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Phytodiversity of Ayubia National Park Pakistan: Conservation and Management issues

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Abstract

This paper communicates the results of the current study conducted to analyze the phytosociological attributes of Ayubia National Park (ANP) for identifying the major threats to biodiversity of the Park. We report the structure and composition of vegetation of ANP through fixed point survey techniques. Circular quadrates of 18m² radius were used to sample trees while the understory vegetation was sampled by recording data through 15 m line transects. Sum of 250 plant species belonging to 79 plant families recorded in 32km²area of the Park. Furthermore, hierarchical clustering identified three plant communities in the park. Our results delineated important phytosociological attributes of the Park which can be used for facilitating further research on conservation of biodiversity and developing strategies for effective management of the Park.

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Introduction

Plant communities are not merely a determination of the time period but also indicative of the environmental impacts i.e. edaphic and climatic factors have a critical role in the distribution pattern of plant species and their organization as communities (Kharkwal and Rawat, 2010; Khan *et al.*, 2011). In hilly areas elevation is associated with temperature and pressure, which ultimately causes the altitudinal parameters of plant species and idiosyncratic habitats (Karr and Freemark, 1983; Rickart *et al.*, 1991 Balete *et al.*, 2007). Species segregation and diversity in relation to environmental gradients have been thoroughly addressed in terms of habitat heterogeneity, biotic interaction, climatic factors and productivity (Parmesan and Yohe, 2003). It is therefore, imperative to consider the vegetation type of an area along other phyto-ecological gradients of these delicate ecosystems (Kahmen *et al.*, 2005). Over the years, plant communities have been classified using robust computer packages designated for vegetation assessments (Olson *et al.*, 2001). However, the available literatures suggest that classification and ordination techniques have been rarely employed for mapping the high elevation vegetation in Pakistan.

Material and methods

Study area

Ayubia National Park is situated in the Galliat area District Abbottabad, Pakistan. Geographically it falls within the Lesser Himalayas from North to South (lies between 34°1' to 34° 3.8 ′N and 73° 22.8′ to 73° 27.1' E; elevation range is about ±1450 to 3,033m (Fig. 1). Mean annual rainfall and temperature are 1500 mm (with heavy winter snow) and 11°C respectively (Ahmad and Afza, 2014).

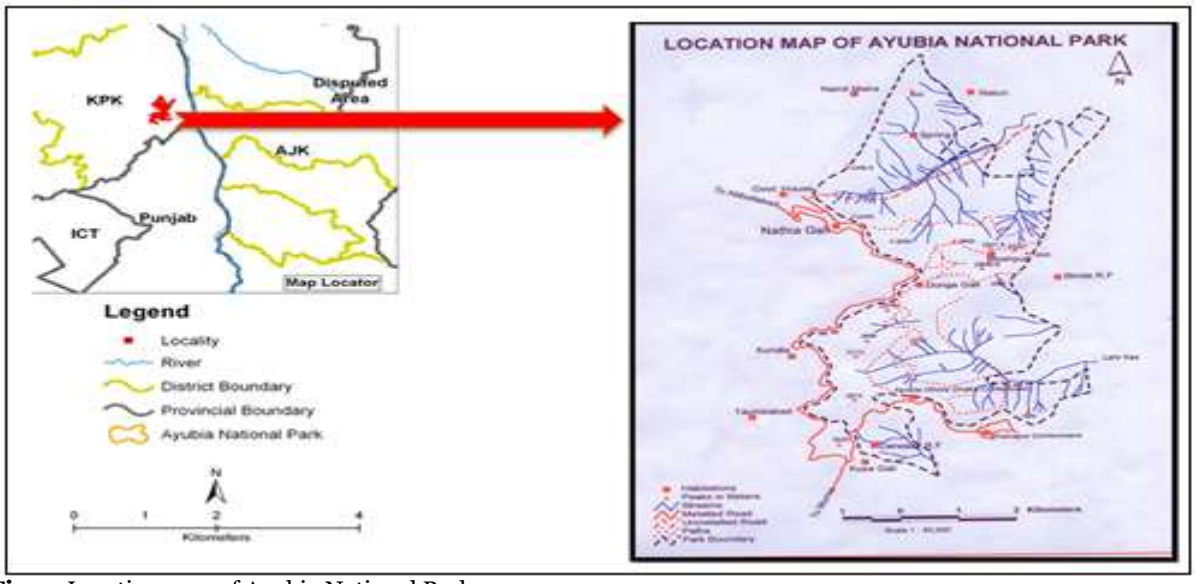

Fig. 1. Location map of Ayubia National Park.

Geologically the entire region is composed of precipitous rocks of about 40 million to 170 million years old. The sedimentary rocks are composed of limestone, sandstone and shale particles (Calkins *et al.*, 1975; Latif, 1976). The soil is rather very shallow or scarce with reducing capacity to sustain plant flora on steep slopes. There is heavy snowfall in winter and high monsoon rains in summer (July and August). Late March (*Bergenia* sp and *Primula* sp) to end of September (*Gentiana Kuroo*) are the notable growing periods with average daytime temperature ranging from 3 to 11°C.

Ayubia National Park is the only protected moist temperate region of Pakistan. It is situated in the Galliat area of the District Abbottabad

with an estimated population of 50,000 residing in seven major villages surrounding ANP. Geographically, ANP falls in Lesser Himalayas from North to South and has a robust floristic affinity to Saharo-Japanese Phytogeographic-region (Mani, 1974). The park is a part of the Western Himalayan (sub-alpine) coniferous forests ecoregion of the world (Olson *et al.*, 2001; Shrestha *et al.*, 2012). Despite of being a declared protected area, its natural resources are under immense pressure. The major conservation issues of the park include deforestation and wood cutting for fuel and construction, free grazing and harvesting of plants for livestock and medicinal purposes (Enright *et al.*, 2004; Afza, 2006).

Vegetation Analysis

Fixed point survey techniques were used for sampling the vegetation of ANP. The park area was divided in to 0.1 hectare sampling plots. Quadrate size of 18 × 18m was used for trees while 15m line transects were used for shrubs and ground vegetation data collection (Braun-Blanquet 1932; Raunkiaer, 1934). The qualitative and quantitative attributes of vascular plants were calculated during a time period from 2011 -2014. GPS readings were recorded for all sampling plots taken within 32Km² area. The plant specimens were identified in the herbariums of Department of Botany, Hazara University Mansehra and Department of Plant Sciences, Quaid-e-Azam University, Islamabad. Locals were interviewed to analyze the vegetation history of the park and current biodiversity threats and the key vectors for biodiversity loss in the area.

Hierarchical cluster analysis

Hierarchical Clustering , a widely used method for clustering species in the studying area by assigning species to its own cluster and then algorithm proceeds iteratively (Bray and Curtis, 1957). Cluster analysis was performed by Bray-Curtis (1957) and Wards (1963) methods, where the clustering criterion is based on applied distance matrix, using the default setting in R-Software (Vegan package).

The classification procedure was as described in Bray-Curtis and Wards (Bray and Curtis, 1957; Ward, 1963) that are considered as the highly applicable classification tool and easily attainable for ecological data exploration analysis (Borcard *et al.*, 2011; Oksanen *et al.*, 2007; Kahmen *et al.*, 2005). Quadrat data were analysed using NMDS-ordination based on Bray-Curtis classification tools with the default settings of R-software (Vegan).

Species diversity and plant communities

Species diversity of the ecological communities were analyzed by Shannon and Wiener species diversity index (H') by following equation.

$$Diversity H p_i \ln p_i \quad \text{.....(Eq.1)}$$

Where p_i is the proportion of individuals extracted as a proportion of total cover or abundance, where ln = natural logarithm.

Species richness

The species richness was calculated for all the three ecological communities for further use in analyses.

Equitability or evenness of species

The Shannon-evenness index (E_1) was used to calculate the evenness factor of species diversity by following equation:

$$E_1 H/\ln s \quad \text{.....(Eq.2)}$$

Where H' is Shanon - Wiener index; s is the total number of species in a community and ln is the natural logarithm of the total number of the species.

Results

A sum of 250 plant species of 216 genera and 79 families were observed. Bray-curtis cluster analysis break up the plant species data matrix into plant assemblages.

The clustering methods, classified the vegetation of ANP into of three ecological communities on the basis of presence-only data set (Table1).

Table 1. Classification and distribution of Plant communities in Ayubia National Park.

Plant Community No.	Plant community	Plant Community code	No. of sampled plots	Elevation Range (m)
I	*Pinus wallichiana – Viola canescens – Vibernum mullaha*	PVV	74	1467 - 2693
II	*Pinus wallichiana – Fragaria nubicola- Indigofera heterantha*	PFI	22	1709 - 2685
III	*Abies pindrow - Viburnum grandiflorum - Dryopteris stewartii*	AVD	34	1752 - 3033

Plant Community I: Pinus wallichiana – Viola canescens - Vibernum mullaha

This plant community was spread at an elevation range from 1467 to 2693m and comprised 74 sampling plots that were mostly located on the steep and rugged mountains of the park. This plant community was dominated by trees e.g. *Pinus roxburghii*, *Olea ferrogena*, *Punica granatum* and *Zanthoxylum armatum* at lower elevation (subtropical vegetation) while at the high altitude vegetation was represented by *Pinus wallichiana, A. pindrow*, *C. deodara*, *T. baccata* and broad leaved *i.e. A. caesium*, *P. padus*, *J. regia*, *C. machrophylla*, *Parrotiopsis jacquemontiana* , *Quercus dilatata* and *Q. incana* .The prominent layer comprised *Viola canescens*, *Dioscorea deltoidea*, *Iris hookerana*, *Geranium wallichianum*, *Bergenia ciliata, Dryopteris stewartii*, *Adiantum venustum*, *Gentiana kuroo*, *Swartia sp* were common. Similarly the shrub layer was dominated by *V. mollah*, Lonicera sp, *Berberis kunawurensis*, *B. parkeriana*, *Skimia laureola*.

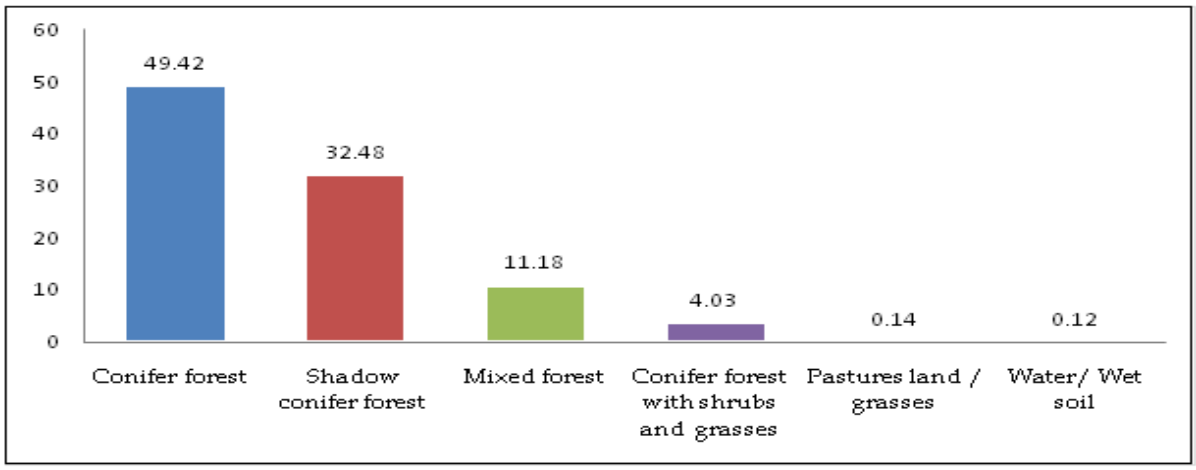

Fig. 2. Land cover classes (%) in Ayubia National Park.

Plant community II: Abies pindrow – Vibernum grandiflorum – Dryopteris stewartii

This plant community was spread between an altitudinal range of 1709m to 2685m with 22 sampling plots, wherein 199 plant species were

recorded (Table 1). The dominant conifers were represented by *Abies pindrow, P. wallichiana, C. deodara, and P. smithiana. T. baccata* was also present while the dominant broad leaved were *A. caesium, Prunus padus, Rhamnus purpurea, Quercus baloota* and *Pyrus pashia*. The herb layer comprised D. *stewartii, F. nubicola, A. venustum, P. haxandrum, H. nepalensis, G. kuroo, B. tenue* and *A. filicinus*. The shrubs were *R. fruiticosus, I. heterantha, Vibernum grandiflorum, Lonicera quinqueloculari*s, *R. macrophylla, S. laureola, Isodon coesta* and *S. affinis* etc.

Plant Community III: Pinus wallichiana – Fragaria nubicola –Indigofera heterantha

This plant community was mainly found at an elevation of 1752-3033m within the study area (highest elevation range) and is mostly found in all aspects. This plant community comprised 34 sampled plots with176 plant species.

The conifers were dominated by *P. wallichiana, A. pindrow, T. baccata* and *C. deodara* while *Picea. Smithiana* was not rare while the prevailing broad leaved was *Acer caesium, A. indica* and *P. padus* were dominant.

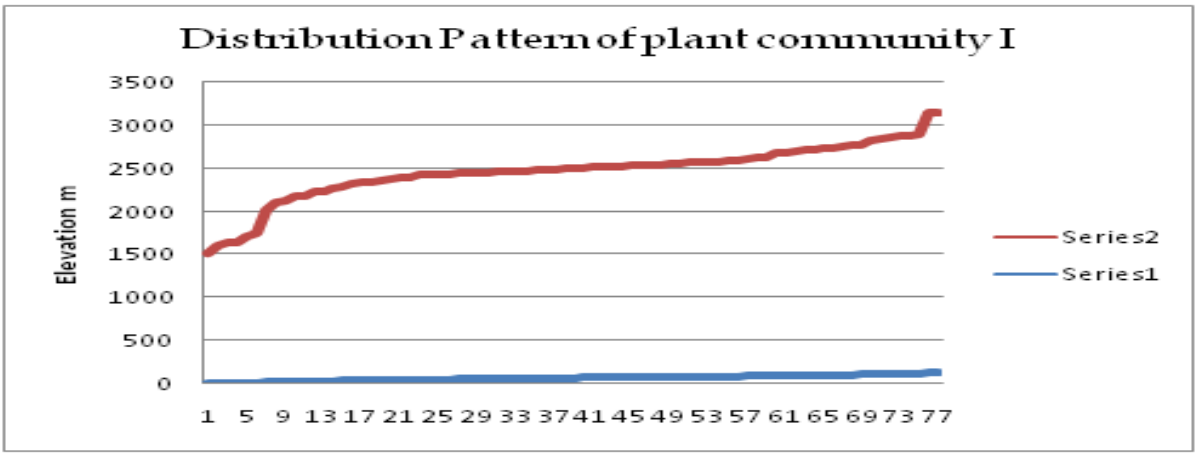

Fig. 3. Distribution pattern of plant community I in Ayubia National Park.

The highest mountainous peaks (Alpine and subalpine region) were fall in this plant community, where stunted growth of tree species including the *Betula utilis and Salix denticulata* (endemic *sp.*) and lush grasses were recorded. The herbaceous flora was dominated by *B. amplexicaulis, F. nubicola, Viola sp, A. millefolium, E. wallichii*, R. *muricatus, Leontopodium brachyactis (endemic sp.), V. jatamonsii, Veronica laxa, T. repens, O. vulgare, P. nepalensis, S. emodi, I. hookerana* while the prevailing shrubs were *I. heterantha, V. grandiflorum, , Isodon coetsa* and *Desmodium elegans.*

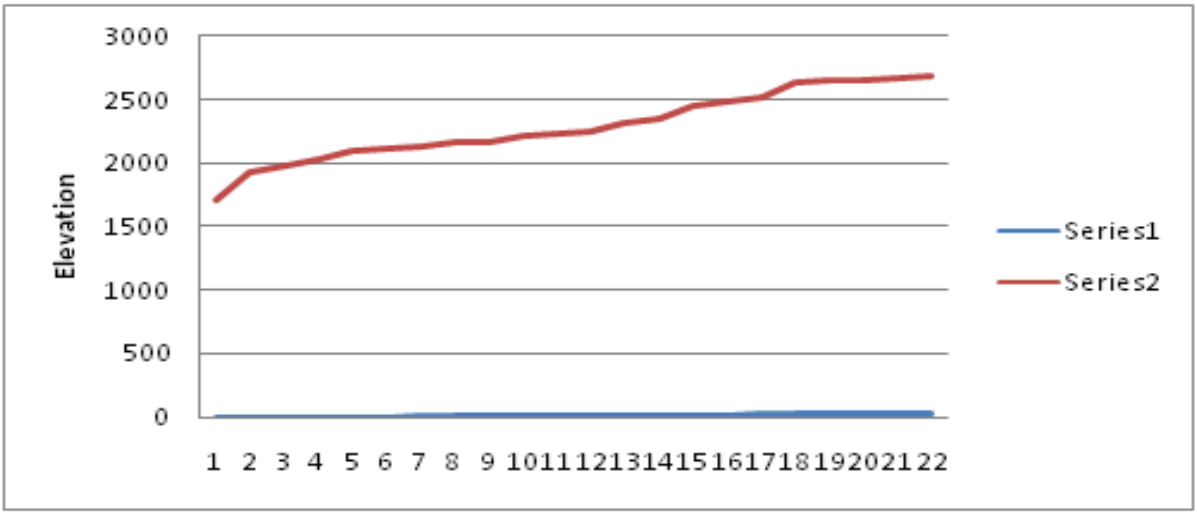

Fig. 4. Distribution pattern of plant community II in t ANP.

Plant-Species Diversity, Richness and Evenness

Plant communities revealed variation in terms of species-richness, diversity and evenness (Fig.6). The highest value of species richness (Fig. 6A) is attained in plant community I (236), followed by plant community-III (coniferous zone) and declined to 177 in ecological community II. The Evenness (H value) of different ecological communities (Fig. 6) showed the maximum value of H (0.925) by ecological community III, followed by ecological community II (0.914) and I (0.896). The Shannon Diversity Index (H') of the three ecological communities revealed more or less similar trend to that obtained in the case of species-richness. As richness increases, diversity also increased (Fig.6). The highest H' value with 4.898 is recorded in ecological community I, and chased by ecological community III (4.895) and community II (4.732) respectively (6B).

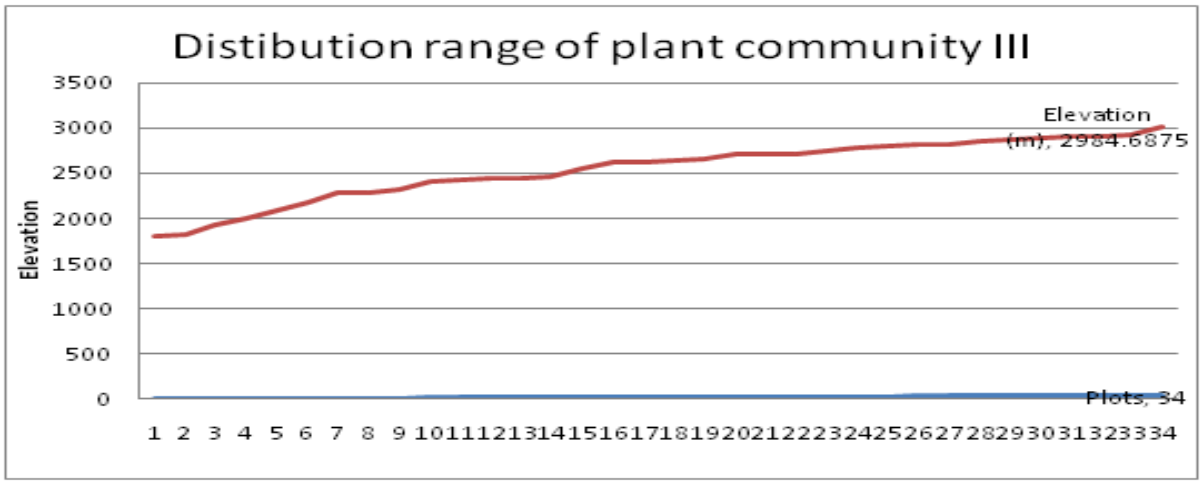

Fig. 5. Distribution pattern of plant community III in ANP.

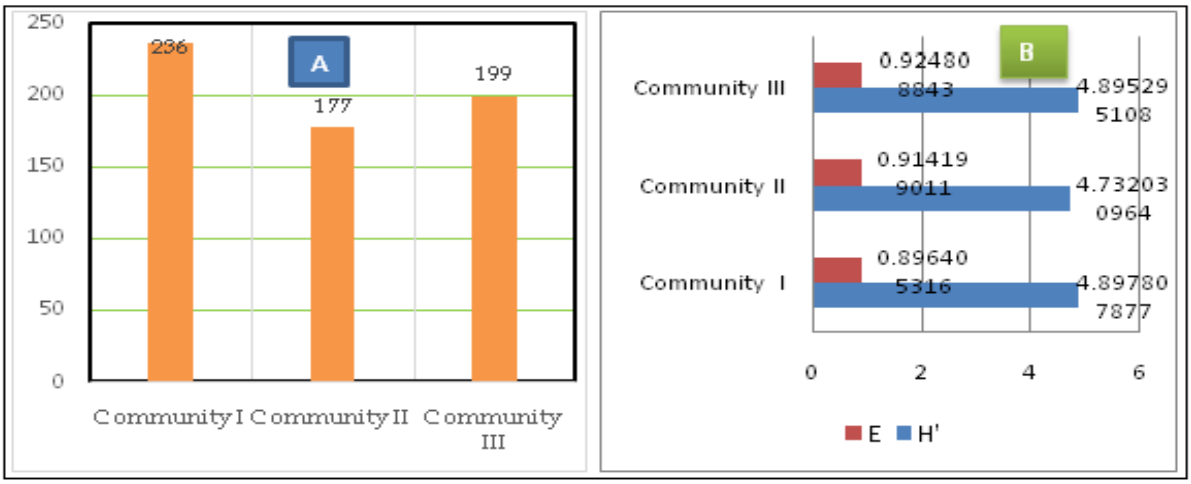

Fig. 6. Species richness in different ecological communities of the study area is shown in A, while Shanon diversity index is shown with species evenness values are presented in B.

This study has presented a high diversity of plant species in ANP (250) than previously observed *e.g*. Saima *et al*., 2009, where the authors recorded 142 plant specimens within 180 sampling stands from the park area. Similarly Ahmad (2012) analysed the floristic composition of ANP and recorded 59 plant species from 32 families by using quadrate method. The study also characterised the dominant and representative species of the park i.e. *P. wallichiana, T. baccata A. pindrow,* and *C. deodara* and *P. smithiana*, while among the broad leaves *A. caesium*, *C. macrophyllus, A. indica, P.*

padus, *Quercus dilatata and Q. incana* which can also be seen in a significant quantity in the study area (Kharkwal *et al.*, 2005; Kluge 2006; Fu *et al.*, 2006; Khan *et al.*, 2011). But some of the braod leaved were recorded in less frequent e.g. *Ulmus wallichiana* from the entire park that is and endangered species according to IUCN Redlist. Similarly excessive grazing pressure was noticed at Mushkpuri top of the park and at lower altitudes due to which flora of the park is extremely under pressure in terms of free grazing, fodder collection and fuelwood collection from the adjacent village around ANP. The important trees e.g. *Taxus baccata*, *Ulmus* sp and *Quercus* Sp are collected for fuelwood @35 kg/day per household. Similarly important medicinal plants are collected as fodder @ of 36% per day per house.

Fig. 7. Important medicinal plants of Ayubia National Park. A-*Swartia chirata, B-Peonia emodi, C- Bergenia ciliata,* D- *Gallium aprine,* E- *Androsace foliosa*, F- *Viola canescens.*

The fodder collection was recorded three plant communities including species being enlisted by IUCN redlist under category of endangered species like *D. hatagirea, Abelia* sp. *Taxus baccata, Dioscorea deltoidia* and *P. hexandrum. Further we combine the social data of ethnobotanical uses of plant species with the scientific data and come on the conclusion that* the anthropogenic pressure on in the park is not only on flora diversity but also is a major threat for pheasents nests in the park that is an important factor od biodiversity loss. As the study area is a best example of moist temperate Himalayan region of global ecoregions 200 (Myers *et al.*, 2000) therefore; there is a need of management anthropogenic pressure in

terms of deforestation, medicinal plant/ fodder collection and free grazing in the park (Brook *et al.*, 2006; Kukshal *et al.*, 2009; McGlone *et al.*, 2010).

Conclusion

Physical and biological factors together shape the plant communities (assemblage). Floristically ANP shows a high diversity with respect to plant species richness and composition; easily distinguish from eastern Himalayan region. This is most probably due to geological, physiographical and environmental factors (Küchler, 1967; Franklin, 1995; Kruckeberg, 2004). The classification (Bray-Curtis and Wards method) provided a distinct description of plant communities in the prevailing environment conditions.

It is expected that this baseline study will provide and facilitate a set of new gateway for conservation measures in protected areas including the precious flora and fauna of Ayubia National park that hosting endemic and endangered species subjected to biotic pressure pressures.

Recommendations

Biodiversity conservation programme should be started at broader scale by the Ministry of Environment Pakistan not only to protect the threaten species of Ayubia National park but also from the adjacent areas. Capacity building of local community should be built particularly for the plantation of *Ulmus wallichiana* to protect it from further loss.

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