Forest communities and factors responsible for vegetation pattern in the legally protected areas of the Kashmir Himalaya, India

Sheikh Marifatul Haq
University of Kashmir

Umer Yaqoob
University of Kashmir

Hilal Qazi (qaziha@gmail.com)
Post Graduate Government College

Research

Keywords: Protected areas; Forest communities; Vegetation biology; Phytosociological; Multivariate analysis; Kashmir Himalaya

DOI: https://doi.org/10.21203/rs.3.rs-27538/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License. Read Full License
Abstract

Background

The protected areas (PAs) of any region are contributing people’s livelihoods and are proving to be the backbone of all forms of biodiversity conservation. The reforms in protection rules at global level and legal protection at local level has contributed a lot to the conservation of forests and other associated biodiversity. However, due to various anthropogenic activities and other climatic changes, protected areas and other species rich sites are being exposed to a continuous threat. Realizing the future perspective of potential and economic value of these protected forests, the phytosociological investigations were carried out in protected forests of Jammu and Kashmir in Kashmir Himalaya.

Results

Floristically, a total of 84 species belonging to 71 genera in 39 families were recorded. The floristic analysis revealed that the dominant plant families in the study area comprises of Rosaceae with (14%) species, followed by Asteraceae (8%) species and Poaceae (7%) species. Species richness of the vascular plants varied from 38–55, and Shannon-Wiener diversity index value of scrub forest type was statistically lower than that of the coniferous forest and other forest types. The average tree density of 890 individual's ha$^{-1}$ was recorded throughout the study area.

Conclusions

The diversity of various plant species differed across the dimensions. The phytosociological parameters are being affected by discrete levels within soil parameters. Plant community composition displayed a significant change within forest types even when species richness didn’t alter. Furthermore, the prototype of conservation biology has got shifted towards updated patter of biodiversity safeguarding by highlighting various multi-scale approaches. There are some critical abiotic factors, which prove very much helpful in understanding the mechanisms operating at a specific level to create variation in species diversity as well as in community composition.

Introduction

Over the recent past, the science of conservation biology has developed a lot, its stress has changed drastically from the conservation and management of particular species within habitats to its emphasis on management of total species living within Protected areas (PAs), (Gaston et al. 2001; Summerville et al. 2003). Moreover, PAs encompass valuable landscapes and are key indicators of the accelerated climate changes and may interact with other human-induced changes (i.e., changes in land use patterns and climate) and degradation (Hannah et al. 2007; Gaston et al. 2008). Although, the conservation measures inside PAs are enjoying the special level of protection in various parts of the world, despite
diversity of living organisms continues to decline (Butchart et al. 2010). However, there is not any proper system of classification in which the PAs are placed for the planning of utilisation of land resources at the local level. As a consequence of lack of land use planning, there is escalating level of heterogeneity in habitats, decreasing the quantity of large areas, resulting in diminishing the dimensions of the accessible habitation for core zone of plant types, which normally require well-built neighbouring areas of a reasonably untouched habitat (Debinski and Holt 2000). In addition, there is inadequate information related to important factors that would be associated with any stable program for conservation of biodiversity in the protected forests of Himalaya region, particularly Kashmir Himalaya.

However, it is imperative to understand the situations through which the protected areas provide conservation benefits is vital for conservation advocates and policy makers (Margules and Pressey 2000). One of the important factors for effective forest resource management in the protected areas is the appropriate assessment of biodiversity for resource management actions that have an impact on the forest wealth (Foxcroft et al. 2013). In Himalayan protected forests ecosystem, the complex of differences in community structure, diversity, richness, and distribution are owed topographic heterogeneity (e.g. elevation, slope, soil composition) (Sharma et al. 2010; Khan et al. 2017; Saima et al. 2018) forest productivity, biotic-forest interaction and evolutionary competition between different species (Criddle et al. 2003). Combination of all these variables determines the ecological conditions unique for each community attributes such as architecture, species richness and the spatial association patterns and hence can assist in vegetation evaluation and quantification (Khan et al. 2017). The identification of these key variables is of extreme significance in efficient diversity conservation in case of forests (Ehrlich 1996). The use of multivariate analysis and statistical techniques for investigating vegetation-environment relationships enabled ecologists to get results for a large dataset in more efficient way with expense of less time and labour (Massberg et al. 2002; Hair et al. 2006). However, these methods are very less in practice for forest community classification in particularly protected area of Kashmir Himalayan region.

Kashmir Himalayan part of the Indian Himalayan arc supports a huge floristic diversity (Sharma et al. 2010) however, this area is neglected for multivariate phytosociological investigations by ecologists and foresters. Although the accumulated scientific knowledge on the protected forest is growing fast, yet there are substantial knowledge gaps across the world, especially in the global south. The important protected areas of the North-western part of the Himalayan, such as the Kashmir Himalaya have received little research attention. Thus, the broad-scale classification is important for understanding regional patterns of plant associations and habitat types for management, planning and the use of forest based natural resources (Rahman et al. 2017; Haq et al. 2017). Based on these stimuli, we selected protected areas in the Dachigam National Park of Kashmir Himalaya. This investigation will highlight the essential protocols for understanding the present scenario and guide lines for potential conservation efforts required for these protected forest ecosystems.

**Materials And Methods**
Study area

The Dachigam National Park (DNP) which is falling underneath Zabarwan hill range in the North-western Himalayan region of India (Fig. 1), which being a part of J&K state. DNP is geographically situated between the latitude of 34°05'–34°11'N and the longitude of 74°54'–75°09'E, and occupy a total area of 141 Sq. Km. Since 1910, this forest region is under protection of J&K government, and later declared as a National Park in 1981. Initially, it was protected to ensure clean drinking water supply for Srinagar city, the summer capital town of J&K. DNP is predominantly inhabited by peculiar subtropical deciduous trees with semi-evergreen to evergreen broad-leaved forests (Haq et al. 2019)

Sampling design and measurements

The forest working arrangement of the Dachigam National Park was consulted for validating administrative jurisdiction, topographical position and forest vegetation patterns. Several field reconnaissance surveys and botanical expedition tours were carried out during 2017–2018 to have an idea about the landscape pattern, species diversity, accessibility and distribution of various forest forms. Major forms of forests present in Dachigam National Park include Acacia forest (ACFT), Broad leaved forest (BLFT), Coniferous forest (PNFT), Oak forest (OKFT) and Scrub (Parrotiopsis jacquemontiana) (SRFT) forest type. Forest types were studied considering the authentic reference of Champion and Seth (1968). During field investigation, the relevant data pertaining to the plant specimens were recorded and the standard herbarium techniques were used as per Jain and Rao (1977) in this study. The vouchers were identified by comparing the housed herbarium samples at the Centre for Biodiversity and Taxonomy, University of Kashmir and consulting appropriate taxonomic literatures (Stewart 1972; eFloras). The specialized taxonomic database of The Plant List (www.theplantlist.org) was referred for the updated nomenclature of recorded species from Dachigam National Park.

The data collection related to floristic diversity of the study area was done by quadrant method of vegetation sampling (Shaheen et al. 2012). In each of the selected forest types, four sample plots were laid for trees sampling in all the four directions i.e. NE, NW, SW and SE each of 31.6 × 31.6 m (≈ 0.1 ha) size respectively. The density of live stem in each sample plot was recorded. Within each mentioned plot, the shrub density data was recorded from its 2 sub-plots of 5 × 5 m size. For recording herbaceous diversity, five plots of 1 × 1 m size (one in the center and four in corners) have been laid down. In total, sixty forest stand (12 × 5 = 60) plots were sampled in the present study. Twenty-four (5 × 5 m²) quadrants for shrubs and sixty (1 × 1 m²) quadrants for herbs were randomly laid for understory diversity at each forest type. In total, three hundred (60 × 5 = 300) quadrants (1 × 1 m²) for herbs and one hundred twenty (24 × 5 = 120) plots (5 × 5 m²) for shrubs were sampled in the present study. Within these four sample plots (0.1 ha), four soil samples in all four direction and two replicate soil samples were taken for analysis. The 2 mm mesh screen was used to sieve soil samples. The soil conductivity and pH were determined in 1:2 ratio by digital conductivity & pH meter, OC by wet digestion, ascorbic acid method and
kelpluskjeldahl nitrogen method were used to calculate available P and nitrogen respectively. Other physic-chemical parameters of soil are determined by Gupta et al. (2000) and Jackson (1973).

In order to minimize any sampling bias, as far as possible, it was ensured to accommodate the differences in vegetation growth caused by variation in slope and aspect. The clinometer was used to measure slope angle. The GPS devices were used to study physiographic factors, viz altitude and other aspects across different forest sites (Garmin, GPS map76cs).

**Data analysis**

The Importance Value Index (IVI) of plant species was used to determine the dominance plant species. The IVI of herb and shrub layers (Curtis and McIntosh 1951) and of tree species (Naidu and Kumar, 2016) were determined as the sum of relative density, relative abundance and relative frequency respectively.

**Vegetation diversity and composition**

The IVI along with environmental data of stands were used for multivariate analysis. For diversity analyses, the following indexes were used: Shannon–Wiener (1948), Simpson (1949), Margalef richness index, Evenness Index (Pielou 1969), and Dominance index.

**Impacts of environmental variables on vegetation composition**

The Canonical Correspondence Analysis (CCA) were utilized to examine vegetation samples and allocation of species with respect to their ecological factors by utilizing the CANOCO software version 4.5 (Ter Braak and Smilauer, 2002; Hejcmanova and Hejcman, 2006) after the utilization of PCORD version 5 (Khan et al. 2017). We also utilized the detrended correspondence analysis (DCA) to notice length the gradient length and the correlation among different vegetation types (Ter-Braak, 1986; Haq et al. 2017). CCA was additionally applied to draw and comprehend the relationship of each natural variable on quantitative traits of the plant species and relationship in the region. Presence/nonappearance information were investigated utilizing cluster and two-way cluster examinations by means of PCORD version 5 (Leps and Smilauer 2003).

**Results**

**Vegetation composition and distribution of plant species**

The vegetation composition of the study plot reported a sum of 84 species belonging to 39 families and 71 genera. The flora of the region based on the plant habits, can be classified into herbs 54 (64%), trees 18 (22%), shrubs 10 (12%) and climbers 2(2%) respectively. The floristic analysis relieved the perennial with 71 species (84%) was dominant life span category, followed by annual 10 (12%) and biennial 3 (4%).

**Species-family relationship**
The species grouping patterns across the families were unequal with 8 families contributes half of the species, while as 31 families represents remaining half and large numbers of families 23 are monotypic. The floristic analysis revealed the dominant plant families in the study area included Rosaceae with 12 (14%) species, followed by Asteraceae 7 (8%) species, Poaceae 6 (7%) species, Fabaceae 5 (6%) and Asparagaceae 4 (5%). Rest of the species was represented by Polygonaceae, Geraniaceae, Lamiaceae, Plantaginaceae, Acanthaceae, Apiaceae, Berberidaceae, Moraceae, Ranunculaceae etc. Families such as Adoxaceae, Amaranthaceae, Araliaceae, Aspleniaceae, Dioscoreaceae, Pinaceae, Juglandaceae, Orchidaceae, Ulmaceae and others were monotypic (Fig. 2).

Diversity and phytosociological attributes

The species richness recorded at the DNP ranged from 38 to 55 with maximum 55 at BLFT and minimum 38 at SRFT. Shannon–Wiener diversity index value of SRFT was statistically lower than that of the PNFT and other forest types; Simpson's diversity index, ranging from 0.923 at SRFT to 0.966 at BLFT. Dominance index ranging from 0.033 at BLFT to 0.076 at SRFT; Species evenness ranged between a minimum of 0.502 at PNFT to a maximum of 0.709 at BLFT. The highest values of Fisher's alpha value and Margalef value (16.63; 8.88) was observed in BLFT and lowest value (14.89; 7.17) in OKFT respectively (Table 2). An average tree density of 890 Nha$^{-1}$ was recorded overall. Minimum was 640 ± 140.95 Nha$^{-1}$ at OKFT and maximum of 1197.5 ± 199.56 N ha$^{-1}$ at SRFT. Forests stands showed an average basal area of 47.35 m$^2$ ha$^{-1}$. SRFT had the least, 15.4 m$^2$ ha$^{-1}$ but 74.49 m$^2$ ha$^{-1}$ was found at PNFT (Table 1).
Table 1
Diversity and phytosociological attributes of sampled forest stands

| Forest types | BLFT | OKFT | PNFT | ACFT | SRFT |
|--------------|------|------|------|------|------|
| Species richness | 55   | 44   | 46   | 51   | 38   |
| Dominance | 0.033 | 0.066 | 0.075 | 0.041 | 0.076 |
| Shannon | 3.664 | 3.26 | 3.14 | 3.524 | 3.092 |
| Simpson | 0.966 | 0.933 | 0.924 | 0.958 | 0.923 |
| Evenness | 0.709 | 0.592 | 0.502 | 0.664 | 0.579 |
| Margalef | 8.881 | 7.178 | 8.162 | 8.517 | 7.675 |
| Equitability | 0.914 | 0.861 | 0.820 | 0.896 | 0.850 |
| Fisher-alpha | 16.63 | 14.89 | 16.62 | 16.33 | 15.03 |
| Berger-Parker | 0.076 | 0.201 | 0.188 | 0.101 | 0.193 |
| Density | 1057.5 ± 367.28 | 640 ± 140.95 | 707.5 ± 148.18 | 850 ± 204.61 | 1197.5 ± 199.56 |
| Basal area | 58.63 ± 21.57 | 41.41 ± 3.81 | 74.49 ± 12.09 | 46.82 ± 14.73 | 15.40 ± 6.20 |

Cluster analyses

The 2 clusters were distinguished from the 5 different forest types through Cluster Analyses by pruning the dendrogram at 22% information remaining (Fig. 3). The dendrogram generated 2 distinctly separate clusters based on floristic similarity. The forest type’s viz. BLFT and ACFT forms one limb cluster. OKT, PNFT and SRFT second limb of cluster. The cluster forest types that grouped in one limb are more similar in species composition and close proximity to each other.

The Two-Way Cluster Analyses of 5 forest types transect (elevation classes) including 84 species result 2 major plant communities. In diagram the white boxes display absence whereas the black one shows presence of a plant species in the forest types (Fig. 4).

DCA ordination

Along with the supplementary variables, in DCA ordination, the maximum 6.84 gradient length was recorded for axis 1 with eigen value 0.81. The minimum gradient length for axis 4 was 2.07 with eigen value 0.04; total inertia (sum of all eigenvalues) was 4.61. The different species clustered in ordination space in DCA ordination (Table 2). The DCA ordination displayed that most of the species were positively correlated with both axes 1 and 2. These plant species include Dryopteris barbigera, Rubus ulmifolius, Prunus persica, Quercus robur, Trifolium repens, Asplenium feliae, Dioscorea deltoidea, Conyza...
canadensis, Fragaria nubicola, Geranium nepalense, Pteris cretica, Impatiens glandulifera and Viburnum grandiflorum etc.

In ordination space, the species which clustered on negative side of both axes displayed difference in habitat types include Aesculus indica, Berberis lyceum, Celtis australis, Cynodon dactylon, Delphinium roylei, Geranium wallichianum, Prunus tomentosa, Pinus wallichiana, Populus alba, Morus alba, Rosa webbiana and Ulmus wallichiana etc (Fig. 5).

Table 2
Summary of the four axes of the DCA for the vegetation data (using importance value index (IVI) data).

| Total inertia | 4.603 |
|---------------|-------|
| Statistics    |       |
| Axis (1)      | 0.81  |
| Axis (2)      | 0.42  |
| Axis (3)      | 0.28  |
| Axis (4)      | 0.04  |
| Explained variation |  |
| 17.6          | 26.8  |
| 32.9          | 33.9  |
| Gradient length |       |
| 6.84          | 3.04  |
| 2.44          | 2.07  |

In CCA ordination the highest eigenvalue recorded were (0.73) for axis 1 trailed by axis 2 (0.44) and axis 3 (0.38). The rate fluctuation clarified for hub 1, 2 and 3 were 17.92, 28.78 and 38.23, separately. The complete change (dormancy) in the species information were 4.10, illustrative factors represent 100%. Pseudo-authoritative relationships for all tomahawks were 0.98. The Monte Carlo test results for all tomahawks were eigenvalue 0.75; F-proportion 0.977, P-esteem 0.028 (Table 3). The CCA appointment shows that the species are consistently disseminated along various ecological factors.

Environmental gradient and vegetation

In CCA ordination, the maximum eigenvalues were recorded for axis 1 (0.73) followed by axis 2 and 3 viz (0.44) and (0.38) respectively. The proportion of variance observed for axis 1, 2 and 3 were 17.92, 28.78 and 38.23, respectively. The sum of variance (inertia) in data related to species were 4.10, illustrative factors represent 100%. Pseudo-canonical correlations for all axes were 0.98. The results from Monte Carlo test revealed that all axes were having eigenvalue0.75; F-ratio 0.977, P-value 0.028 (Table 3). The CCA ordination depicts that there is uniform distribution of species along various environmental variables. The species that occurred sensitive to pH include Acer caesium, Artemisia vulgaris, Berberis lyceum, Conyza Canadensis, Digitalis purpurea, Fragaria nubicola, Geum urbanum, Populus alba, Salix alba, Juglans regia, Hypericum perforatum and Ulmus wallichiana etc. The influenced species to Ca include Asyneum athomsonii, Celtis australis, Crataegussongarica, Desmodium elegans, Delphinium roylei, Pinus wallichiana, Oplismenus burmanni and Viburnum grandiflorum etc. The species that occurred sensitive to OC includes Asparagus filicinus, Quercus robur, Sorghum halepense, Salvia moorcroftiana and Prunella vulgaris etc. The other factors such as N, P, K and EC is having a great influence over species distribution; on the other hand, the plant species, which significantly correlated
with its value includes *Achyranthes aspera*, *Carpesium abrotanoides*, *Strobilanthes urticifolia*, 
*Polygonatum aconitifolium*, *Parrotiopsis jacquemontiana* and *Verbascum Thapsus* etc (Fig. 6).

### Table 3

| Total inertia | 4.10938 |
|---------------|---------|
| Statistics    |         |         |         |         |
| Eigen values  | Axis (1)| Axis (2)| Axis (3)| Axis (4)|
|               | 0.7363  | 0.4463  | 0.3886  | 0.3473  |
| Explained variation | 17.92  | 28.78  | 38.23  | 46.69  |
| Pseudo-canonical correlation | 0.9835 | 0.9523 | 0.9557 | 0.9642 |
| Explained fitted variation | 31.53  | 50.64  | 67.28  | 82.15  |

#### Discussion

All over the globe, the forest ecosystems generally have varied community assemblages because of its rapidly altering microclimate, edaphic factors, topography, landscape, and geomorphological attributes (Martijn and Herben 2003; Fosaa 2004; Khan et al. 2011; Khan et al. 2017). In this current observation, the floristic composition and distribution comprises 84 species, which belong to 39 families, this value was found to be within the range as reported by earlier researchers in the different forests of Himalayas (Shaheen et al. 2011). The number of species observed in the present study area was higher than the number found by several other workers. Nazir et al. (2012) recorded a total of 40 species in Kotli district of Azad Jammu and Kashmir in Pakistan. Similarly, Shahid and Joshi (2016) recorded total of 35 species in Shiwalik hills of lower Himalayas. Further the total species reported from the current study was lesser than the species reported by several other similar studies. In addition to this, Qureshi and Bhatti (2010) reported a presence of 93 species from Pai forest region of Nawab Shah, in Sindh Pakistan. Sharma and Kant (2014) reported total of 112 species in Jammu hills, India.

In case of floristic distribution patterns, the present findings could be compared with rest of the observations from mountain regions in the Himalayas, where floristic groups like Poaceae, Asteraceae, Rosaceae, Fabaceae, and Lamiaceae were the most dominant distributed families (Shaheen et al. 2012; Rahman et al. 2017). The inline results were observed by Rahman et al. (2018) in Manoor valley, Pakistan.
and Gairola et al. (2010) in Uttarakhand, Garhwal Himalaya, India. Similarly, Suyal et al. (2010) in Uttarakhand, Garhwal Himalaya, India observed Lamiaceae as the prevailing family and Khan et al. (2015) in Kabal (Swat), Pakistan. On the other hand, Singh et al. (2018) in Nandini Wildlife Sanctuary in Western Himalaya, reported Fabaceae as dominant family. The floristic analyses revealed the unequal distribution of species across families and with large numbers of families are monotypic. These values are in line with the earlier reported values from different region of Himalaya (Gairola et al. 2010; Rahman et al. 2018).

The parameters like tree density and basal area are key phytosociological characteristics that contribute to the structure of forests (Yam and Tripathi 2016). The average basal area reported in all forests stands was 47.35 m$^2$ha$^{-1}$; (ranged between 15.4 m$^2$ ha$^{-1}$and 74.49 m$^2$ ha$^{-1}$). These values are more or less comparable with the earlier reports from Garhwal Himalaya (19.83–56.46 m$^2$ha$^{-1}$), from temperate forests of Northern Kashmir Himalaya (33.36–78.98 m$^2$ha$^{-1}$), from moist tropical montane of the Garhwal Himalaya (32.77–86.56 m$^2$ha$^{-1}$) and from Mandal-chopta Garhwal Himalaya (32.77–86.56 m$^2$ha$^{-1}$) respectively (Baduni and Sharma 1996; Dar and Sahu 2018; Gairola et al. 2011; Gairola et al. 2012). A comparatively higher value (78–92 m$^2$ ha$^{-1}$) in moist temperate forests from Lesser Himalayan and (86–129 m$^2$ ha$^{-1}$) in Garhwal Himalayas were reported by Ahmed et al. (2006) and Pande (2001) respectively. Kunwar and Sharma (2004) reported a value of 90.1-151.9 m$^2$ha$^{-1}$ from Himalayan regions of Nepal. Likewise, Shah et al. (2009) reported a value of 89–97 m$^2$ha$^{-1}$ in Nainital, Central Himalayas, 42.2-105.2 m$^2$ha$^{-1}$ by Shaheen et al. (2012) from Pakistan, Himalayas, 9.38-137.45 m$^2$ha$^{-1}$ by Bharali et al. (2011) from West Siang, India. An average value of 69.31 m$^2$ha$^{-1}$ in the subtropical forests in lesser Himalayas by Shaheen et al. (2011), 26.5–91.13 m$^2$ha$^{-1}$ by Sharma et al. (2016) from five high mountains of Garhwal Himalaya, India, and 94.18 m$^2$ha$^{-1}$ by Mane et al. (2019) from Baratang Reserve Forest in India were reported respectively.

In the present study, stem density was lowest in OKFT (640 ± 140 ha$^{-1}$) and highest in SRFT (1197 ± 199 ha$^{-1}$), with average stem density of 890 ± 234 ha$^{-1}$. These values corroborate with earlier reports by Dar and Sundarapandian (2015) from Kashmir Himalaya (103 and 1201 Nha$^{-1}$), Sundriyal et al. (1994) from western Himalayas (1158 Nha$^{-1}$) and Saxena and Singh (1982) from Kumaun Himalaya (420 and 1300 Nha$^{-1}$). The presently calculated values are higher than those reported by Wani et al. (2015) from Kashmir Himalaya (110 and 530 Nha$^{-1}$), Banday et al. (2017) from subtropical forests of Northwestern Himalaya (483 – 417 Nha$^{-1}$), Shaheen et al. (2016) from Pakistan Himalaya (492 Nha$^{-1}$), Ahmed et al. (2006) from Pakistan Himalaya (534–620 Nha$^{-1}$), Kharakwal(2009) from Kumaun Himalayas (530–940 Nha$^{-1}$), Sharma et al. (2010) from Garhwal Himalaya (380–626 Nha$^{-1}$), Gairola et al. (2010) from Garhwal Himalaya (295–850 Nha$^{-1}$), 540 Nha$^{-1}$ by Saxena and Singh (1982) and 534–620 Nha$^{-1}$ by Ahmed et al. (2006) in lesser Himalayas, 440–550 Nha$^{-1}$by Sharma et al. (2009) in Garhwal Himalaya, 457 Nha$^{-1}$ in North Western Himalaya India by Singh and Samant (2010), 288–498 Nha$^{-1}$ subtropical Shiwaliks of Jammu, India by Sharma and Kant (2014), 235–505 Nha$^{-1}$ in Garhwal.
Himalaya by Malik and Bhatt (2015), 492 Nha⁻¹ in subtropical forest of Pakistan Himalaya by Shaheen et al. (2016), 578 Nha⁻¹ from Western Himalaya by Dar and Sahu (2018), 390–433 Nha⁻¹ from Saptasajya hill range, India, by Sahu et al. (2019) and higher than other region of western Himalayas 90–302 Nha⁻¹ by Shaheen et al. (2012). Similarly, the average 90.99 Nha⁻¹ was reported by Shaheen et al. (2016) in forest of Kashmir Himalaya and 149.99 Nha⁻¹ was reported by Akash and Bhandari (2019) from Garhwal Himalaya, India, respectively.

The rough terrain, uneven topography and remote area make it intricate to carry exhaustive vegetation sampling in the Kashmir Himalayan region. Maximum phytosociological studies performed so far in the Himalayan region have often used conventional protocols of community classifications, where the names of plant types were characterized on the basis of dominant species having high importance value index. In the present study, new statistical approaches have been adopted for ordination and classification of plant species. The DCA and CCA bi-plot diagram revealed that diversity, distribution and association of plant species were the expressions of the differences in the environmental and biotic interactions. Besides, any variation in soil parameters causes considerable impact in the development of plant communities (Khan et al. 2017). The effect of soil composition in species pattern was also found in other mountain forest ecosystems around the globe (Hegazy et al. 1998; Wang and Singh 2006; Davies et al. 2008; Khan et al. 2012). These studies carried out vary from the present study as they were carried out in the un-protected forest ecosystems. Further, it was found that the pH of the soil, which was slightly acidic, played an important role in the growth of particular plant species in this ecosystem. The determination of natural inclination methodology through CCA both for stations and species advocates that the first axes was basically connected with soil pH and Ca; the second axes were associated mostly with phosphorous, electrical conductivity and potassium contents. These findings are in agreement with Khan et al. (2017), where carrying out their studies in the Thandiani forests of the Western Himalayas, Pakistan. The CCA bi-plot also revealed that species were highly sensitive to organic carbon, electric conductivity and phosphorous. The current findings corroborate with Hussain et al. (2019) who also reported the positive correlation between edaphic factors, vegetation structure and its distribution patterns.

Conclusions

The composition and diversity of various plant species differed across spatial scales. On the other hand, phytosociological parameters gave off an impression of being differentially impacted by discrete levels within soil parameters. Plant community composition varied significantly within forest types even when total species richness does not reveal much alteration. Furthermore, the prototype of conservation biology has got shifted towards updated patter of biodiversity safeguarding by highlighting various multi-scale approaches. There are some critical abiotic factors, which prove very much helpful in understanding the mechanisms operating at a specific level to create variation in species diversity as well as in community composition. The upcoming and promising tools like diversity partitioning is making us competent in
identifying the factors at which species diversity is more or less than that depicted by a random distribution of species in space.

**Abbreviations**

PA= Protected Areas, DNP= Dachigam National Park, CCA= Canonical Correspondence Analysis, DCA= Detrended Correspondence Analysis, P = Phosphorus, K = Potassium, Ca = Calcium, EC = Electrical conductivity, OC= Organic, Sal= Salinity, N= Nitrogen

**Declarations**

**Acknowledgment**

The authors are thankful to the Department of Botany, University of Kashmir, Srinagar (Jammu and Kashmir) for providing the laboratory facilities to complete this research.

**Author's contributions**

SMH did the experimental work. UY and HAQ did manuscript writing and editing. All authors crosschecked and approved the final manuscript.

**Funding**

NA

**Availability of data and materials**

Data available on request from the authors

**Ethics approval and consent to participate**

The subject has no ethic risk.

**Consent for publication**

Not applicable.

**Competing interest**

The authors declare that they have no conflict of interest.

**References**

Ahmed M, Husain T, Sheikh AH, Hussain SS, Siddiqui MF (2006) Phytosociology and structure of Himalayan forests from different climatic zones of Pakistan. Pak J Bot 38(2): 361-383
Akash N, Bhandari BS (2019) A community analysis of woody species in a Tropical Forest of Rajaji Tiger Reserve. Environ Eco 37(1): 48-55

Baduni NP, Sharma CM (1996) Effect of aspect on the structure of some natural stands of *Quercus semecarpifolia* in Himalayan moist temperate forest. Ind J For 19(4): 335-341

Banday M, Bhardwaj DR, Pala NA (2017) Variation of stem density and vegetation carbon pool in subtropical forests of Northwestern Himalaya. J Sust Fors 37(4): 389-402 DOI: 10.1080/10549811.2017.1416641

Bharali S, Paul A, Khan ML, Singha LB (2011) Species diversity and community structure of a temperate mixed Rhododendron forest along an altitudinal gradient in West Siang district of Arunachal Pradesh, India Nat Sci 9(12): 125–140

Butchart SH,Walpole M, Collen B, Van Strien A, Scharlemann JP, Almond RE, Baillie JE, Bomhard B, Brown C, Bruno J, Carpenter KE (2010) Global biodiversity: indicators of recent declines. Sci 328(5982):1164-1168

Champion SH, Seth SK (1968) A revised survey of the forest types of India. A revised survey of the forest types of India.

Criddle RS, Church JN, Smith BN (2003) Fundamental causes of the global patterns of species range and richness. Russi J Plant Physio 50:192-199

Curtis JT, McIntosh RP (1951) The interrelations of certain analytic and synthetic phytosociological characters. Ecol 31:434-455

Dar DA, Sahu P (2018) Assessment of biomass and carbon stock in temperate forests of Northern Kashmir Himalaya, India. Proc. Int Acad Ecol 8(2):139

Dar JA, Sundarapandian S (2016) Patterns of plant diversity in seven temperate forest types of Western Himalaya, India. J Asia Pac Biodiv 9(3):280–292 doi:10.1016/j. japb.2016.03.018.

Davies RG, Barbosa O, Fuller RA, Tratalos J, Burke N, Lewis D, Warren PH, Gaston KJ (2008) City-wide relationships between green spaces, urban land use and topography. Urban Ecosyst 11:269-287

Debinski DM, Holt RD (2000) A survey and overview of habitat fragmentation experiments. Conserv Biol 14:342–355.
efloras. Available from: www.efloras.org (Accessed on 06-10-2018).

Ehrlich PR (1996) Conservation in temperate forests: what do we need to know and do? For Eco Manag 85:9–19
Forest Survey of India, Ministry of Environment and Forests. Govt. of India. FSI. (2017) State of forest report. Dehradun: Forest Survey of India.

Fosaa AM (2004) Biodiversity patterns of vascular plant species in mountain vegetation in the Faroe Islands. Divers Distr 10: 217-223

Foxcroft LC, Richardson DM, Pysek P, Genovesi P (2013) Invasive alien plants in protected areas: threats, opportunities, and the way forward. In Plant Invasions in Protected Areas pp. 621-639 Springer, Dordrecht

Gairola S, Sharma CM, Ghildiyal SK, Suyal S (2011) Live tree biomass and carbon variation along an altitudinal gradient in moist temperate valley slopes of the Garhwal Himalaya (India). Curr Sci 100(12):1862–1870

Gairola S, Sharma CM, Ghildiyal SK, Suyal S (2012) Chemical properties of soils in relation to forest composition in moist temperate valley slopes of Garhwal Himalaya, India. Environmentalist 32:512-523

Gairola S, Sharma CM, Rana CS, Ghildiyal SK, Suyal S (2010) Phytodiversity (Angiosperms and Gymnosperms) in Mandal-Chopta forest of Garhwal Himalaya, Uttarakhand, India. J Nat Sci 8(1):1-17

Gaston KJ, Rodrigues ASL, van Rensburgh BJ, Koleff P, Chown S (2001) Complementary representation and zones of ecological transition. Ecol Let 4:4-9

Gaston KJ, Jackson SF, Cantu-Salazar L, Cruz-Pinon G (2008) The ecological performance of protected areas. Ann Rev Ecol Evol System 39:93-113

Gupta PK (2000) Soil, plant, water and fertilizer analysis. New Delhi: Agrobios

Hair JF, Black WC, Babin BJ, Anderson RE, Tatham RL (2006) Multivariate Data Analysis, vol. 6. Pearson Prentice Hall, Upper Saddle River, NJ.

Hannah L, Midgley G, Andelman S, Araujo M, Hughes G, Martinez-Meyer E, Pearson R, Williams P (2007) Protected area needs in a changing climate. Front Ecol Environm 5:131-138

Haq SM, Malik ZA, Rahman IU (2019) Quantification and characterization of vegetation and functional trait diversity of the riparian zones in protected forest of Kashmir Himalaya, India. Nordic J Bot 37(11)

Haq F, Ahmad H, Iqbal Z, Alam M, Aksoy A (2017) Multivariate approach to the classification and ordination of the forest ecosystem of Nandiar valley western Himalayas. Ecol Indic 80:232-241

Hegazy AK, El-Demerdash MA, Hosni HA (1998) Vegetation, species diversity and floristic relations along an altitudinal gradient in south-west Saudi Arabia. J Arid Environ 38:3-13

Hejcmanova-Nezerkova P, Hejcman M (2006) A canonical correspondence analysis (CCA) of the vegetation–environment relationships in Sudanese savannah, Senegal. S Afr J Bot 72(2):256-262
Hussain M, Khan SM, Abd-Allah EF, Ul Haq Z, Alshahrani TS, Alqarawi AA, Ur Rahman I, Iqbal M, Abdullah A, Ahmad H (2019) Assessment of plant communities and identification of indicator species of an ecotonal forest zone at Durand line, district kurram, Pakistan. Appl Ecol Env Res 17(3):6375-6396

Jackson ML (1973) *Soil chemical analysis*. Ist Edn., Prentice Hall of India Pvt. Ltd., New Delhi, India.

Jain SK, Rao RR (1977) *Field and Herbarium Methods*. Today and Tomorrow Publishers, New Delhi, India.

Khan W, Khan SM, Ahmad H (2015) Altitudinal variation in plant species richness and diversity at Thandiani sub forests division, Abbottabad, Pakistan. J Biodiver Environ Sci 7:46-53

Khan M, Khan MS, Ilyas M, Alqarawi AA, Ahmad Z, Abd-Allah FE (2017) Plant species and community’s assessment in interaction with edaphic and topographic factors; an ecological study of the mount Eelum District Swat, Pakistan. Saudi J Biologi Sci 24: 778-786

Khan SM, Harper D, Page S, Ahmad H (2011) Species and community diversity of vascular Flora along environmental gradient in Naran Valley: A multivariate approach through indicator species analysis. Pak J Bot 43:2337-2346

Khan SM, Page S, Ahmad HA, Shaheen H, Harper DM (2012) Vegetation dynamics in the Western Himalayas, diversity indices and climate change. Sci Tech Dev 31(3):232-43

Kunwar RM, Sharma SP (2004) Quantitative analysis of tree species in two community forests of Dolpa district, mid-west Nepal. Him J Sci 2(3):23-28

Leps J, Smilauer P (2003) *Multivariate analysis of ecological data using CANOCO*. Cambridge university press.

Malik ZA, Bhatt AB (2015) Phytosociological analysis of woody species in Kedarnath Wildlife Sanctuary and its adjoining areas in Western Himalaya, India. J For Environ Sci 31:149-163

Mane AM, Prabakaran N, Manchi SS (2019) Floral diversity, composition, and recruitment on the karstland of Baratang Island, India. Ecolo Complex 37:47-54

Margules CR, Pressey R (2000) Systematic conservation planning. Nature 405: 243-253

Martijn EFT, Herben MHAJ (2003) Characterization of radio wave propagation into buildings at 1800 MHz. IEEE Antenn Wirel Pr 2:122-125

Massberg S, Brand K, Grüner S, Page S, Muller E, Muller I, Bergmeier W, Richter T, Lorenz M, Konrad I, Nieswandt B (2002) A critical role of platelet adhesion in the initiation of atherosclerotic lesion formation. J Exp Med 196:887-896

Naidu TM, Kumar AO (2016) Tree diversity, stands structure, and community composition of tropical forests in Eastern Ghats of Andhra Pradesh, India. J Asia Pac Biodivers 9:328-334
Nazir A, Malik RN, Ajaib M (2012) Phytosociological Studies of the vegetation of Sarsawa Hills District Kotli, Azad Jammu & Kashmir. Biol. (Pak) 58(1&2):123-133

Pande PK, Negi JDS, Sharma SC (2001) Plant species diversity and vegetation analysis in moist temperate Himalayan forest. Ind J For 24(4):456-470

Pielou EC (1969) An introduction to mathematical ecology. Wiley-Interscience, New York, 286 p.

Qureshi R, Bhatti GR (2010) Floristic inventory of Pai forest, Nawab Shah, Sindh, Pakistan. Pak J Bot 42(4):2215-2224

Rahman IU, Afzal A, Iqbal Z, Ijaz F, Ali N, Asif M, Alam J, Majid A, Hart R, Bussmann RW (2018) First insights into the floristic diversity, biological spectra and phenology of Manoor valley, Pakistan. Pak J Bot 50:1113-1124

Rahman IU, Khan N, Ali K (2017) Classification and ordination of Understory vegetation using multivariate techniques in the Pinus wallichiana forests of Swat valley, Northern Pakistan. Sci Nat 104:24

Rashid YN and Sharma LK (2016) Management plan Dachigam National park.jkwildlife.com.

Sahu SC, Pani AK, Mohanta MR, Kumar J (2019) Tree species diversity, distribution and soil nutrient status along altitudinal gradients in Saptasajya hill range, Eastern Ghats, India. Taiwania 64(1):28

Saima S, Altaf A, Faiz MH, Shahnaz F, Wu G (2018) Vegetation patterns and composition of mixed coniferous forests along an altitudinal gradient in the Western Himalayas of Pakistan. Aust J For Sci 135(2):159-180

Saxena AK, Singh JS (1982) A phytosociological analysis of woody species in forest communities of a part of Kumaun Himalaya. Vegeta. 50:3-22

Shah S, Tewari A, Tewari B (2009) Impact of human disturbance on forest vegetation and water resources of Nainital catchment. Nat Sci 7:74-78

Shaheen H, Khan RWA, Hussain K, Saiffullah T, Nasir M, Mehmood A (2016) Carbon stocks assessment in subtropical forest types of Kashmir Himalayas. Pak J Bot 48(6): 2351-2357

Shaheen H, Qureshi RA, Ullah Z, Ahmad T (2011) Anthropogenic pressure on the western Himalayan moist temperate forests of Bagh, Azad Jammu & Kashmir. Pak J Bot 43(1): 695-703

Shaheen H, Ullah Z, Khan SM (2012) Species composition and community structure of western Himalayan moist temperate forests in Kashmir. For Ecol Manag 278:138-145

Shahid M, Joshi SP (2016) pytosociological assessment and distribution pattern of tree species in forest of doon valley shivalik Hills of lower Himalaya. Trop Plant Res 3(2): 263-271
Shannon CE (1948) A mathematical theory of communication. Bell Syst Tech 27(3):379-423

Sharma CM, Baduni NP, Gairola S, Ghildiyal SK, Suyal S (2010) Tree diversity and carbon stocks of some major forest types of Garhwal Himalaya, India. For Ecol Manag 260: 2170-2179

Sharma CM, Ghildiyal SK, Gairola S (2009) Vegetation structure, composition and diversity in relation to the soil characteristics of temperate mixed broadleaved forest along an altitudinal gradient in Garhwal Himalaya. Indian J Sci Tech 2:39-45

Sharma CM, Mishra AK, Krishan R, Tiwari OP, Rana YS (2016) Variation in vegetation composition, biomass production, and carbon storage in ridge top forests of high mountains of Garhwal Himalaya. J Sust For 35(2):119-132

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. Inter J Basic Appli Sci 3(4):382

Simpson EH (1949) Measurement of diversity. Nat 163:688

Singh A, Samant S (2010) Conservation prioritization of habitats and forest communities in the Lahaul Valley of proposed cold desert biosphere reserve, north western Himalaya, India. Appli Eco Environ Res 8(2):101-117

Singh V, Chauhan DS, Dasgupta S (2018) Effect of stand structure and aspect on the regeneration of banj oak (*Quercus leucotrichophora* A. Camus) forest along disturbance in Garhwal Himalaya, Uttarakhand, India. Forest Stud 68(1):33-39

Stewart RR (1972) An annotated catalogue of the vascular plants of West Pakistan and Kashmir. Fakhri Printing Press, Karachi.

Summerville KS, Boulware MJ, Veech JA, Crist TO (2003) Spatial variation in species diversity and composition of forest Lepidoptera in eastern deciduous forests of North America. Conser Biol 17(4):1045-1057

Sundriyal RC, Sharma E, Rai LK, Rai SC (1994) Tree structure, regeneration and woody biomass removal in a sub-tropical forest of Mamlay watershed in the Sikkim Himalaya. Vegetatio 113(1):53-63

Suyal S, Sharma CM, Gairola S, Ghildiyal SK, Rana CS, Butola DS (2010) Phytodiversity (angiosperms and gymnosperms) in Chaurangikhal forest of Garhwal Himalaya, Uttarakhand, India. Indian J Sci Tech 3(3):267-275

Ter Braak CJF (1986) The analysis of vegetation ± environment relationship by canonical correspondence analysis. Vegeta 69:69-77
Ter Braak CJF, Smilauer P (2002) CANOCO Reference manual and CanoDraw for Windows User's guide: Software for Canonical Community Ordination (version 4.5). Microcomputer Power, Ithaca, New York. 500 pp. [http://www.canoco.com](http://www.canoco.com).

Wang Y, Singh MP (2006) Trust representation and aggregation in a distributed agent system. AAAI 6:1425-1430

Wani AA, Joshi PK, Singh O, Bhat JA (2015) Estimating biomass and carbon mitigation of temperate coniferous forests using spectral modeling and field inventory data. Ecol Infor 25:63-70

Yam G, Tripathi OP (2016) Tree diversity and community characteristics in Talle Wildlife Sanctuary, Arunachal Pradesh, Eastern Himalaya, India. J Asia Pac Biodivers 9:160-165

**Figures**

![Map of Dachigam National Park in Kashmir Himalaya](image)

**Figure 1**

Map of Dachigam National Park in Kashmir Himalaya
Figure 2

Species-family relationship of forest flora
Figure 3

The dendrogram of 5 forest types based on Sorenson's similarity index separating into 2 clusters.
Figure 4

Two Way Cluster Analysis base on Sorenson’s similarity index of 84 plant species and 5 forest types (prepared in PCORD).
Figure 5

The DCA ordination of study area for the observed vegetation.
Figure 6

The diagram showing CCA distribution of plant species along the environmental variables. P = Phosphorus, K = Potassium, Ca = Calcium, EC = Electrical Conductivity, OC = Organic, Sal = Salinity, N = Available Nitrogen.