacted by biogeography, habitat, and disturbances(Sharma & Kant, 2014)**.** The shrub layer is essential to forest ecosystems asthey provide food and habitat for various organisms and also aids in environmental restoration (Moreno-Fernández et al., 2021). In forest ecosystems, herbaceous plants are crucial because they preserve soil and water, control local microclimates, and provide resources for wildlife(Hart and Chen, 2008). Therefore, knowledge of woody vegetation's diversity and distribution is essential to comprehending forest ecology restoration. Altitudinal variation-based phytosociological analysis has been studied by a number of researchers(Gupta et al., 2018; Rana & Gairola, 2009; Meena et al., 2020; Kumari et al., 2023; Verma & Kapoor, 2014; Rana & Gairola, 2009).

The diverse climate of the Outer Seraj region contributes to its enormous ecological importance and abundance of valuable species (Singh et al., 1999).Although little is known about the floristic composition of the Outer Seraj location, it has great ecological value. In order to fully investigate the floristic composition characteristics in the Outer Seraj region of the Kullu district in Himachal Pradesh, a phytosociological study was carried out.

**2. MATERIALS AND METHODS**

**2.1Study site**

The study was conducted in the Anni block of Outer Seraj area of Kullu district, India. It is located between latitudes 31°39'32"N to 31°20'40"N and longitudes 77°41'22"E to 77°23'12"E. The overall area of the Outer Seraj is 715 km² with elevations ranging from 738 to 5227 meters.

**2.2Methods**

In order to conduct floristic surveys, the study area was divided using the Global Positioning System into three altitudinal zones: Zone I (800–1600 m), Zone II (1601-2400 m), and Zone III (2401-3200 m)**(Table1).** The phytosociological analysis of vegetation was conducted between the years 2022 to 2024 across the selected study sites. The vegetation features along various altitudinal gradients were evaluated using random sampling. Quadrats of the proper size, as established by the species-area curve approach, were used for sampling at each location(Mishra, 1968).The running mean approach was used to calculate the number of quadrats required for sufficient sampling(Kershaw, 1973).In each aspect/site/habitat, 60 plot of 50x50 m was marked. Within this plot for trees, 10 quadrates (10x10m) were randomly placed for tree sampling, 20 quadrates (5x5 m) for shrubs, and 20 quadrates (1x1m) for herbs.Every individual's circumference at breast height (CBH) was measured in each quadrat at a height of 1.37 meters above the ground.

**Table 1Details of the study sites to conduct floristic studies**

|  |  |  |
| --- | --- | --- |
| **Block** | **Zone** | **Name of the Study sites** |
| Anni | Zone 1 (800-1600m) | Behna (I), Nimla (II), Jamedi (III), Nigan (IV), Shamesha (V), Panjvi (VI), Showad (VII), Shamshar (VIII), Runa (IX) and Tihni (X) |
| Zone II (1601-2400m) | Kammand(I),Kungash(II), Namhong(III), Deori(IV), Batala (V), Karana (VI),Dalash (VII), Gugra (VIII), Rewari (IX) andAmarbaag (X) |
| Zone III (2401-3200m) | Khanag (I),Jalori Pass (II),Karshala (III),Karad (IV),Buchair (V), Deem (VI), Sroa (VII), Kothi (VIII), Khani (IX) and Lajheri (X) |

Standard ecological methods were used to analyze the data, which included relative density, relative frequency, relative abundance, and Importance Value Index (IVI) (Curtis & McIntosh, 1950; Singh & Singh, 1992; Dhar et al., 1997; Samant et al*.,* 2002; Joshi & Samant, 2004; Samant & Joshi, 2005). In order to analyze the data, Microsoft Excel Office 2019 was used.

**2.2.1 Relative frequency, Relative density, Relative dominance and Importance Value Index**

Relative frequency is the degree of dispersion of individual species in an area in relation to the number of all the species occurred and was calculated as follows:

Relative frequency =

Relative densityis the study of numerical strength of a species in relation to the total number of individuals of all the species and was calculated as follows:

Relative density =

Relative dominanceis determined by the value of the basal cover. Relative dominance is the coverage value of a species with respect to the sum of coverage of the rest of the species in the area and was calculated as follows:

Relative dominance =

Importance Value Index provides an overall dominance of a species in a community. It is the sum of Relative Frequency, Relative Density and Relative Dominance for each species involved. It was assessed by the following formula:

Importance Value Index = Relative Frequency (RF) + Relative Density (RD) + Relative Dominance

The abundance-to-frequency ratio (A/F) values were used to determine the distribution pattern of plant diversity. Species exhibits contiguous (>0.050), random (0.025 to 0.050), and regular (<0.025) distributions according to the A/F values (Curtis & Cottam, 1953). The following Diversity Indices were used to calculate the plant diversity:

**2.2.2 Species richness, Species diversity and Concentration of dominance:** The overall number of species in a given community, place, or habitat is known as species richness. The concentration of dominance by Simpson's Index (Simpson, 1949) and the Shannon and Wiener Information Statistics (H') (Shannon & Weiner, 1963) were used to quantify species diversity.Shannon-Wiener diversity Index (H) was calculated by following formula (Shannon & Wiener, 1963).

Where, ni = Importance value of species i and N = total importance value of all species.

The equation used to calculate Concentration of dominance (Simpson’s index) was

D=

Where D = Simpson (1949) Index of dominance, ni = total number of individuals of particular species, and N = total number of individuals of all species.

The Richness Index was measured as per Margalef, (1958).

R = S-1/ln N

Where, S = Total number of species, N = Total number of individuals of all the species

**3. Results and Discussion**

The vegetation of Anni block of Outer Seraj area exhibited notable variations across different altitudes.A total of 102 species (32.67 percent trees, 27.72 percent shrub species and 39.6 percent herb species) belonging to 89 genera and 63 families were recorded in the study area **(Figure 1).**The dominant families were Fabaceae and Rosaceae (11 spp. each), Pinaceae and Asteraceae (5 spp. each), Sapindaceae and Lamiaceae (4 spp. each), and Polygonaceae and Urticaceae (3 spp. each)**(Figure 2)**. The phytosociological status of plant species of Anni block is described as follows:

**Figure 1Contribution of wild plant species according to their habit in Anni block of Outer Seraj area**

**Figure 2Dominant families with the number of species found in Anni block of Outer Seraj area**

**Tree species distribution**

A total of 33 tree species belonging to 29 genera and 15 families were recorded in the study area. Photographs of some tree species recorded during field surveys are given in **Plate 1.** The dominant families were Fabaceae (6 spp.), Pinaceae (5 spp.), Fagaceae and Sapindaceae (3 spp. each), Myrtaceae, Moraceae, Malvaceae, Rosaceae and Meliaceae (2 spp. each) **(Figure 3).***Quercus* (3 spp.) was the dominant genera, followed by *Pinus* and *Eucalyptus* (2 spp. each)**.**

At Zone-I,*Quercus leucotrichophora*(IVI=158.34) at study site IX was the dominant species followed by *Grewia optiva*(IVI=126.08) at site IV and *Dalbergia sissoo* (IVI=117.02) at site II. Maximum value of frequency (%) was observed for *Quercus leucotrichophora*(38.46) at study site X followed by *Grewia optiva*(35.29) at site IV and *Dalbergia sissoo*(33.32) at site II. Maximum density was recorded for *Quercus leucotrichophora*(49.09) at site X followed by *Dalbergia sissoo*(39.66) at site II*and Grewia optiva*(36.84) at site IV. Abundance was found to be highest for *Quercus leucotrichophora*(70.79)at site Xfollowed by *Grewia optiva*(57.81) at site IX and *Dalbergia sissoo* (44.04) at site II.The distribution pattern of species showed contiguous distribution **(Table 2).**

At Zone-II, the highest importance value was recorded for *Cedrus deodara*(IVI = 244.76) at site III followed by *Abies pindrow*(IVI = 98.91) atsite I and *Picea smithiana*(IVI = 67.87) at site II. Maximum value of frequency (%) was observed for *Cedrus deodara*(47.37) at study site IX followed by *Abies pindrow*(31.25) at site VII and *Picea smithiana*(29.41) at site II. Maximum density was recorded for *Cedrus deodara*(90.16) at site III followed by *Abies pindrow*(32.65) at site VI and *Picea smithiana*(20.00) at site II.Abundance was found to be highest for *Cedrus deodara* (94.60)at site IIIfollowed by*Abies pindrow*(50.06) at site Iand *Picea smithiana* (20.14) at site IX. All the recorded species showed contagious distribution **(Table 3).**

At Zone-III, the highest importance value was recorded for *Quercus semecarpifolia*(IVI = 239.42) at site VII followed by *Cedrus deodara*(IVI = 203.96) at site II and *Abies pindrow* (IVI = 122.23) at site III. Maximum value of frequency (%) was observed for *Quercus semecarpifolia*(67.31) at study site IX followed by *Cedrus deodara* (50.00) at site II and *Abies pindrow*(43.75) at site III. Maximum density was recorded for *Cedrus deodara* (87.93) at site VII followed by *Cedrus deodara* (73.47) at site VI and *Picea smithiana*(32.08) at site IV.Abundance was found to be highest for *Quercus semecarpifolia*(88.99)at site VIIfollowed by*Cedrus deodara* (80.62) at site II and *Abies pindrow* (58.14) at site III. All the recorded species showed contagious distribution **(Table 4).**

**Table 2Phytosociological attributes of Trees at Zone-I**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Site | Species | Family | Relative frequency | Relative density | Relative dominance | R/F | IVI |
| I | *Grewia optiva* J.R.Drumm. ex Burret | Malvaceae | 19.04 | 27.66 | 31.58 | 1.66 | 78.28 |
|  | *Pyrus pashia* Buch.-Ham. ex D.Don | Rosaceae | 14.29 | 12.77 | 18.92 | 1.32 | 45.98 |
|  | *Sapindus mukorossi* Gaertn. | Sapindaceae | 14.29 | 8.51 | 21.08 | 1.48 | 43.88 |
|  | *Bombax ceiba* L. | Malvaceae | 14.29 | 14.89 | 10.78 | 0.75 | 39.96 |
|  | *Morus albaL*. | Moraceae | 14.29 | 12.76 | 8.93 | 0.62 | 35.98 |
|  | *Toona ciliata* M.Roem. | Meliaceae | 4.76 | 8.51 | 1.68 | 0.35 | 14.95 |
|  | *Ficus palmata* Forssk. | Moraceae | 4.76 | 8.51 | 1.65 | 0.35 | 14.92 |
|  | *Leucaena leucocephala* (Lamk.) de Wit | Fabaceae | 4.76 | 2.13 | 2.05 | 0.43 | 8.94 |
|  | *Eucalyptus globulus* Labill. | Myrtaceae | 4.76 | 2.13 | 1.97 | 0.41 | 8.86 |
|  | *Dalbergia sissoo* Roxb. ex DC. | Fabaceae | 4.76 | 2.13 | 1.35 | 0.28 | 8.24 |
| II | *Dalbergia sissoo* Roxb. ex DC. | Fabaceae | 33.32 | 39.66 | 44.04 | 1.32 | 117.02 |
|  | *Morus alba* L. | Moraceae | 22.22 | 17.24 | 26.19 | 1.18 | 65.65 |
|  | *Leucaena leucocephala* (Lamk.) de Wit | Fabaceae | 16.67 | 15.52 | 14.45 | 0.87 | 46.64 |
|  | *Albizia chinensis* (Osbeck) Merr. | Fabaceae | 16.67 | 17.24 | 12.57 | 0.75 | 46.48 |
|  | *Pyrus pashia* Buch.-Ham. ex D.Don | Rosaceae | 5.56 | 6.9 | 1.5 | 0.27 | 13.96 |
|  | *Bauhinia variegata* L. | Fabaceae | 5.56 | 3.45 | 1.25 | 0.22 | 10.26 |
| III | *Ficus palmata* Forssk. | Moraceae | 21.74 | 31.03 | 28.35 | 1.3 | 81.12 |
|  | *Toona ciliata* M.Roem. | Meliaceae | 21.74 | 12.07 | 26.06 | 1.199 | 59.87 |
|  | *Bauhinia variegata* L. | Fabaceae | 17.39 | 20.69 | 19.03 | 1.09 | 57.11 |
|  | *Morus alba* L. | Moraceae | 17.39 | 15.52 | 12.08 | 0.69 | 44.99 |
|  | *Dalbergia sissoo* Roxb. ex DC. | Fabaceae | 13.04 | 13.79 | 12.18 | 0.93 | 39.01 |
|  | *Robinia pseudoacacia* Linn | Fabaceae | 4.35 | 5.17 | 1.34 | 0.31 | 10.86 |
|  | *Grewia optiva*  J.R.Drumm. ex Burret | Malvaceae | 4.35 | 1.72 | 0.96 | 0.22 | 7.03 |
| IV | *Grewia optiva* J.R.Drumm. ex Burret | Malvaceae | 35.29 | 36.84 | 53.95 | 1.53 | 126.08 |
|  | *Sapindus mukorossi* Gaertn. | Sapindaceae | 23.53 | 28.07 | 26.73 | 1.12 | 78.33 |
|  | *Dalbergia sissoo* Roxb. ex DC. | Fabaceae | 11.76 | 17.54 | 6.61 | 0.56 | 35.91 |
|  | *Pyrus pashia* Buch.-Ham. ex D.Don | Rosaceae | 11.76 | 7.02 | 6.82 | 0.58 | 25.6 |
|  | *Toona ciliata* M.Roem. | Meliaceae | 11.76 | 5.26 | 3.78 | 0.32 | 20.8 |
|  | *Leucaena leucocephala* (Lamk.) de Wit | Fabaceae | 5.88 | 5.26 | 2.11 | 0.36 | 13.25 |
| V | *Grewia optiva* J.R.Drumm. ex Burret | Malvaceae | 15.8 | 18.36 | 15.79 | 1 | 49.94 |
|  | *Dalbergia sissoo* Roxb. ex DC. | Fabaceae | 15.79 | 16.33 | 15.79 | 1 | 47.91 |
|  | *Pyrus pashia* Buch.-Ham. ex D.Don | Rosaceae | 15.79 | 8.16 | 15.79 | 1 | 39.74 |
|  | *Melia azedarach* L. | Meliaceae | 10.52 | 16.33 | 10.53 | 1 | 37.38 |
|  | *Bombax ceiba* L. | Malvaceae | 10.52 | 14.29 | 10.53 | 1 | 35.34 |
|  | *Leucaena leucocephala* (Lamk.) de Wit | Fabacaee | 10.52 | 10.2 | 10.53 | 1 | 31.25 |
|  | *Ficus palmata* Forssk. | Moraceae | 10.52 | 6.12 | 10.53 | 1 | 27.17 |
|  | *Toona ciliata* M.Roem. | Meliacaee | 5.26 | 6.12 | 5.26 | 1 | 16.64 |
|  | *Sapindus mukorossi* Gaertn. | Saindaceae | 5.26 | 4.09 | 5.26 | 1 | 14.61 |
| VI | *Grewia optiva* J.R.Drumm. ex Burret | Malvaceae | 29.17 | 28.33 | 37.46 | 1.28 | 94.96 |
|  | *Toona ciliata* M.Roem. | Meliaceae | 25 | 18.33 | 32.77 | 1.31 | 76.1 |
|  | *Leucaena leucocephala* (Lamk.) de Wit | Fabaceae | 16.67 | 23.33 | 14.44 | 0.87 | 54.44 |
|  | *Dalbergia sissoo* Roxb. ex DC. | Fabaceae | 16.67 | 21.67 | 9.5 | 0.57 | 47.84 |
|  | *Morus alba* L. | Moraceae | 8.33 | 5 | 5.04 | 0.61 | 18.37 |
|  | *Pyrus pashia* Buch.-Ham. ex D.Don | Rosaceae | 4.17 | 3.33 | 0.79 | 0.19 | 8.29 |
| VII | *Grewia optiva* J.R.Drumm. ex Burret | Malvaceae | 18.75 | 9.26 | 21.48 | 1.15 | 49.49 |
|  | *Melia azedarach* L. | Meliaceae | 12.5 | 18.52 | 15.46 | 1.24 | 46.48 |
|  | *Pyrus pashia* Buch.-Ham. ex D.Don | Rosaceae | 12.5 | 16.67 | 14.19 | 1.14 | 43.36 |
|  | *Dalbergia sissoo* Roxb. ex DC. | Fabaceae | 12.5 | 11.11 | 15.84 | 1.27 | 39.45 |
|  | *Bauhinia variegata* L. | Fabaceae | 12.5 | 11.11 | 11.89 | 0.95 | 35.5 |
|  | *Eucalyptus tereticornis* Domin | Myrtaceae | 12.5 | 11.11 | 9.11 | 0.73 | 32.72 |
|  | *Toona ciliata* M.Roem. | Meliaceae | 6.25 | 11.11 | 2.97 | 0.48 | 20.33 |
|  | *Bombax ceiba* L. | Malvaceae | 6.25 | 3.7 | 6.6 | 1.06 | 16.55 |
|  | *Ficus palmata* Forssk. | Moraceae | 6.25 | 7.41 | 2.46 | 0.39 | 16.12 |
| VIII | *Bauhinia variegata* L. | Fabaceae | 22.24 | 20.45 | 35.86 | 1.61 | 78.55 |
|  | *Jacaranda mimosifolia* D.Don | Bignoniaceae | 16.68 | 13.64 | 22.14 | 1.33 | 52.46 |
|  | *Pinus roxburghii* Sarg. | Pinaceae | 11.12 | 6.82 | 14.32 | 1.29 | 32.26 |
|  | *Pyrus pashia* Buch.-Ham. ex D.Don | Rosaceae | 5.56 | 11.37 | 3.24 | 0.58 | 20.17 |
|  | *Acacia catechu* (L.f.) Willd. | Fabaceae | 5.56 | 9.09 | 3.51 | 0.63 | 18.16 |
|  | *Celtis australis* L. | Cannabaceae | 5.56 | 9.09 | 2.97 | 0.53 | 17.62 |
|  | *Grewia optiva* J.R.Drumm. ex Burret | Malvaceae | 5.56 | 6.82 | 2.83 | 0.51 | 15.21 |
|  | *Toona ciliata* M.Roem. | Meliaceae | 5.56 | 6.82 | 2.41 | 0.43 | 14.79 |
|  | *Dalbergia sissoo* Roxb. ex DC. | Fabaceae | 5.56 | 4.54 | 3.98 | 0.72 | 14.08 |
|  | *Eucalyptus tereticornis* Domin | Myrtaceae | 5.56 | 4.54 | 3.4 | 0.61 | 13.5 |
|  | *Melia azedarach* L. | Meliaceae | 5.56 | 4.54 | 2.26 | 0.41 | 12.36 |
|  | *Morus alba* L. | Moraceae | 5.56 | 2.27 | 3.07 | 0.55 | 10.9 |
| IX | *Grewia optiva* J.R.Drumm. ex Burret | Malvaceae | 26.32 | 19.3 | 57.81 | 2.2 | 103.43 |
|  | *Dalbergia sissoo* Roxb. ex DC. | Fabaceae | 15.79 | 19.3 | 11.04 | 0.7 | 46.13 |
|  | *Acacia catechu* (L.f.) Willd. | Fabaceae | 10.52 | 19.3 | 9.35 | 0.89 | 39.17 |
|  | *Jacaranda mimosifolia* D.Don | Bignoniaceae | 10.52 | 7.02 | 8.12 | 0.77 | 25.66 |
|  | *Morus alba* L. | Moraceae | 5.26 | 7.02 | 2.56 | 0.49 | 14.84 |
|  | *Toona ciliata* M.Roem. | Meliaceae | 5.26 | 7.02 | 2.11 | 0.4 | 14.39 |
|  | *Bauhinia variegata* L. | Fabaceae | 5.26 | 7.02 | 1.96 | 0.37 | 14.24 |
|  | *Melia azedarach* L. | Meliaceae | 5.26 | 5.26 | 1.66 | 0.32 | 12.18 |
|  | Pyrus pashiaBuch.-Ham. ex D.Don | Rosaceae | 5.26 | 3.51 | 1.96 | 0.37 | 10.73 |
|  | *Populus ciliata* Wall. ex Royle | Salicaceae | 5.26 | 3.52 | 1.56 | 0.3 | 10.34 |
|  | *Bombax ceiba* L. | Malvaceae | 5.26 | 1.76 | 1.87 | 0.36 | 8.89 |
| X | *Quercus leucotrichophora*  A. Camus | Fagaceae | 38.46 | 49.09 | 70.79 | 1.84 | 158.34 |
|  | *Dalbergia sissoo* Roxb. ex DC. | Fabaceae | 15.38 | 18.18 | 7.56 | 0.49 | 41.12 |
|  | *Celtis australis* L. | Cannabaceae | 15.38 | 14.55 | 10.54 | 0.69 | 40.47 |
|  | *Bauhinia variegata* L. | Fabaceae | 7.69 | 7.27 | 2.61 | 0.34 | 17.57 |
|  | *Pinus roxburghii* Sarg. | Pinaceae | 7.69 | 7.27 | 1.77 | 0.23 | 16.73 |
|  | *Morus alba* L. | Moraceae | 7.69 | 1.82 | 4.03 | 0.52 | 13.54 |
|  | *Robinia pseudoacacia* Linn | Fabaceae | 7.69 | 1.82 | 2.7 | 0.35 | 12.21 |

**Table 3Phytosociological attributes of Trees at Zone-II**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Site | Species | Family | Relative frequency | Relative density | Relative dominance | R/F | IVI |
| I | *Abies pindrow* Zucc. | Pinaceae | 26.92 | 21.43 | 50.06 | 1.86 | 98.41 |
|  | *Cedrus deodara* (Roxb. ex D.Don) G.Don | Pinaceae | 26.92 | 33.93 | 29.3 | 1.09 | 90.15 |
|  | *Picea smithiana* (Wall.) Boiss. | Pinaceae | 15.39 | 17.86 | 9.2 | 0.6 | 42.45 |
|  | *Pinus wallichiana* (Wall. ex. D.Don) A.B.Jacks. | Pinaceae | 11.54 | 10.71 | 4.96 | 0.43 | 27.21 |
|  | *Prunus cornuta* (Wall. ex Royle) Steud. | Rosaceae | 7.69 | 8.93 | 3.4 | 0.44 | 20.02 |
|  | *Ulmus wallichiana* Planch. | Ulmaceae | 7.69 | 5.36 | 1.8 | 0.23 | 14.85 |
|  | *Acer caesium* Wall. ex Brandis | Sapindaceae | 3.85 | 1.78 | 1.29 | 0.34 | 6.92 |
| II | *Cedrus deodara* (Roxb. ex D.Don) G.Don | Pinaceae | 41.18 | 56.36 | 64.12 | 1.56 | 161.66 |
|  | *Picea smithiana* (Wall.) Boiss. | Pinaceae | 29.41 | 20 | 18.46 | 0.63 | 67.87 |
|  | *Abies pindrow* Zucc. | Pinaceae | 17.65 | 12.73 | 11.9 | 0.67 | 42.28 |
|  | *Pinus wallichiana* (Wall. ex. D.Don) A.B.Jacks. | Pinaceae | 11.76 | 10.91 | 5.52 | 0.47 | 28.19 |
| III | *Cedrus deodara* (Roxb. ex D.Don) G.Don | Pinaceae | 60 | 90.16 | 94.6 | 1.58 | 244.76 |
|  | *Picea smithiana* (Wall.) Boiss. | Pinaceae | 13.33 | 3.28 | 3.01 | 0.23 | 19.62 |
|  | *Abies pindrow* Zucc. | Pinaceae | 13.33 | 3.28 | 0.91 | 0.07 | 17.52 |
|  | *Pinus wallichiana* (Wall. ex. D.Don) A.B.Jacks. | Pinaceae | 6.67 | 1.64 | 0.84 | 0.13 | 9.15 |
|  | *Aesculus indica* (Wall. ex Cambess.) Hook. | Sapindaceae | 6.67 | 1.64 | 0.64 | 0.1 | 8.95 |
| IV | *Cedrus deodara* (Roxb. ex D.Don) G.Don | Pinaceae | 60 | 86.54 | 83 | 1.38 | 229.54 |
|  | *Picea smithiana* (Wall.) Boiss. | Pinaceae | 20 | 5.77 | 10.43 | 0.52 | 36.2 |
|  | *Pinus wallichiana* (Wall. ex. D.Don) A.B.Jacks. | Pinaceae | 13.33 | 3.85 | 0.92 | 0.1 | 18.1 |
|  | *Abies pindrow* Zucc. | Pinaceae | 6.67 | 3.85 | 5.66 | 0.85 | 16.18 |
| V | *Cedrus deodara* (Roxb. ex D.Don) G.Don | Pinaceae | 50 | 77.97 | 79.02 | 1.58 | 206.99 |
|  | *Picea smithiana* (Wall.) Boiss. | Pinaceae | 25 | 11.86 | 11.48 | 0.46 | 48.34 |
|  | *Aesculus indica* (Wall. ex Cambess.) Hook. | Sapindaceae | 18.75 | 6.78 | 4.63 | 0.25 | 30.16 |
|  | *Abies pindrow* Zucc. | Pinaceae | 6.25 | 3.39 | 4.87 | 0.78 | 14.51 |
| VI | *Cedrus deodara* (Roxb. ex D.Don) G.Don | Pinaceae | 40 | 46.94 | 46.55 | 1.16 | 133.49 |
|  | *Abies pindrow* Zucc. | Pinaceae | 30 | 32.65 | 32.75 | 1.09 | 95.4 |
|  | *Picea smithiana*  (Wall.) Boiss. | Pinaceae | 20 | 14.29 | 18.72 | 0.94 | 53.01 |
|  | *Ulmus wallichiana* Planch. | Ulmaceae | 5 | 4.08 | 0.94 | 0.19 | 10.02 |
|  | *Juglans regia* L. | Juglandaceae | 5 | 2.04 | 1.03 | 0.21 | 8.07 |
| VII | *Cedrus deodara* (Roxb. ex D.Don) G.Don | Pinaceae | 43.75 | 65.45 | 67.66 | 1.55 | 176.86 |
|  | *Abies pindrow* Zucc. | Pinaceae | 31.25 | 14.55 | 23.23 | 0.74 | 69.03 |
|  | *Picea smithiana*  (Wall.) Boiss. | Pinaceae | 18.75 | 10.91 | 7.42 | 0.4 | 37.08 |
|  | *Pinus wallichiana* (Wall. ex. D.Don) A.B.Jacks. | Pinaceae | 6.25 | 9.09 | 1.69 | 0.27 | 17.03 |
| VIII | *Cedrus deodara* (Roxb. ex D.Don) G.Don | Pinaceae | 38.1 | 43.08 | 66.52 | 1.75 | 147.7 |
|  | *Pinus wallichiana*(Wall. ex. D.Don) A.B.Jacks. | Pinaceae | 23.81 | 16.92 | 26.45 | 1.11 | 67.18 |
|  | *Populus ciliata* Wall. ex Royle | Salicaceae | 19.05 | 18.46 | 2.43 | 0.13 | 39.94 |
|  | *Picea smithiana* (Wall.) Boiss. | Pinaceae | 9.52 | 9.23 | 2.29 | 0.24 | 21.04 |
|  | *Abies pindrow* Zucc. | Pinaceae | 4.76 | 6.15 | 1.34 | 0.28 | 12.25 |
|  | *Quercus leucotrichophora* A. Camus | Fagaceae | 4.76 | 6.15 | 0.98 | 0.21 | 11.89 |
| IX | *Cedrus deodara* (Roxb. ex D.Don) G.Don | Pinaceae | 47.37 | 66.67 | 80.44 | 1.7 | 194.48 |
|  | *Picea smithiana* (Wall.) Boiss. | Pinaceae | 15.79 | 11.11 | 5.35 | 0.34 | 32.25 |
|  | *Pinus wallichiana* (Wall. ex. D.Don) A.B.Jacks. | Pinaceae | 10.53 | 11.11 | 8.71 | 0.83 | 30.35 |
|  | *Aesculus indica* (Wall. ex Cambess.) Hook. | Sapindaceae | 15.79 | 7.41 | 4.25 | 0.27 | 27.45 |
|  | *Abies pindrow* Zucc. | Pinaceae | 5.26 | 1.85 | 0.81 | 0.15 | 7.92 |
|  | *Quercus floribunda* Lindl. ex A.Camus | Fagaceae | 5.26 | 1.85 | 0.44 | 0.08 | 7.55 |
| X | *Cedrus deodara* (Roxb. ex D.Don) G.Don | Pinaceae | 46.67 | 60.34 | 70.65 | 1.51 | 177.66 |
|  | *Picea smithiana* (Wall.) Boiss. | Pinaceae | 20 | 18.97 | 20.14 | 1.01 | 59.11 |
|  | *Pinus wallichiana* (Wall. ex. D.Don) A.B.Jacks. | Pinaceae | 20 | 12.07 | 5.88 | 0.29 | 37.95 |
|  | *Abies pindrow* Zucc. | Pinaceae | 13.33 | 8.62 | 3.33 | 0.25 | 25.28 |

**Table 4Phytosociological attributes of Trees at Zone-III**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Site | Species | Family | Relative frequency | Relative density | Relative dominance | R/F | IVI |
| I | *Cedrus deodara* (Roxb. ex D.Don) G.Don | Pinaceae | 31.58 | 49.06 | 38.35 | 1.21 | 118.99 |
|  | *Picea smithiana* (Wall.) Boiss. | Pinaceae | 26.32 | 18.87 | 32.67 | 1.24 | 77.86 |
|  | *Acer caesium* Wall. ex Brandis | Sapindaceae | 26.32 | 20.75 | 25.73 | 0.98 | 72.8 |
|  | *Abies pindrow* Zucc. | Pinaceae | 10.53 | 9.43 | 2.38 | 0.23 | 22.34 |
|  | *Prunus cornuta* (Wall. ex Royle) Steud. | Rosaceae | 5.26 | 1.89 | 0.86 | 0.16 | 8.01 |
| II | *Cedrus deodara* (Roxb. ex D.Don) G.Don | Pinaceae | 50 | 73.34 | 80.62 | 1.61 | 203.96 |
|  | *Picea smithiana* (Wall.) Boiss. | Pinaceae | 15 | 8.89 | 8.78 | 0.59 | 32.67 |
|  | *Abies pindrow* Zucc. | Pinaceae | 15 | 6.67 | 6.12 | 0.41 | 27.79 |
|  | *Acer caesium* Wall. ex Brandis | Sapindaceae | 10 | 4.44 | 2.93 | 0.29 | 17.37 |
|  | *Prunus cornuta* (Wall. ex Royle) Steud. | Rosaceae | 5 | 4.44 | 0.95 | 0.19 | 10.39 |
|  | *Taxus wallichiana* Zucc. | Taxaceae | 5 | 2.22 | 0.6 | 0.12 | 7.82 |
| III | *Abies pindrow* Zucc. | Pinaceae | 43.75 | 20.34 | 58.14 | 1.33 | 122.23 |
|  | *Quercus semecarpifolia* Sm. | Fagaceae | 25 | 35.59 | 18.83 | 0.75 | 79.42 |
|  | *Cedrus deodara* (Roxb. ex D.Don) G.Don | Pinaceae | 18.75 | 25.42 | 16.4 | 0.87 | 60.57 |
|  | *Quercus floribunda* Lindl. ex A.Camus | Fagaceae | 12.5 | 18.64 | 6.62 | 0.53 | 37.76 |
| IV | *Abies pindrow* Zucc. | Pinaceae | 33.33 | 16.98 | 41.56 | 1.25 | 91.87 |
|  | *Cedrus deodara* (Roxb. ex D.Don) G.Don | Pinaceae | 27.78 | 24.53 | 23.6 | 0.85 | 75.91 |
|  | *Picea smithiana* (Wall.) Boiss. | Pinaceae | 22.22 | 32.08 | 21.53 | 0.97 | 75.83 |
|  | *Cedrus deodara* (Roxb. ex D.Don) G.Don | Pinaceae | 16.67 | 26.42 | 13.32 | 0.8 | 56.41 |
| V | *Acer caesium* Wall. ex Brandis | Sapindaceae | 33.33 | 28 | 53.02 | 1.59 | 114.35 |
|  | *Cedrus deodara* (Roxb. ex D.Don) G.Don | Pinaceae | 27.78 | 34 | 19.82 | 0.71 | 81.6 |
|  | *Picea smithiana* (Wall.) Boiss. | Pinaceae | 22.22 | 30 | 20.92 | 0.94 | 73.14 |
|  | *Taxus wallichiana* Zucc. | Taxaceae | 11.11 | 4 | 5.49 | 0.49 | 20.6 |
|  | *Abies pindrow* Zucc. | Pinaceae | 5.56 | 4 | 0.75 | 0.13 | 10.31 |
| VI | *Cedrus deodara* (Roxb. ex D.Don) G.Don | Pinaceae | 45.45 | 73.47 | 63.36 | 1.39 | 182.28 |
|  | *Abies pindrow* Zucc. | Pinaceae | 31.82 | 14.29 | 29.9 | 0.94 | 76.01 |
|  | *Acer caesium* Wall. ex Brandis | Sapindaceae | 13.64 | 6.12 | 5.43 | 0.4 | 25.19 |
|  | *Picea smithiana* (Wall.) Boiss. | Pinaceae | 4.55 | 4.08 | 0.61 | 0.13 | 9.24 |
|  | *Taxus wallichiana* Zucc. | Taxaceae | 4.55 | 2.04 | 0.7 | 0.15 | 7.29 |
| VII | *Quercus semecarpifolia* Sm. | Fagaceae | 62.5 | 87.93 | 88.99 | 1.42 | 239.42 |
|  | *Abies pindrow* Zucc. | Pinaceae | 18.75 | 6.9 | 7.81 | 0.42 | 33.46 |
|  | *Picea smithiana* (Wall.) Boiss. | Pinaceae | 12.5 | 3.45 | 2 | 0.16 | 17.95 |
|  | *Acer caesium* Wall. ex Brandis | Sapindaceae | 6.25 | 1.72 | 1.2 | 0.192 | 9.17 |
| VIII | *Quercus semecarpifolia* Sm. | Fagaceae | 30.43 | 46.07 | 50 | 1.6 | 126.5 |
|  | *Taxus wallichiana* Zucc. | Taxaceae | 26.09 | 15.73 | 22.13 | 0.85 | 63.95 |
|  | *Abies pindrow* Zucc. | Pinaceae | 17.39 | 8.99 | 11.54 | 0.66 | 37.92 |
|  | *Picea smithiana* (Wall.) Boiss. | Pinaceae | 13.04 | 11.24 | 10.47 | 0.8 | 34.75 |
|  | *Cedrus deodara* (Roxb. ex D.Don) G.Don | Pinaceae | 8.7 | 15.73 | 5.39 | 0.62 | 29.82 |
|  | *Prunus cornuta* (Wall. ex Royle) Steud. | Rosaceae | 4.35 | 2.25 | 0.46 | 0.11 | 7.06 |
| IX | *Quercus semecarpifolia* Sm. | Fagaceae | 67.31 | 45 | 79.7 | 1.18 | 192.01 |
|  | *Picea smithiana* (Wall.) Boiss. | Pinaceae | 5.77 | 15 | 9.47 | 1.64 | 30.24 |
|  | *Abies pindrow* Zucc. | Pinaceae | 5.77 | 10 | 4.38 | 0.76 | 20.15 |
|  | *Taxus wallichiana* Zucc. | Taxaceae | 5.77 | 10 | 2.81 | 0.49 | 18.58 |
|  | *Cedrus deodara* (Roxb. ex D.Don) G.Don | Pinaceae | 7.69 | 5 | 0.65 | 0.08 | 13.34 |
|  | *Acer caesium* Wall. ex Brandis | Sapindaceae | 3.85 | 5 | 0.8 | 0.21 | 9.65 |
|  | *Prunus cornuta* (Wall. ex Royle) Steud. | Rosaceae | 1.92 | 5 | 1.3 | 0.68 | 8.22 |
|  | *Quercus floribunda* Lindl. ex A.Camus | Fagaceae | 1.92 | 5 | 0.89 | 0.46 | 7.81 |
| X | *Quercus semecarpifolia* Sm. | Fagaceae | 40 | 60 | 35.86 | 0.9 | 135.86 |
|  | *Picea smithiana* (Wall.) Boiss. | Pinaceae | 30 | 14 | 32.73 | 1.09 | 76.73 |
|  | Abies pindrowZucc. | Pinaceae | 10 | 8 | 5.92 | 0.59 | 23.92 |
|  | *Quercus floribunda* Lindl. ex A.Camus | Fagaceae | 10 | 6 | 3.17 | 0.32 | 19.17 |
|  | *Cedrus deodara* (Roxb. ex D.Don) G.Don | Pinaceae | 5 | 8 | 0.67 | 0.13 | 13.67 |
|  | *Taxus wallichiana* Zucc. | Taxaceae | 5 | 4 | 1.65 | 0.33 | 10.65 |

**Table 5Diversity indices of tree species**

|  |  |  |  |
| --- | --- | --- | --- |
| Study Site | Shanon’s index (H) | Simpson index (CD) | Species richness (R)Margadex |
| Zone-I | | | |
| I | 2.05 | 0.15 | 9.40 |
| II | 1.54 | 0.25 | 5.43 |
| III | 1.75 | 0.19 | 6.43 |
| IV | 1.50 | 0.27 | 5.43 |
| V | 2.10 | 0.13 | 8.41 |
| VI | 1.58 | 0.23 | 5.44 |
| VII | 2.13 | 0.13 | 8.42 |
| VIII | 2.25 | 0.13 | 11.39 |
| IX | 2.04 | 0.18 | 10.43 |
| X | 1.48 | 0.33 | 6.43 |
| Zone-II | | | |
| I | 1.63 | 0.24 | 6.43 |
| II | 1.17 | 0.37 | 3.43 |
| III | 0.72 | 0.68 | 4.44 |
| IV | 0.79 | 0.61 | 3.42 |
| V | 0.93 | 0.51 | 3.44 |
| VI | 1.24 | 0.33 | 4.41 |
| VII | 1.07 | 0.42 | 3.43 |
| VIII | 1.40 | 0.32 | 5.45 |
| IX | 1.16 | 0.45 | 6.42 |
| X | 1.10 | 0.41 | 3.43 |
| Zone-III | | | |
| I | 1.35 | 0.29 | 4.42 |
| II | 1.10 | 0.49 | 5.40 |
| III | 1.30 | 0.29 | 3.44 |
| IV | 1.37 | 0.26 | 3.42 |
| V | 1.37 | 0.28 | 4.41 |
| VI | 1.06 | 0.44 | 4.41 |
| VII | 0.70 | 0.65 | 3.43 |
| VIII | 1.5 | 0.27 | 5.41 |
| IX | 133 | 0.35 | 7.42 |
| X | 1.10 | 0.49 | 5.41 |

**Figure 3 Dominant families with the number of tree species found in Anni block of Outer Seraj area**

****

**Plate 1 A.** *Pinus wallichiana,* **B**. *Albizzia chinensis*, **C.** *Abies pindrow*, **D.** *Jacaranda mimosifolia,***E.***Aesculus indica***, F.** *Bauhinia variegata*, **G.** *Pyrus pashia,* **H.** *Ficus palmata*

**Shrub species distribution**

A total of 28shrub species belonging to 23 genera and 17 families were recorded in the study area. Photographs of some shrub species recorded during field surveys are given in **Plate 2.** The dominant families were Rosaceae (7 spp.), Fabaceae (3 spp.), Berberidaceae, Rutaceae, and Thymelaeaceae (2 spp. each) **(Figure 4).***Rosa* (3 spp.) was the dominant genera, followed by *Rubus, Indigofera*and *Berberis* (2 spp. each)**.**

At Zone-I,*Debregeasiasaeneb*(IVI=191.15) at sudy site IX was the dominant species followed by*Prinsepia utilis*(IVI=174.80) at siteVIIIand*Rosa brunonii*(IVI=155.38) at site VI.Maximum value of frequency (%) was observed for *Debregeasiasaeneb*(60.87) at study site IX followed by *Prinsepia utilis*(47.22) at site VIIIand *Rosa brunonii*(42.42) at site VI.Maximum density was recorded for *Debregeasiasaeneb*(63.73) at site IXfollowed by *Prinsepiautiis*(57.60) at site VIIIand*Rosa brunonii*(54.15) at site VI.Abundance was found to be highest for *Prinsepia utilis*(69.98)at site VIIIfollowed by*Debregeasiasaeneb*(66.55) at site IX and *Rosa brunonii* (58.81) at site VI.The distribution pattern of species showed contiguous distribution **(Table 6).**

At Zone-II, *Rosa brunonii* (IVI=138.84) at sudy site IV was the dominant species followed by*Prinsepia utilis* (IVI=105.40) at siteVIIand*Desmodium elegans* (IVI=103.90) at site VI. Maximum value of frequency (%) was observed for *Rosa macrophylla*(42.11) at study site IV followed by *Berberis lycium*(31.58) at site V and *Prinsepia utilis*(30.19) at site VII. Maximum density was recorded for *Rosa macrophylla*(54.62) at site IVfollowed by *Daphne papyracea*(40.94) at site X and*Prinsepia utilis*(34.47) at site VI.Abundance was found to be highest for *Desmodium elegans*(45.08)at site VIfollowed by*Debregeasiasaeneb*(42.11) at site IVand *Indigofera heterantha* (58.81) at site VI.The distribution pattern of species showed contiguous distribution **(Table 7).**

At Zone-III, *Myrsineafricana*(IVI=194.98) at sudy site VIII was the dominant species followed by *Berberis aristata* (IVI=131.97) at siteVIand*Desmodium elegans* (IVI=130.09) at site II. Maximum value of frequency (%) was observed for *Coriarianepalensis*(56.00) at study site IIIfollowed by *Rosa sericea*(50.00) at site VIIand *Prinsepia utilis*(45.45) at site I. Maximum density was recorded for *Coriarianepalensis*(59.93) at site IIIfollowed by *Berberis aristata*(49.56) at site VIand*Desmodium elegans*(46.15) at site II.Abundance was found to be highest for *Coriarianepalensis*(73.52*)* at site IIIfollowed by*Myrsineafricana*(71.23) at site VIIIand *Rosa sericea* (54.77) at site V. All the recorded species showed contagious distribution **(Table 8).**

**Table 6 Phytosociological attributes of Shrubs at Zone-I**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Site | Species | Family | Relative frequency | Relative density | Relative dominance | R/F | IVI |
| I | *Debregeasia saeneb* (Forssk.) Hepper &J.R.I.Wood | Urticaceae | 32.73 | 34.81 | 37.19 | 1.14 | 104.73 |
|  | *Prinsepia utilis* Royle | Rosaceae | 25.45 | 25.16 | 27.89 | 1.1 | 78.5 |
|  | *Woodfordia fruticosa* (L.) Kurz | Lythraceae | 21.82 | 21.08 | 18.52 | 0.85 | 61.42 |
|  | *Berberis lycium* Royle | Berberidaceae | 20 | 18.95 | 16.33 | 0.82 | 55.28 |
| II | *Justicia adhatoda* L. | Acanthaceae | 31.03 | 32.89 | 37.64 | 1.21 | 101.56 |
|  | *Ricinus communis* L. | Euphorbiaceae | 23.91 | 23.89 | 28.69 | 1.2 | 76.49 |
|  | *Rubus ellipticus* Sm. | Rosaceae | 22.41 | 24.05 | 22.15 | 0.1 | 68.61 |
|  | *Carissa spinarum* L. | Apocynaceae | 22.41 | 20.74 | 22.68 | 1.01 | 65.83 |
|  | *Ricinus communis* L. | Euphorbiaceae | 24.14 | 22.32 | 17.53 | 0.73 | 63.99 |
| III | *Ricinus communis* L. | Euphorbiaceae | 23.91 | 23.89 | 28.69 | 1.2 | 76.49 |
|  | *Berberis lycium* Royle | Berberidaceae | 30.43 | 26.57 | 19.23 | 0.63 | 76.23 |
|  | *Cotinus coggygria* Scop. | Anacardiaceae | 21.74 | 26.37 | 22.09 | 1.02 | 70.2 |
|  | *Prinsepia utilis* Royle | Rosaceae | 15.22 | 14.73 | 20.7 | 1.36 | 50.65 |
|  | *Justicia adhatoda* L. | Acanthaceae | 8.7 | 8.44 | 9.29 | 1.07 | 26.43 |
| IV | *Rubus ellipticus* Sm. | Rosaceae | 39.02 | 41.91 | 45.29 | 1.16 | 126.22 |
|  | *Cotinus coggygriya* Scop. | Anacardiaceae | 17.07 | 20.23 | 17.84 | 1.05 | 55.14 |
|  | *Coriaria nepalensis* Wall. | Coriariaceae | 17.07 | 13.32 | 12.87 | 0.75 | 43.26 |
|  | *Berberis lycium* Royle | Berberidaceae | 9.76 | 9.4 | 7.52 | 0.77 | 26.68 |
|  | *Woodfordia fruticosa* (L.) Kurz | Lythracaee | 9.76 | 8.22 | 7.63 | 0.78 | 25.61 |
|  | *Prinsepia utilis* Royle | Rosaceae | 7.32 | 6.92 | 8.85 | 1.21 | 23.09 |
| V | *Prinsepia utilis* Royle | Rosaceae | 33.33 | 41.54 | 35.68 | 1.07 | 110.55 |
|  | *Cotinus coggygria* Scop. | Anacardiaceae | 33.33 | 28.61 | 35.82 | 1.07 | 97.76 |
|  | *Ricinus communis* L. | Euphorbiaceae | 17.78 | 18.29 | 14.25 | 0.8 | 50.32 |
|  | *Berberis lycium* Royle | Berberidaceae | 15.56 | 11.55 | 14.25 | 0.92 | 41.36 |
| VI | *Rosa brunonii* Lindl. | Rosaceae | 42.42 | 54.15 | 58.81 | 1.39 | 155.38 |
|  | *Berberis lycium* Royle | Berberidaceae | 30.3 | 22.7 | 22.24 | 0.73 | 75.24 |
|  | *Rubus ellipticus* L. | Rosaceae | 27.27 | 23.15 | 18.95 | 0.69 | 69.37 |
| VII | *Berberis lycium* Royle | Berberidaceae | 41.02 | 44.25 | 40.75 | 0.99 | 126.02 |
|  | *Carissa spinarum* L. | Apocynaceae | 20.51 | 17.32 | 25.71 | 1.25 | 63.54 |
|  | *Rubus ellipticus* Sm. | Rosaceae | 17.95 | 21.52 | 17.69 | 0.99 | 57.16 |
|  | *Zanthoxylum armatum* DC. | Rutaceae | 20.51 | 16.91 | 15.85 | 0.77 | 53.27 |
| VIII | *Prinsepia utilis* Royle | Rosaceae | 47.22 | 57.6 | 69.98 | 1.48 | 174.8 |
|  | *Dodonaea viscosa* Jacq. | Sapindaceae | 25 | 20.46 | 11.18 | 0.45 | 56.64 |
|  | *Indigofera heterantha* Wall. ex Brandis | Fabaceae | 19.44 | 16.55 | 14.47 | 0.74 | 50.46 |
|  | *Murraya koenigii* (L.) Spreng. | Rutaceae | 8.33 | 5.38 | 4.38 | 0.53 | 18.09 |
| IX | *Dabregesia saeneb* (Forssk.) Hepper &J.R.I.Wood | Urticaceae | 60.87 | 63.73 | 66.55 | 1.09 | 191.15 |
|  | *Prinsepia utilis* Royle | Rosaceae | 39.13 | 36.27 | 33.45 | 0.85 | 108.85 |
| X | *Murraya koenigii* (L.) Spreng. | Rutaceae | 33.33 | 40.48 | 47.26 | 1.42 | 121.07 |
|  | *Cotinus coggygria* Scop. | Anacardiaceae | 21.57 | 21.64 | 22.22 | 1.03 | 65.43 |
|  | *Carissa spiarum* L. | Apocynaceae | 19.61 | 16.05 | 10.68 | 0.54 | 46.34 |
|  | *Rubus ellipticus* Sm. | Rosaceae | 15.69 | 15.11 | 14.75 | 0.94 | 45.55 |
|  | *Berberis lycium* Royle | Berberidaceae | 9.8 | 6.73 | 5.09 | 0.52 | 21.62 |

**Table 7Phytosociological attributes of Shrubs at Zone-II**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Site | Species | Family | Relative frequency | Relative density | Relative dominance | R/F | IVI |
| I | *Rubus niveus* Thunb. | Rosaceae | 28.85 | 30.09 | 29.42 | 1.02 | 88.36 |
|  | *Daphne papyracea* Wall. ex G.Don | Thymelaeaceae | 17.3 | 29.9 | 28.62 | 1.65 | 75.82 |
|  | *Sarcococca saligna*  Mull.Arg. | Buxaceae | 25 | 19.07 | 16.2 | 0.65 | 60.27 |
|  | Indigofera gerardianaWall. ex Baker | Fabaceae | 21.15 | 12.76 | 16.08 | 0.76 | 49.99 |
|  | *Coriaria nepalensis* Wall. | Coriariaceae | 7.69 | 8.18 | 9.68 | 1.26 | 25.55 |
| II | *Indigofera heterantha* Wall. ex Brandis | Fabaceae | 23.08 | 30.09 | 36.96 | 1.6 | 90.13 |
|  | *Dodonaea viscosa* Jacq. | Sapindaceae | 13.85 | 16.15 | 16.29 | 1.18 | 46.29 |
|  | *Daphne papyracea* Wall. ex G.Don | Thymelaeaceae | 13.85 | 17.26 | 14 | 1.01 | 45.11 |
|  | *Berberis lycium* Royle | Berberidaceae | 12.31 | 10.93 | 13.45 | 1.09 | 36.69 |
|  | *Debregeasia saeneb* (Forssk.) Hepper &J.R.I.Wood | Urticaceae | 12.31 | 9.74 | 6.22 | 0.51 | 28.27 |
|  | *Zanthoxylum armatum* DC. | Rutaceae | 12.31 | 7.36 | 7.5 | 0.61 | 27.17 |
|  | *Cotoneaster microphyllus* Wall. ex Lindl. | Rosaceae | 7.69 | 5.15 | 4.3 | 0.56 | 17.14 |
|  | *Prinsepia utilis* Royle | Rosaceae | 4.62 | 3.33 | 1.28 | 0.28 | 9.23 |
| III | *Desmodium elegans* DC. | Fabaceae | 26.92 | 32.06 | 32.11 | 1.19 | 91.09 |
|  | *Berberis lycium* Royle | Berberidaceae | 25 | 24.08 | 19.69 | 0.79 | 68.77 |
|  | *Indigofera gerardiana* Wall. ex Baker | Fabaceae | 17.31 | 17.66 | 18.35 | 1.06 | 53.32 |
|  | *Prinsepia utilis* Royle | Rosaceae | 17.31 | 15.22 | 19.27 | 1.11 | 51.8 |
|  | *Rosa macrophylla* Lindl. | Rosaceae | 13.46 | 10.98 | 10.58 | 0.79 | 35.02 |
| IV | *Rosa brunonii* Lindl. | Rosaceae | 42.11 | 54.62 | 42.11 | 1 | 138.84 |
|  | *Berberis lycium* Royle | Berberidaceae | 31.58 | 29.6 | 31.58 | 1 | 92.76 |
|  | *Desmodium elegans* DC. | Fabaceae | 21.06 | 12.02 | 21.06 | 1 | 54.14 |
|  | *Zanthoxylum armatum* DC. | Rutaceae | 5.26 | 3.76 | 5.26 | 1 | 14.28 |
| V | *Daphne papyracea* Wall. ex G.Don | Thymelaeaceae | 26.53 | 27.43 | 22.3 | 0.84 | 76.26 |
|  | *Prinsepia utilis* Royle | Rosaceae | 26.53 | 27.62 | 21.2 | 0.8 | 75.35 |
|  | *Berberis lycium* Royle | Berberidaceae | 22.45 | 22.71 | 26.99 | 1.2 | 72.15 |
|  | *Rubus ellipticus* Sm. | Rosaceae | 14.29 | 15.59 | 24.67 | 1.73 | 54.55 |
|  | *Zanthoxylum armatum* DC. | Rutaceae | 10.2 | 6.64 | 4.84 | 0.47 | 21.68 |
| VI | *Rosa macrophylla* Lindl. | Rosaceae | 32.5 | 34.21 | 38 | 1.17 | 104.71 |
|  | *Desmodium elegans* DC. | Fabaceae | 27.5 | 31.32 | 45.08 | 1.64 | 103.9 |
|  | *Prinsepia utilis* Royle | Rosaceae | 40 | 34.47 | 16.92 | 0.42 | 91.39 |
| VII | *Prinsepia utilis* Royle | Rosaceae | 30.19 | 30.92 | 44.29 | 1.47 | 105.4 |
|  | *Zanthoxylum armatum* DC. | Rutaceae | 28.3 | 32.69 | 25.34 | 0.9 | 86.33 |
|  | *Sarcococca saligna*  Mull.Arg. | Buxaceae | 28.3 | 25.19 | 23.54 | 0.83 | 77.03 |
|  | *Desmodium elegans* DC. | Fabaceae | 13.21 | 11.2 | 6.83 | 0.52 | 31.24 |
| VIII | *Desmodium elegans* DC. | Fabaceae | 28.3 | 29.57 | 27.74 | 0.98 | 85.61 |
|  | *Cotoneaster microphyllus* Wall. ex Lindl. | Rosaceae | 26.42 | 29.04 | 27.36 | 1.04 | 82.82 |
|  | *Prinsepia utilis* Royle | Rosaceae | 24.53 | 22.95 | 21.47 | 0.88 | 68.95 |
|  | *Rubus ellipticus* Sm. | Rosaceae | 11.32 | 11.56 | 16.78 | 1.48 | 39.66 |
|  | *Wilkestromea canescens* Meisn. | Thymelaeaceae | 9.43 | 6.88 | 6.65 | 0.71 | 22.96 |
| IX | *Zanthoxylum armatum* DC. | Rutaceae | 21.92 | 22.43 | 23.72 | 1.08 | 68.07 |
|  | *Carissa spinarum* L. | Apocynaceae | 16.44 | 17.33 | 9.9 | 0.6 | 43.67 |
|  | *Sarcococca saligna*  Mull.Arg. | Buxaceae | 13.7 | 15.11 | 13.28 | 0.97 | 42.09 |
|  | *Cotoneaster microphyllus* Wall. ex Lindl. | Rosaceae | 16.44 | 19.61 | 29.71 | 1.81 | 65.76 |
|  | *Indigofera heterantha* Wall. ex Brandis | Fabaceae | 12.33 | 13.43 | 18.06 | 1.46 | 43.82 |
|  | *Berberis aristata* DC. | Berberidaceae | 2.74 | 1.54 | 0.44 | 0.16 | 4.72 |
|  | *Desmodium elegans*  DC. | Fabaceae | 16.44 | 10.54 | 4.9 | 0.3 | 31.88 |
| X | *Daphne papyracea* Wall. ex G.Don | Thymelaeaceae | 25 | 40.94 | 29.83 | 1.19 | 95.77 |
|  | *Cotoneaster microphylla* Wall. ex Lindl. | Rosaceae | 25 | 20.51 | 29.6 | 1.18 | 75.11 |
|  | *Zanthoxylum armatum* DC. | Rutaceae | 25 | 18.5 | 22.9 | 0.92 | 66.4 |
|  | *Prinsepia utilis* Royle | Rosaceae | 25 | 20.06 | 17.67 | 0.71 | 62.73 |

**Table 8Phytosociological attributes of Shrubs at Zone-III**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Site | Species | Family | Relative frequency | Relative density | Relative dominance | R/F | IVI |
| I | *Prinsepia utilis* Royle | Rosaceae | 45.45 | 45.31 | 38.29 | 0.84 | 129.05 |
|  | *Rosa sericea* Lindl. | Rosaceae | 33.33 | 37.13 | 53.94 | 1.62 | 124.4 |
|  | *Coriaria nepalensis* Wall. | Coriariaceae | 21.21 | 17.56 | 7.77 | 0.37 | 46.54 |
| II | *Desmodium elegans* DC. | Fabaceae | 39.47 | 46.15 | 44.47 | 1.13 | 130.09 |
|  | *Daphne papyracea* Wall. ex G.Don | Thymelaeaceae | 28.95 | 27.57 | 29.37 | 1.01 | 85.89 |
|  | *Rhododendron campanulatum* D.Don | Ericaceae | 31.58 | 26.28 | 26.16 | 0.83 | 84.02 |
| III | *Coriaria nepalensis* Wall. | Coriariaceae | 56 | 59.93 | 73.52 | 1.31 | 189.45 |
|  | *Desmodium elegans* DC. | Fabaceae | 44 | 40.07 | 26.48 | 0.6 | 110.55 |
| IV | *Daphne papyracea* Wall. ex G.Don | Thymelaeaceae | 33.33 | 38.74 | 38.76 | 1.16 | 110.83 |
|  | *Rosa sericea* Lindl. | Rosaceae | 33.33 | 30.1 | 35.69 | 1.07 | 99.12 |
|  | *Berberis lycium* Royle | Berberidaceae | 33.33 | 31.17 | 25.55 | 0.77 | 90.05 |
| V | *Rosa sericea* Lindl. | Rosaceae | 35.55 | 47.65 | 54.77 | 1.54 | 137.97 |
|  | *Desmodium elegans* DC. | Fabaceae | 22.22 | 21.2 | 19.99 | 0.9 | 63.41 |
|  | *Myrisine africana* L. | Primulaceae | 22.22 | 18.58 | 15.44 | 0.69 | 56.24 |
|  | *Rubus niveus* Thunb. | Rosaceae | 20 | 12.57 | 9.8 | 0.49 | 42.37 |
| VI | *Berberis aristata* DC. | Berberidaceae | 42.42 | 49.56 | 39.99 | 0.94 | 131.97 |
|  | Prinsepia utilis Royle | Rosaceae | 33.33 | 33.04 | 46.75 | 1.4 | 113.12 |
|  | *Daphne papyracea* Wall. ex G.Don | Thymelaeaceae | 24.24 | 17.4 | 13.26 | 0.55 | 54.9 |
| VII | *Rosa sericea* Lindl. | Rosaceae | 50 | 50.11 | 40.21 | 0.8 | 140.32 |
|  | *Berberis aristata* DC. | Berberidaceae | 28.95 | 32.94 | 46.54 | 1.61 | 108.43 |
|  | *Coriaria nepalensis* Wall. | Coriariaceae | 21.05 | 16.95 | 13.25 | 0.63 | 51.25 |
| VIII | *Myrsine africana* L. | Primulaceae | 52.94 | 60.81 | 71.23 | 1.35 | 194.98 |
|  | *Rubus niveus* Thunb. | Rosaceae | 35.29 | 34.58 | 26.63 | 0.75 | 96.5 |
|  | *Rhododendron campanulatum* D.Don | Ericaceae | 11.76 | 4.61 | 2.14 | 0.18 | 18.51 |
| IX | *Berberis aristata* DC. | Berberidaceae | 23.91 | 27.25 | 37.71 | 1.58 | 88.87 |
|  | *Rosa macrophylla* Lindl. | Rosaceae | 26.09 | 28.48 | 20.99 | 0.8 | 75.56 |
|  | *Lonicera angustifolia* Wall. ex DC. | Caprifoliaceae | 28.26 | 21.67 | 18.11 | 0.64 | 68.04 |
|  | *Daphne papyracea* Wall. ex G.Don | Thymelaeaceae | 21.74 | 22.61 | 23.18 | 1.07 | 67.53 |
| X | *Berberis aristata* DC. | Berberidaceae | 37.5 | 43.65 | 36.12 | 0.96 | 117.27 |
|  | *Prinsepia utilis* Royle | Rosaceae | 34.38 | 28.85 | 28.5 | 0.83 | 91.73 |
|  | *Coriaria nepalensis* Wall. | Coriariaceae | 28.12 | 27.5 | 35.38 | 1.26 | 91 |

**Table 9Diversity indices of Shrub layer**

|  |  |  |  |
| --- | --- | --- | --- |
| Study Site | Shanon’s index (H) | Simpson index (CD) | Species richness (R)Margalef index |
| Zone-I | | | |
| I | 1.36 | 0.26 | 3.67 |
| II | 1.37 | 0.26 | 3.68 |
| III | 1.55 | 0.22 | 4.67 |
| IV | 1.58 | 0.25 | 5.65 |
| V | 1.31 | 0.29 | 3.65 |
| VI | 1.03 | 0.38 | 2.65 |
| VII | 1.32 | 0.29 | 3.65 |
| VIII | 1.10 | 0.41 | 3.65 |
| IX | 0.66 | 0.54 | 1.63 |
| X | 1.46 | 0.26 | 4.66 |
| Zone-II | | | |
| I | 1.54 | 0.23 | 4.69 |
| II | 1.90 | 0.17 | 7.68 |
| III | 1.56 | 0.22 | 4.68 |
| IV | 1.12 | 0.37 | 3.70 |
| V | 1.54 | 0.22 | 4.67 |
| VI | 1.10 | 0.33 | 2.65 |
| VII | 1.31 | 0.28 | 3.67 |
| VIII | 1.52 | 0.23 | 4.67 |
| IX | 1.81 | 0.17 | 6.68 |
| X | 1.37 | 0.26 | 3.68 |
| Zone-III | | | |
| I | 1.02 | 0.38 | 2.67 |
| II | 1.08 | 0.35 | 2.67 |
| III | 0.66 | 0.53 | 1.66 |
| IV | 1.10 | 0.34 | 2.67 |
| V | 1.28 | 0.31 | 3.68 |
| VI | 1.04 | 0.37 | 2.67 |
| VII | 1.03 | 0.38 | 2.66 |
| VIII | 0.83 | 0.49 | 2.61 |
| IX | 1.38 | 0.25 | 3.67 |
| X | 1.09 | 0.34 | 2.66 |

**Figure 4 Dominant families with the number of shrub species found in Anni block of Outer Seraj area**



**Plate 2I.***Rosa brunonii,***J**. *Rubus ellipticus,***K.***Rosa sericea,***L.***Justicia adhatoda,***M.***Debregeasiasaeneb,* **N.***Lonicera angustifolia*, **O.***Indigofera heterantha,***P.***Woodfordiafruticosa*

**Herb species distribution**

A total of 40 herb species belonging to 38 genera and 22 families were recorded in the study area. Photographs of some herb species recorded during field surveys are given in **Plate 3.** The dominant families were Asteraceae (5 spp.), Lamiaceae and Solanaceae,(4 spp. each), and Polygonaceae (3 spp.) Urticaceae, Rosacea and, Amaranthaceae (2 spp. each)**(Figure 5).**

At Zone-I,*Cannabis sativa*(IVI=133.23) at sudy site IX was the dominant species followed by*Hypericum perforatum*(IVI=117.07) at site IVand*Centella asiatica*(IVI=109.26) at site II. Maximum value of frequency (%) was observed for *Cannabis sativa*(43.24) at study site IX followed by *Centella asiatica*(39.02) at site II and *Trifolium repens*(37.50) at site IV. Maximum density was recorded for *Cannabis sativa*(42.34) at site IXfollowed by *Hypericum perforatum*(41.05) at site IX and*Asparagus officinalis*(37.07) at site VI.Abundance was found to be highest for *Cannabis sativa*(47.65)at site IXfollowed by*Hypericum perforatum*(41.02) at site IVand *Trifolium repens* (40.38) at site IX.The distribution pattern of species showed contiguous distribution **(Table 10).**

At Zone-II,*Boenninghauseniaalbiflora*(IVI=199.71) at sudy site II was the dominant species followed by*Circium wallichii*(IVI=166.71) at siteVIand*Ajuga bracteosa*(IVI=166.71) at site VI. Maximum value of frequency (%) was observed for *Boenninghauseniaalbiflora*(55.55) at study site IIfollowed by *Chrysopogon fulvus*(48.39) at site Iand *Circium wallichii*and *Ajuga bacteosa*(45.16 each) at site VI. Maximum density was recorded for *Boenninghauseniaalbiflora*(68.87.) at site IIfollowed by *Chrysopogon fulvus* (58.95) at site I and *Ajuga bracteosa*and *Circium wallichii*(50.39 each) at site VIand *Prinsepia utilis*(34.47) at site VI.Abundance was found to be highest for *Boenninghauseniaalbiflora*(75.29)at site IIfollowed by*Circium wallichii*(61.75) at site IIand *Chrysopogon fulvus* (57.8) at site I.The distribution pattern of species showed contiguous distribution **(Table 11).**

At Zone-III,*Galium aparine*(IVI=229.86) at sudy site I was the dominant species followed by*Achyranthes aspera*(IVI=228.06) at siteII and*Galium aparine*(IVI=202.71) at site V. Maximum value of frequency (%) was observed for *Thymus linearis*(77.88) at study site VIII followed by *Girardianadiversifolia*(70) at site Xand *Galium aparine*(68.42) at site I. Maximum density was recorded for *Girardianadiversifolia*(79.99) at site Xfollowed by *Thymus linearis*(77.97) at site VIIIand*Galium aparine*(75.67) at site IX.Abundance was found to be highest for *Achyranthes aspera*(99.42*)* at site VIfollowed by*Potentilla astrosanguinea*(97.29) at site Xand *Galium aparine* (89.19) at site V.Most of the recorded species showed contagious distribution. Only one species i.e., *Thymus linearis* (0.01) showed random distribution **(Table 12).**

**Table 10Phytosociological attributes ofHerbs at Zone-I**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Site | Species | Family | Relative frequency | Relative density | Relative dominance | R/F | IVI |
| I | *Ageratum conyzoides* L. | Asteraceaeae | 23.26 | 30.63 | 28.31 | 1.22 | 82.2 |
|  | *Galinsoga parviflora* Cav. | Solanaceae | 27.91 | 25.74 | 24.14 | 0.86 | 77.79 |
|  | *Urtica dioica* L. | Urticaceae | 23.26 | 23.57 | 30.06 | 1.29 | 76.89 |
|  | *Asparagus filicinus* Buch.-Ham. ex D.Don | Asparagaceae | 13.96 | 9.89 | 10.11 | 0.72 | 33.96 |
|  | *Cannabis sativa* L. | Cannabaceae | 11.63 | 10.17 | 7.38 | 0.63 | 29.18 |
| II | *Centella asiatica*  (L.) Urb. | Apiaceae | 39.02 | 36 | 34.24 | 0.88 | 109.26 |
|  | *Bidens pilosa* L. | Asteraceae | 24.4 | 28.78 | 24.99 | 1.02 | 78.17 |
|  | *Galinsoga parviflora* Cav. | Solanaceae | 22.81 | 23.67 | 16.81 | 0.74 | 63.29 |
|  | *Girardiana diversifolia* (Link) Friis | Urticaceae | 21.95 | 19.43 | 21.38 | 0.97 | 62.76 |
|  | *Galinsoga parviflora* Cav. | Solanaceae | 14.63 | 15.79 | 19.39 | 1.33 | 49.81 |
| III | *Datura stramonium* L. | Solanaceae | 28.07 | 27.44 | 32.75 | 1.17 | 88.26 |
|  | *Anaphalis busua* (Buch.-Ham.) DC. | Asteraceae | 22.81 | 24.45 | 25.14 | 1.1 | 72.4 |
|  | *Galinsoga parviflora* Cav. | Solanaceae | 22.81 | 23.67 | 16.81 | 0.74 | 63.29 |
|  | *Chrysopogon fulvus* (Spreng.) Chiov. | Poaceae | 14.04 | 11.23 | 15.37 | 1.09 | 40.64 |
|  | *Mentha longifolia* (L.)Huds. | Lamiaceae | 8.77 | 6.42 | 8.09 | 0.92 | 23.28 |
|  | *Bidens pilosa* L. | Asteraceae | 3.5 | 6.79 | 1.84 | 0.53 | 12.13 |
| IV | *Hypericum purforatum*L. | Hypericaceae | 35 | 41.05 | 41.02 | 1.17 | 117.07 |
|  | *Trifolium repens* L. | Fabaceae | 37.5 | 34.24 | 40.38 | 1.08 | 112.12 |
|  | *Solanum nigrum* L. | Solanaceae | 22.5 | 20.76 | 17.29 | 0.77 | 60.55 |
|  | *Atropa acuminata* Royle ex Lindl. | Solanaceae | 5 | 3.95 | 1.31 | 0.26 | 10.26 |
| V | *Solanum nigrum* L. | Solanaceae | 31.7 | 32.62 | 37.11 | 1.17 | 101.43 |
|  | *Ageratum conyzoides* L. | Asteraceae | 31.7 | 33.3 | 31.58 | 0.1 | 96.58 |
|  | *Asparagus filicinus* Buch.-Ham. ex D.Don | Asparagaceae | 26.83 | 26.86 | 24.56 | 0.92 | 78.25 |
|  | *Trifolium repens* L. | Fabaceae | 9.76 | 7.22 | 6.75 | 0.69 | 23.73 |
| VI | *Asparagus filicinus* Buch.-Ham. ex D.Don | Asparagaceae | 28.89 | 37.07 | 37.72 | 1.31 | 103.68 |
|  | *Ageratum conyzoides* L. | Asteraceae | 26.67 | 21.94 | 20.04 | 0.75 | 68.65 |
|  | *Argemone maxicana* L. | Papaveraceae | 17.77 | 17.86 | 15.55 | 0.88 | 51.18 |
|  | *Urtica dioica* L. | Urticaceae | 17.78 | 13.1 | 17.59 | 0.99 | 48.47 |
|  | *Galinsoga parviflora* Cav. | Solanaceae | 8.89 | 10.03 | 9.1 | 1.02 | 28.02 |
| VII | *Ageratum conyzoides* L. | Asteraceae | 31.58 | 34.34 | 35.62 | 1.13 | 101.54 |
|  | *Asparagus filicinus*Buch.-Ham. ex D.Don | Asparagaceae | 31.58 | 31.48 | 37.63 | 1.19 | 100.69 |
|  | *Urtica dioica* L. | Urticaceae | 21.05 | 17.68 | 18.03 | 0.86 | 56.76 |
|  | *Saccharum spontaneum* L. | Poaceae | 10.53 | 10.1 | 8.2 | 0.78 | 28.83 |
|  | *Argemone maxicana* L. | Papaveraceae | 5.26 | 6.4 | 0.52 | 0.1 | 12.18 |
| VIII | *Nicotiana tabacum* L. | Solanaceae | 24.79 | 27.23 | 33.82 | 1.36 | 85.84 |
|  | *Acorus calamus* L. | Acoraceae | 26.85 | 28.59 | 26.64 | 0.99 | 82.08 |
|  | *Datura stramonium* L. | Solanaceae | 18.6 | 17.51 | 18.75 | 1.01 | 54.86 |
|  | *Centella asiatica* (L.) Urb. | Apiaceae | 14.88 | 13.02 | 14.55 | 0.98 | 42.45 |
|  | *Plantago major* L. | Plantaginaceae | 14.88 | 13.64 | 6.24 | 0.42 | 34.76 |
| IX | *Cannabis sativa* L. | Cannabaceae | 43.24 | 42.34 | 47.65 | 1.1 | 133.23 |
|  | *Bidens pilosa* L | Asteraceae | 32.43 | 35.34 | 33.8 | 1.04 | 101.57 |
|  | *Solanum nigrum* L. | Solanaceae | 24.32 | 22.32 | 18.55 | 0.76 | 65.21 |
| X | *Circium wallichii* DC. | Asteraceae | 30.95 | 32.59 | 27.03 | 0.873 | 90.57 |
|  | *Trifolium repens* L. | Fabaceae | 23.81 | 22.95 | 21.58 | 0.91 | 68.34 |
|  | *Bidens pilosa* L | Asteraceae | 21.43 | 19.64 | 17.58 | 0.82 | 58.65 |
|  | *Galinsoga parviflora* Cav. | Solanaceae | 11.9 | 11.09 | 20.9 | 1.76 | 43.89 |
|  | *Ajuga bracteosa* Wall. ex Benth. | Lamiaceae | 11.9 | 13.73 | 12.91 | 1.08 | 38.54 |

**Table 11**Phytosociological attributes of Herbs at Zone-II

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Site | Species | Family | Relative frequency | Relative density | Relative dominance | A/F | IVI |
| I | *Chrysopogon fulvus* (Spreng.) Chiov. | Poaceae | 48.39 | 58.95 | 57.88 | 1.2 | 165.22 |
|  | *Galinsoga parviflora* Cav. | Solanaceae | 29.03 | 30 | 31.7 | 1.09 | 90.73 |
|  | *Circium wallichii* DC. | Asteraceae | 22.58 | 11.05 | 10.42 | 0.46 | 44.05 |
| II | *Boenninghausenia albiflora* (Hook.) Meisn. | Rutaceae | 55.55 | 68.87 | 75.29 | 1.36 | 199.71 |
|  | *Chenopodium album* L. | Amaranthaceae | 37.04 | 26.33 | 23.28 | 0.63 | 86.65 |
|  | *Potentilla indica* (Andrews) Th.Wolf | Rosaceae | 7.41 | 4.8 | 1.43 | 0.193 | 13.64 |
| III | *Anaphalis busua* (Buch.-Ham.) DC. | Asteraceae | 38.1 | 42.98 | 50.15 | 1.32 | 131.23 |
|  | *Potentilla indica* (Andrews) Th.Wolf | Rosaceae | 21.43 | 22.57 | 24.67 | 1.15 | 68.67 |
|  | *Datura stramonium* L. | Solanaceae | 26.19 | 23.92 | 18.22 | 0.7 | 68.33 |
|  | *Urtica dioica* L. | Urticaceae | 14.29 | 10.53 | 6.96 | 0.49 | 31.78 |
| IV | *Ajuga bracteosa* Wall. ex Benth. | Lamiaceae | 17.65 | 11.32 | 92.5 | 5.24 | 121.47 |
|  | *Potentilla indica* (Andrews) Th.Wolf | Rosaceae | 27.45 | 28.96 | 2.02 | 0.07 | 58.43 |
|  | *Trifolium pretense* L. | Fabaceae | 25.49 | 28.54 | 3.29 | 0.13 | 57.32 |
|  | *Circium wallichii* DC. | Asteraceae | 17.65 | 17.84 | 0.84 | 0.05 | 36.33 |
|  | *Galinsoga parviflora* Cav. | Solanaceae | 11.76 | 13.34 | 1.35 | 0.11 | 26.45 |
| V | *Rumex hastatus* D.Don | Polygonaceae | 37.5 | 39.3 | 43.56 | 1.16 | 120.36 |
|  | *Chenopodium album* L. | Amaranthaceae | 37.5 | 35.58 | 30.55 | 0.81 | 103.63 |
|  | *Potentilla indica* (Andrews) Th.Wolf | Rosaceae | 25 | 25.12 | 25.89 | 1.04 | 76.01 |
| VI | *Ajuga bracteosa* Wall. ex Benth. | Lamiaceae | 45.16 | 50.39 | 46.32 | 1.03 | 166.71 |
|  | *Circium wallichii* DC. | Asteraceae | 45.16 | 50.39 | 46.32 | 1.03 | 166.71 |
|  | *Thalictrum foliolosum* DC. | Ranunculaceae | 29.03 | 29.34 | 31.79 | 1.1 | 106.13 |
|  | *Persicaria capitata* (Buch.-Ham. ex D.Don) H.Gross | Polygonaceae | 25.81 | 20.27 | 21.89 | 0.85 | 82.16 |
| VII | *Urtica dioica* L. | Urticaceae | 23.68 | 29.58 | 36.88 | 1.56 | 90.14 |
|  | *Ageratum conyzoides* L. | Asteraceae | 28.95 | 30 | 22.05 | 0.76 | 81 |
|  | *Rumex hastatus* D.Don | Polygonaceae | 18.42 | 25.17 | 28.41 | 1.54 | 72 |
|  | *Anaphalis busua* (Buch.-Ham.) DC. | Asteraceae | 28.95 | 15.25 | 12.66 | 0.44 | 56.86 |
| VIII | *Rheum australe* D.Don | Polygonaceae | 28.95 | 32.55 | 37.28 | 1.29 | 98.78 |
|  | *Rumex hastatus* D.Don | Polygonaceae | 28.95 | 28.27 | 18.59 | 0.64 | 75.81 |
|  | *Chrysopogon fulvus* (Spreng.) Chiov. | Poaceae | 23.68 | 20.8 | 30.28 | 1.28 | 74.76 |
|  | *Ageratum conyzoides* L. | Asteraceae | 18.42 | 18.38 | 13.85 | 0.75 | 50.65 |
| IX | *Circium wallichii* DC. | Asteraceae | 39.39 | 44.35 | 44.94 | 1.14 | 128.68 |
|  | Urtica dioica L. | Urticaceae | 30.3 | 30.73 | 33.63 | 1.11 | 94.66 |
|  | *Anaphalis busua* (Buch.-Ham.) DC. | Asteraceae | 30.3 | 24.92 | 21.42 | 0.71 | 76.64 |
| X | *Circium wallichii* DC. | Asteraceae | 40.54 | 45.07 | 61.75 | 1.52 | 147.36 |
|  | *Anaphalis busua* (Buch.-Ham.) DC. | Asteraceae | 35.14 | 31.79 | 24.02 | 0.68 | 90.95 |
|  | *Salvia moorcroftiana* Wall. ex Benth. | Lamiaceae | 24.32 | 23.14 | 14.23 | 0.59 | 61.69 |

**Table 12**Phytosociological attributes of Herbs at Zone-III

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Site | Species | Family | Relative frequency | Relative density | Relative dominance | A/F | IVI |
| I | *Galium aparine* L. | Rubiaceae | 68.42 | 75.67 | 89.19 | 1.3 | 229.86 |
|  | *Artemisia roxburghiana* Besser | Asteraceae | 31.58 | 24.33 | 10.81 | 0.34 | 65.14 |
| II | *Achyranthes aspera* L. | Amaranthaceae | 73.68 | 73.2 | 81.18 | 1.1 | 228.06 |
|  | *Galium aparine* L. | Rubiaceae | 26.32 | 26.8 | 18.82 | 0.72 | 71.94 |
| III | *Thymus linearis* Benth. | Lamiaceae | 56.25 | 62.21 | 64.74 | 1.15 | 183.2 |
|  | *Bergenia ciliata*  (Haw.) Sternb. | Saxifragaceae | 43.75 | 37.79 | 35.26 | 0.81 | 116.8 |
| IV | *Galium aparine* L. | Rubiaceae | 61.9 | 59.89 | 61.46 | 0.99 | 183.25 |
|  | *Thymus linearis* Benth. | Lamiaceae | 38.1 | 40.11 | 38.54 | 1.01 | 116.75 |
| V | *Galium aparine* L. | Rubiaceae | 54.17 | 65.01 | 83.53 | 1.54 | 202.71 |
|  | *Achyranthes aspera* L. | Amaranthaceae | 25 | 22.86 | 9.39 | 0.38 | 57.25 |
|  | *Geranium wallichianum* D.Don | Geraniaceae | 20.83 | 12.13 | 7.05 | 0.34 | 40.01 |
| VI | *Achyranthes aspera* L. | Amaranthaceae | 42.11 | 36.52 | 99.42 | 2.36 | 178.05 |
|  | *Galium aparine* L. | Rubiaceae | 57.89 | 63.48 | 0.58 | 0.01 | 121.95 |
| VII | *Galium aparine* L. | Rubiaceae | 47.62 | 50.78 | 39.57 | 0.83 | 137.97 |
|  | *Podophyllum hexandrum* Royle | Berbeiadaceae | 33.33 | 32.71 | 30.8 | 0.92 | 96.84 |
|  | *Potentilla astrosanguinea* G.Lodd. ex D.Don | Rosaceae | 19.05 | 16.51 | 29.63 | 1.56 | 65.19 |
| VIII | *Thymus linearis* Benth. | Lamiaceae | 77.78 | 77.97 | 75.41 | 0.97 | 231.16 |
|  | *Potentilla astrosanguinea*G.Lodd.ex D.Don | Rosaceae | 22.22 | 22.03 | 24.59 | 1.11 | 68.84 |
| IX | *Rheum australe* D.Don | Polygonaceae | 40.74 | 45.01 | 45.31 | 1.11 | 131.06 |
|  | *Geranium wallichianum* D.Don | Geraniaceae | 29.63 | 29.75 | 27.26 | 0.92 | 86.64 |
|  | *Girardinia diversifolia* (Link) Friis | Urticaceae | 29.63 | 25.24 | 27.43 | 0.93 | 82.3 |
| X | *Girardinia diversifolia* (Link) Friis | Urticaceae | 70 | 79.99 | 2.71 | 0.04 | 152.7 |
|  | *Potentilla astrosanguinea*G.Lodd. ex D.Don | Rosaceae | 30 | 20.01 | 97.29 | 3.24 | 147.3 |

**Table 13** Diversity indices of herbspecies distribution

|  |  |  |  |
| --- | --- | --- | --- |
| Study Site | Shanon’s index (H) | Simpson index (CD) | Species richness (R)Margalef index |
| Zone-I | | | |
| I | 1.52 | 0.23 | 4.69 |
| II | 1.35 | 0.27 | 3.69 |
| III | 1.65 | 0.21 | 5.71 |
| IV | 1.19 | 0.33 | 3.70 |
| V | 1.29 | 0.29 | 3.69 |
| VI | 1.52 | 0.24 | 5.69 |
| VII | 1.29 | 0.30 | 4.69 |
| VIII | 1.54 | 0.23 | 4.70 |
| IX | 1.06 | 0.36 | 2.69 |
| X | 1.56 | 0.22 | 4.70 |
| Zone-II | | | |
| I | 0.99 | 0.99 | 2.68 |
| II | 0.76 | 0.53 | 2.67 |
| III | 1.27 | 0.31 | 3.69 |
| IV | 1.47 | 026 | 4.70 |
| V | 1.08 | 0.34 | 2.68 |
| VI | 1.06 | 0.36 | 2.68 |
| VII | 1.37 | 0.26 | 3.69 |
| VIII | 1.37 | 0.26 | 3.69 |
| IX | 1.08 | 0.35 | 2.69 |
| X- | 1.04 | 0.3 | 2.68 |
| Zone-III | | | |
| I | 0.53 | 0.65 | 1.67 |
| II | 0.55 | 0.64 | 1.66 |
| III | 0.67 | 0.52 | 1.66 |
| IV | 0.67 | 0.52 | 1.67 |
| V | 0.85 | 0.51 | 2.67 |
| VI | 0.68 | 0.52 | 1.66 |
| VII | 1.05 | 0.36 | 2.66 |
| VIII | 0.52 | 0.67 | 1.67 |
| IX | 1.07 | 0.35 | 2.67 |
| X | 0.69 | 0.50 | 1.65 |

**Figure 5 Dominant families with the number of herb species found in Anni block of Outer Seraj area**

****

**T**

**S**

**V**

**U**

W

X

**Plate 3 Q.***Trifolium pratense*, **R**. *Persicaria capitata,* **S.***Salvia moorcroftiana****,*T.***Cotoneaster microphyllus,***U.***Thymus linearis***, V.***Geranium wallichianum***, W.** *Potentilla indica,***X.***Podophyllum hexandrum*

**Diversity Indices**

Species richness in the tree layer was highest in Zone I at study site VIII (11.39**) (Table 5)**, for shrubs at study site II of Zone-II (7.68) **(Table 9)** andfor herbsat study site III of Zone-I(5.71) **(Table 13).**The concentration of dominance values ranged from 0.13-0.65 for trees **(Table 5)**, 0.17-0.54 for shrubs **(Table 9)**and 0.21-0.99 for herbs **(Table 13).**The Simpson's Diversity Index (H) showed a reverse relationship with CD across all layers, indicating contrasting patterns of diversity.

*Quercus leucotrichophora* was the dominating species in the 800-1600 m altitude range in the current study, whereas *Cedrus deodara* was the predominant species in the 1601-2400m elevation range.In the 2401-3200m range, *Quercus semecarpifolia* showed dominance. Among shrub,*Debregeasiasaeneb*showed maximum dominancein lower elevation range (800-1600m). *Rosa brunonii* was predominantly found in middle elevation range (1601-2400m). In higher elevation range (2401-3200m) *Myrsineafricana* showed maximum dominance. Among herb communities,*Cannabis sativa* in the 800-1600 m altitude range, *Boenninghauseniaalbiflora* at middle elevation range (1601-2400) and *Galium aparine* athigher elevation zone(2401-3200)have shown dominance over other recorded species.

Few studies have been conducted on the woody species' vegetation structure in the Himalayan region. A number of variables influence the distribution of woody species in a given area, including geography, edaphic conditions, and uncontrolled human activity (Sharma & Kant, 2014). Across three altitudinal zones, the current study found variations in species composition, diversity, and structure. Diversity indices showed that species richness and diversity were highest in the lower altitudinal zone (Zone I) for tree vegetation. The Simpson's Diversity Index (H) revealed a reverse relationship with CD across all layers, other studies found similar findings (Bhat et al., 2020; Meena et al., 2020; Mastan & Reddy, 2023; Sharma et al., 2017). According to diversity indicators, the medium altitude zone (Zone II) has the highest species diversity and richness values for shrub vegetation (Joshi, 2012).

The value of the Shannon diversity index ranged from 0.70 to 2.80 for trees**(Table 5)**, 0.66 to 1.90 for shrubs **(Table 9)**and 0.52-1.65 for herbs **(Table 13)**which is in line with previous studies (Sharma & Kant, 2014; Meena et al., 2020; Verma & Kapoor, 2014; Sharma et al., 2017). The concentration of dominance values for the study site was 0.13-0.65 for trees**(Table 5)**, 0.17-0.54 for shrubs**(Table 9)**and 0.21-0.99 for herbs**(Table 13)**which aligns with previous reports (Whittaker, 1965; Sharma & Kant, 2014; Meena et al., 2020; Verma & Kapoor, 2014; Sharma et al., 2017; Geelani et al., 2018; Sahu et al., 2012). The species richness in the studied forests spanned from 3.42-11.39 for trees**(Table 5)**, 1.63-7.68 for shrubs**(Table 9)**and 1.65-5.71 for herbs **(Table 13)**which aligns with the reported results reported for the Himalayan region (Pande, 2001; Kunwar & Sharma, 2004: Sharma et al., 2014: Shah et al.,2009).

The study found a dominating contagious distribution pattern among tree, shrub and herb species based on the ecological framework proposed by Odum (1971); similar findings have been reported in other studies conducted in the Himalayan region (Hill, 1973; Karshaw, 1973; Kumar & Bhatt, 2006; Kumari et al., 2023; Lata et al., 2024; Verma & Kapoor, 2014; Gupta et al., 2018; Meena et al., 2020).This study investigated on the complex interrelationships among altitude, species distribution, and ecological processes in the locations under study, offering important new information for management and conservation plans.

**4. CONCLUSION**

The phytosociological analysis of plant species has yielded important information about the distribution, variety, and composition of species along the altitudinal gradient. The findings revealed that the community of tree species is dominated by a few key species: *Quercus leucotrichophora, Grewia optiva*& *Dalbergia sissoo* in zone I, *Cedrus deodara, Abies pindrow*and *Picea smithiana*in Zone II, *Quercus semecarpifolia, Cedrus deodara* and *Abies pindrow*in zone III.Among shrub communities,*Debregeasiasaeneb, Prinsepia utilis*and*Rosa brunonii*in zone I, *Rosa brunonii, Prinsepia utilis* and*Desmodium elegans* in Zone II, *Myrsineafricana, Berberis aristata* and*Desmodium elegans*in zone III have shown dominance over other recorded species.Among herb communities,*Cannabis sativa, Hypericum perforatum* and *Centella asiatica* at Zone-I; *Boenninghauseniaalbiflora*, *Circium wallichii*and *Ajuga bracteosa*at Zone II; *Galium aparine, Achyranthes aspera* and*Chrysopogon fulvus* at Zone-III have shown dominance over other recorded species. By contributing to the overall biodiversity, structure, and function of the forest or woodland area, these species are ecologically significant due to their density and frequency.Overall, the current study offers a thorough understanding of plant communities that might direct future research in related habitats, conservation strategies and forest management.

**DISCLAIMER (ARTIFICIAL INTELLIGENCE)**

The authors declare that neither the writing nor the editing of this work involved the use of generative AI tools such as text-to-image generators or large language models (ChatGPT, COPILOT, etc.).

**REFERENCES**

Bhat, J. A., Kumar, M., Negi, A. K., Todaria, N. P., Malik, Z. A., Pala, N. A., Kumar, A., & Shukla, G. (2020). Species diversity of woody vegetation along altitudinal gradient of the Western Himalayas. *Global Ecology and Conservation*, *24*, e01302.

Braun-Blanquet, J. (1932) Plant sociology the study of plant communities. Mc Graw-Hill Book Co., Inc., New York, and London **1**:1- 439.

Concenço, G., de Farias, P. M., Quintero, N. F. A., Schreiber, F., Galon, L., Tomazi, M., Moisinho, I. S., Coradini, M. C., Ceolin, W. C., & Andres, A. (2017). Phytosociological surveys in weed science: Old concept, new approach. In *Plant ecology—Traditional approaches to recent trends* (pp. 121-146). IntechOpen.

Curtis, J. T., & Cottam, G. (1953). *Plant Ecology Work Book: Laboratory Field Reference Manual*. Burgess Publishing Co., Minnesota.

Curtis, J. T., & Mcintosh, R. P. (1950).The interrelations of certain analytic and synthetic phytosociological characters. *Ecology*,  (3), 434-455.

Dengler, J., Chytrý, M., & Ewald, J. (2008). Phytosociology. In *Encyclopedia of Ecology* (pp. 2767-2779). Academic Press. ISBN 9780080454054.

Dhar, U., Rawal, R.S. & Samant, S.S., 1997. Structural diversity and representativeness of forest vegetation in a protected area of Kumaun Himalaya, India: implications for conservation. *Biodiversity & Conservation*, (8), pp. 1045-1062.

Geelani, S. N., Bhat, G. N., Mughal, A., Husain, M., Qaiser, Q. N., & Khan, P. A. (2018). Phytosociological status of trees and shrubs of Romshi range of Shopian forest division in Kashmir valley. *Journal of Pharmacognosy and Phytochemistry*, *7*(3), 696-702.

Gupta, M. K., Suyal, S., & Meena. (2018). Effect of altitudinal gradient on common tree species in Dhanaulti of Garhwal Himalaya. *18*(2), 1979-1986.

Hart, S. A., & Chen, H. Y. (2008). Fire, logging, and overstory affect understory abundance, diversity, and composition in boreal forest. *Ecological Monographs*, *78*(1), 123-140.

Hill, M. O. (1973). Diversity and its evenness, a unifying notation and its consequences. *Ecology*, *54*, 427-432.

Ilorkar, V.M. & Khatri, P.K. (2003) Phytosociological study of Navegoan National Park. (Maharashtra). *Indian Forester* **129**: 377-387.

Joshi, H. C., & Samant, S. S. (2004). Assessment of forest vegetation and conservation priorities of communities in part of Nanda Devi Biosphere Reserve, West Himalaya. Part I. *The International Journal of Sustainable Development & World Ecology*, *11*(3), 326-336.

Kershaw, K.A. (1973) Quantitative and Dynamic Plant Ecology. London: Edward Arnold Limited 308.

Kumar, M., & Bhatt, V. P. (2006). Plant biodiversity and conservation of forests in foothills of Garhwal Himalaya. *Journal of Ecological Applications*, *11*(2), 43-59.

Kumari, K., Verma, R. K., Kumar, R., & Thakur, A. (2023). Study on arboreal floristic diversity, phytosociology and conservation strategy of endangered species in Chandi Beat of Majathal Wildlife Sanctuary, Himachal Pradesh, Western Himalaya. *International Journal of Environment and Climate Change*, *13*(10), 3263-3280.

Kunwar, R.M. & Sharma Shiv, P. (2004) Quantitative analysis of tree species in two community forests of Dolpa district, mid-west Nepal. *Himalayan Journal of Sciences* **2**(3): 23–28.

Lata, S., Paul, S., & Chauhan, V. (2024). Phytosociological analysis of functional components in silvipastoral land use systems of Himachal Pradesh, India. *International Journal of Environment and Climate Change*, *14*(2), 675-685.

Margalef, R. (1958). Temporal succession and spatial heterogeneity in phyto-plankton. In A. A. Buzzati-Traverso (Ed.), *Perspective in Marine Biology*. University of California Press, Berkeley.

Mastan, T., & Reddy, M. S. (2023). Tree species diversity and population structure in tropical dry deciduous forest of Sri Lankamalleswara Wildlife Sanctuary, Southern Eastern Ghats, India. *International Journal of Ecology and Environmental Sciences*, *49*(5), 489-499.

Meena, Gupta, M. K., & Suyal, S. (2020). Species richness and diversity of tree species along an altitudinal gradient in Dhanaulti region of Garhwal Himalaya, India. *20*(2), 8576-8584.

Misra, R. (1968) Ecology Work Book. Oxford and IBH Publication New Delhi.

Moreno-Fernández, D., Cañellas, I., & Alberdi, I. (2021). Shrub richness is primarily driven by climate conditions in Southwestern European woodlands. *Annals of Forest Science*, *78*, 1-20.

Mueller-Dombois, D. & Ellenberg, E. (1974) Aims and methods of vegetation ecology. 1st Edn, John Wiley and Sons, New York, 570.

Odum, E.P. (1971).Fundamentals of ecology, 3rd eds. Philadelphia: *Saunders*. 574.Pande, P.K. (2001) Quantitative vegetation analysis as per aspect and altitude, and regeneration behaviour of tree species in Garhwal Himalayan Forest. *Annals of Forestry* **9**(1): 39–52.

Rana, C. S., & Gairola, S. (2009). Forest community structure and composition along an elevational gradient of Parshuram Kund Area in Lohit District of Arunachal Pradesh, India. *Nature and Science*, *8*, 44-52.

Sahu, S. C., Dhal, N. K., & Mohanty, R. C. (2012). Tree species diversity, distribution and population structure in tropical dry deciduous forest of Malygiri hill ranges, Eastern India. *Tropical Ecology*, *53*(2), 163-168.

Samant, S. S. 2002. Diversity, distribution and conservation of orchids of Trans, Northwest and West Himalaya. *Journal of Orchid Society of India* 16(1-2): 65-74.

Samant, S.S.&Joshi, H.C. 2005. Plant diversity and conservation status of Nanda Devi National Park and comparisons with highland National Parks of Indian Himalayan Region*. International Journal of Biodiversity Science and Management,* 1(1): 65-73.

Shah, S., Tewari A. & Tewari, B. (2009) Impact of Human disturbance on forest vegetation and water resources of Nainital catchment. *Natural Sciences* **7**(10): 74-78.

Shannon, C. E., & Wiener, W. (1963). *The Mathematical Theory of Communication*. University of Illinois Press, Urbana, USA.

Sharma, C. M., Mishra, A. K., Tiwari, O. P., Krishan, R., & Rana, Y. S. (2017). Effect of altitudinal gradients on forest structure and composition on ridge tops in Garhwal Himalaya. *Energy Ecology Environment*, *2*, 404-417.

Sharma, C.M., Mishra, A.K., Prakash, O., Dimri, S. &Baluni, P. (2014). Assessment of forest structure and woody plant regeneration on ridge tops at upper Bhagirathi basin in Garhwal Himalaya. *Tropical Plant Research* **1**(3): 62-71.

Sharma, N., & Kant, S. (2014). Vegetation structure, floristic composition and species diversity of woody plant communities in sub-tropical Kandi Siwaliks of Jammu, J & K, India. *International Journal of Basic and Applied Sciences*, *3*(4), 382.

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

Singh, J.S. &Singh, S.P. 1992. Forest of Himalaya: Structure, Functioning and Impact of Man. GyanodyaPrakashan, Nainital.

Verma, R. K., & Kapoor, K. S. (2014). Status of plant diversity in Alpine area of Rakchham-Chitkul wildlife sanctuary of District Kinnaur, Himachal Pradesh. *Biological Forum*, *6*(1), 5-12.

Whittaker, R.H. (1965) Dominance and Diversity in Land Plant Communities: Numerical relations of species express the importance of competition in community function and evolution. *Science* **147**(3655): 250-260.