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Species composition and community structure of western Himalayan moist temperate forests in Kashmir

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ABSTRACT

The phytosociological attributes of western Himalayan moist temperate forests were investigated in Bagh district, Kashmir. Detailed sampling was carried out in 180 forest stands (30 × 30 m) at 13 sites. Average number of vascular plant species found per site was between 30 and 40; Menhinick's Richness was 0.93–1.63; Simpson's Diversity Index between 0.75 and 2.27; Shannon's Evenness between 0.21 and 0.71; the Maturity Index 38 to 53. Species diversity and community structure patterns were significantly correlated to environmental variables including altitude and slope inclination as well as intensity of anthropogenic pressure. *Abies pindrow* and *Pinus wallichiana* showed exclusive dominance comprising 30% of Importance Value Index (IVI) weight age of all 122 recorded species. Forest ground flora was dominated by grasses of the Poaceae. Average tree density was 151 ha^{-1} whereas basal area was estimated as 68.8 m^2 ha^{-1}. A stem/stump value of 1.62 indicated immense tree felling and logging pressure on local forests. A disturbed forest regeneration pattern was indicated by an average seedling count of 124 ha^{-1}. A negative correlation (CCA) was found between diversity and richness with altitudinal gradient as well as slope and aspect. Diversity values were similar, whereas tree density, basal area and seedling count were lower, compared to other Himalayan forest sites. These results indicate a deteriorated forest structure and reduced regeneration pattern, demanding immediate attention of forest management authorities.

1. Introduction

The Himalayas are one of the richest and most unusual ecosystems on earth with a variety of forest types due to great altitudinal and climatic variations from foothills to alpine peaks; vegetation types have a direct relationship with altitude (Mani, 1978). This influences the temperature gradient, a factor shaping vegetation types and determining their diversity and distribution (Heaney and Proctor, 1989; Tanner et al., 1998; Vazquez and Givnish, 1998). The Himalayas are mainly fed by south-western monsoon rainfalls coming in from the Bay of Bengal, intercepted by the eastern Himalayas; leaving the drier west to receive less precipitation. This moisture gradient also influences the distribution and diversity of vegetation in the region. The eastern parts have higher biodiversity, with the tree line at 4000 m, which descends down to 3300 m in the relatively less biodiverse and drier west (Kenderick, 1989).

Community structure, composition and vegetative function are the most important ecological attributes of forests, which show variations in response to environmental as well as anthropogenic variables (Gairola et al., 2008; Timilsina et al., 2007). These variations in vegetation structure, richness, diversity and distribution are directly correlated with the intensity of variables like geographical location, productivity, evolutionary competition and human-forest interaction (Woodward, 1988; Eriksson, 1996; Criddle et al., 2003). The plant community structure and distribution patterns of Himalayan forests and alpine pastures have not been given due attention until the present by ecologists, and are hence poorly understood (Peer et al., 2007).

It is estimated that three quarters of western Himalayan forest cover have been lost in last century (Gairola et al., 2008; Panthi et al., 2007; Ahmed et al., 2006). Himalayan moist temperate conifer dominant species like *Pinus wallichiana, Abies pindrow* and broad leaved *Quercus dilatata* exhibit very high economical and ecological value being directly linked with agriculture, fodder fuelwood, timber, resins, fruits and compost source and promoting the mountain springs recharge (Valdia, 1998).

This paper analyses the vegetation structure, phytosociological attributes and the intensity of anthropogenic pressure in western

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Himalayan moist temperate forests in Kashmir. It is anticipated that the present study will provide information to understand the current status, ecology as well as conservational efforts required for this vital ecosystem.

2. Material and methods

2.1. Study sites

Sites in forest and higher alpine pastures in Bagh were sampled during spring and summer 2008–2009, in accordance with specific locality procedures (Cox, 1967; Ford, 1978). Quadrats of different sizes were used for sampling vegetation – 30 × 30 (900 m^2) was used for trees; 5 × 5 m (25 m^2) for shrubs; and 1 × 1 (1 m^2) for herbs and grasses. Sampling was started at each site inwards from the outer forest margins, at an average distance of 100 m. Then quadrats were sampled at every 250 m distance until the forest vegetation climax was reached, recognized by minimum disturbance. A total of 195 quadrats, 15 at each site were laid in blue pine, fir and oak zones. Co-ordinates including altitude, longitude and latitude of each studied site were recorded by using a Garmin 2000 hand-held Global Positioning System (GPS). Seedling and stump counts per hectare were made in synchrony with the quadrats after every 250 m.

2.2. Data analysis

Two indices of diversity were calculated – after Simpson (1949), $D = 1 - \frac{N(N-1)}{\sum n(n-1)}$ where D = Diversity index; n = Number of individual of a species; N = Number of individuals of all i; and Shannon, 1948 by $H' = -\sum_{i=1}^{s} p_i l_n p_i$, where p_i is the proportion of individuals of species i. Species evenness was calculated using the Shannon's Evenness Index: $E = H'/\ln S$; where H' is the Shannon-Wiener diversity index and S is species number (Pielou, 1975). Species richness was calculated after Menhinick (1964) as $d = \frac{s}{\sqrt{N}}$, Where d = Species richness; S = Total no of species in a community; N = Total no of individuals of all the species in a community. The Maturity Index was recorded using the method of Pichi-Sermolli (1948), expressed as a percentage of the total number for both the communities.

$$\text{Degree of maturity} = \frac{\text{Frequency of all species in a stand}}{\text{Total no of all the species}}$$

Sorenson's Similarity Index, IS_s, (Sorensen, 1948) was calculated using importance values. $IS_s = \frac{2C}{A+B} \times 100$, where C = Total I.V values for all the number of species common in two communities; A = Total importance value in community A; B = Total importance value in community B; IS_s = Sorenson index.

PC-ORD was used for hierarchical agglomerative clustering of 13 different sites for all 122 species to see the microclimatic similarities and differences among those moist temperate habitats. Presence/absence data was used for this purpose (Greig-Smith, 2010). This method proceeded from the individual samples and gradually combined them into groups, in terms of their similarity. Cluster Analysis (CA) identified significant habitat types based on Sorensen's (Bray-Curtis) distance with the formula $QS = 2C/A + B$, where A and B are the number of species in sites A and B, and C is the number of species shared by the two stations (Dalirsefat et al., 2009; Sorensen, 1948).

CANOCO was used for Canonical Correspondence Analysis (CCA) to analyze the relationship between species and the underlying environmental factors. Abundance data of all the 122 species and at all of 13 sites along with environmental data were analyzed with the following objectives.

i. To evaluate the significance of relationship among floristic and environmental data.
ii. To reconfirm whether the cluster pattern of habitats and species was due to measured environmental variability or something else.
iii. To identify the strength and interrelationship within different environmental variables.

Spearman's Correlation Coefficient was used to relate the ordination axes of CCA plots to measured environmental, and species attribute data. Ultimately, species and stations graphs were scrutinized to recognize the environmental gradients of the floristic dataset (Ter Braak, 1987; Zahran et al., 1990).

3. Results

One hundred and 22 species from 43 families were recorded from the study area. The moist temperate forest communities found in the altitudinal range of 1700–2600 m were dominated by *A. pindrow* and *P. wallichiana*, comprising 18.35% and 12.39% of total IVI weightage of all recorded species respectively. In the lower altitudinal range (1500–2000 m) broad leaves including *Q. dilatata* (1.01%), *Quercus incana* (1.09%) and *Machilus odoratissima* (1.41%) were closely associated with the dominant conifers. The shrub layer was mostly dominated by *Viburnum grandiflorum* (8.21%) with association of *Sarcococca saligna* (4.07%), *Berberis lycium* (1.28%), *Dryopteris stewertii* (1.59) and *Skimmia laureola* (1.16%). Forest ground flora was dominated by representatives of Poaceae including *Poa alpina* (6.65%), *Poa stewartii* (3.98%), *Trifolium repens* (2.62%), *Arthraxon prinoides* (2.66%) and *Dactylis glomerata* (1.18%); with associated species including *Fragaria nubicola* (3.23%), *Plantago major* (1.13%), *Galium aparine* (1.12%) & *Viola canescens* (1.16%). These 19 species comprised 73.2% IVI weightage of the total recorded 122 species.

The average number of species recorded at the sites mostly ranged from 30 to 40 with a few exceptions like 24 in Panjal and or 48 in Tollipir. All study sites showed a low Species Richness index, with a range of 0.9–1.8. Shannon-Wiener diversity indices varied from a minimum of 0.75 at Khori Phaymarg to a maximum of 2.27 at Nangapir. All of the study sites showed striking similarity in terms of Simpson's diversity indices, ranging from 0.88 at Chatti to 0.92 at Tollipir and Sudhangalli. Species evenness varied between a minimum of 0.21 at Bann to a maximum of 0.72 at Nangapir. The study sites with higher intensity of anthropogenic disturbances showed lower richness indices, such as Panjal (0.93), Jabray (1.06) and Bann (1.13) (Table 1).

The sites showed uneven similarity patterns with a minimum similarity of 19.5% for Daira Barikot and Chatti Jabri but a maximum similarity of 72.4% between Panjal and Khori Phaymarg. The *A. pindrow* dominated sites between 2100 and 2800 m showed greater similarity ($\geqslant$50%) with each other (Table 2). Communities between 1500 and 2100 m dominated by *P. wallichiana* were more strongly similar to each other. Altitude appeared to be main factor affecting the community structure dividing the vegetation into two subgroups.

An average tree density of 151 ha^{-1} was recorded overall. Minimum was 90 ha^{-1} at Daira Barikot and maximum of 277 ha^{-1} at Tollipir (Table 5). Forests stands showed an average basal area of 68.8 $m^2\,ha^{-1}$. Nangapir had the least, 42.32 $m^2\,ha^{-1}$ but 105.29 $m^2\,ha^{-1}$ was found at Khori Phaymarg.

An average stem/stump value of 1.6 was determined for the forest stands as a whole. Nangapir represented the most severe deforestation, having a stem/stump value of only 0.47. Tollipir showed the highest, but still poor, value of 2.31 (Table 4). Variation was observed in tree logging practices along altitudinal gradient in all the