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Research Article

Impact of Terrain Slopes and Aspect on the Natural Regeneration of the Coniferous Forest in the Northern Pakistan - A Case Study of Ayubia National Park

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Abstract: Natural regeneration of forest is an important factor for sustainable forestry in Northern Pakistan. In natural forests, the coniferous forest has higher regenerative capacity which enhances their significance for developing countries like Pakistan with rapid depleting forest areas and lack of resources to fund any afforestation campaign. Ayubia National Park is taken as case study to study natural regeneration of forests. The paper explores the status of natural regeneration of conifers forest in Ayubia National Park, Abbottabad, Khyber Pakhtunkhwa, which lies in the moist temperate northern zone of Pakistan. Main objective of the paper is to find out the impacts of two vital factors, i.e., slope and aspect, on regeneration of coniferous forests in the study area. One hundred, fixed circular plots on varying terrain slopes, aspects and accumulated snow were selected randomly as sample representation of the whole Ayubia National Park. Five species were selected to ascertain the density, frequency ratio, abundance and distribution pattern of the regeneration in the six forest blocks. There were better growth status and survival rate of regeneration at the south aspect (56%) than the north (44%). As much as 60.8% regeneration was recorded on the rolling slopes followed by 25.2% and 13.98% at steep and normal slopes, respectively. The present natural regeneration was well distributed at south aspects than its growth on north aspects. This phenomenon indicates a negative impact of the anthropogenic activities on forest regeneration at normal terrain. Similarly, steeper slopes also have a negative impact on natural regeneration of the conifers forest.

Keywords: Anthropogenic activities, coniferous forest, regeneration, terrain, slope

1. INTRODUCTION

Forest regeneration is an important natural process that helps in restoring the forest over large areas. Natural regeneration can successfully occur only with sufficient amount of growing space, understory light, supportive soil composition and ample ground litter that help for seed germination and subsequent growth of seedlings. Natural regeneration is a valuable mean for moving towards forest types that are more efficient in providing valuable forest products and assuring multipurpose forest functions such as recreation, site protection, water conservation and preservation of the habitats of endangered species of plants and wildlife [1, 2] .

Generally, in northern Pakistan the regeneration is abundant on northern and north eastern/ western aspects as compared to southern aspects. There is either inadequate regeneration or at times no regeneration on the southern aspect due to the fact that southern aspects are comparatively warmer because of more sun facing than the northern aspects [3].

Hardwick et al [4] worked on regeneration of forest in south-east Asia. They indicated four sets of factors which influence regeneration of forests,

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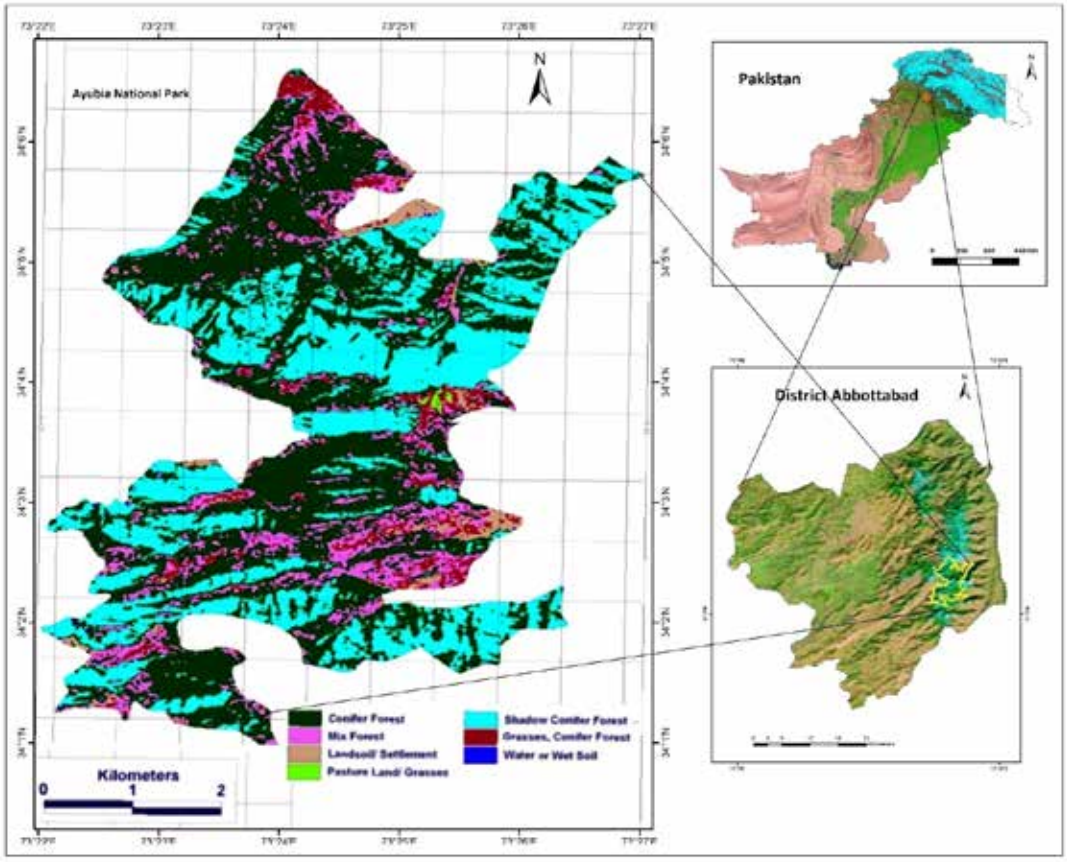

Fig. 1. Ayubia National Park, and its major land uses [15].

i.e., distribution, site sources that include seasonal disparity in moisture, weed competition and plant and propagule availability. Similarly, some scholars like Holland and Steyn [5] have worked on this aspect in relation with in solation period and strength. Numerous researches (e.g., Cantlon [6] in North America, Kutiel and Lavee [7] in Middle East, Kirkpatrick et al. [8] in Australia, Vetaas [9] in Africa, and Ghimire et al [10] and Paudel and Vetaas [11] in Himalayan region) have indicated that the difference among different aspects is the outcome of variation in solar radiation received. Similarly, Cantlon [6] and Pook [12] observed that conflicting gradients differ in intensity of light, top soil, temperature, moisture, and evaporation, as well as length of growing period. In northern hemisphere usually, the south-facing slopes obtain more daylight and thereby supporting drought-resistant vegetation, whereas north-facing slopes maintain humidity and therefore supporting moisture-loving plants.

Khattak [13] reported that in natural forests, the coniferous forest has higher regenerative capacity which enhances their significance for developing countries like Pakistan with rapid depleting forest areas and lack of resources to fund any afforestation campaign. The significance of natural regeneration is extremely high in retaining forest sustainability but its stand density and growth is affected directly or indirectly by the natural and anthropogenic factors due to the local interactions and conditions. Forest density, frequency ratio, abundance and distribution pattern are generally used in determining the status of natural regeneration [14]. This paper focuses on these parameters to explore the status of natural regeneration of coniferous forest in Pakistan using Ayubia National Park as a case study. The study aims to identify the correlation of slope and ground aspect in determining the stand density, abundance and distribution pattern of the regeneration of coniferous and broad leaved forest

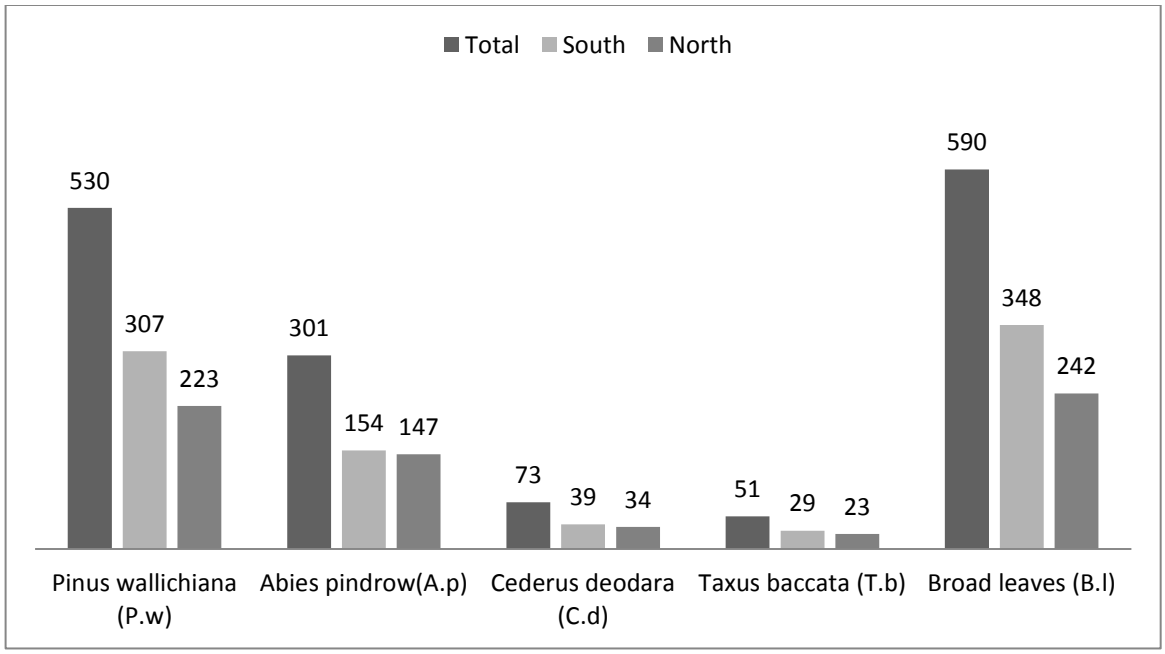

Fig. 2. Spread of regeneration on north and south aspects.

and its relation with the status of pole and mother trees.

1.1 Ayubia National Park

The Ayubia National Parklies between $34^0 01'$ to 34^0 3.8′ N latitude and $73^0 22.8'$ to $73^0 27.1'$ E longitude which are spread over a total area of 3312 hectares [15]. In relative terms, Ayubia National Park lies in the eastern side of District Abbottabad, while the Park is one of the 14 declared national parks in Pakistan that fall in IUCN category '*V*'. The Park is known as the hotspot in the moist temperate zone of Himalayan Range Mountains in District Abbottabad of Khyber Pakhtunkhwa province of Pakistan [16]. Coniferous forest is the major land use of the forest though other land uses like rangeland, agriculture land, shrubs and bushes can also be seen sporadically dispersed in small parcels of land (Fig. 1).

Topography of Ayubia National Park is rugged with slopes varying from normal to the steep which is the common features of the whole Galliat area. The Ayubia National Park occupies predominantly the eastern slope of the main mountain ridge running in north south direction between the town of Donga Gali and Ayubia. The average elevation of Ayubia National Park is 2440 meter above sea level while the highest peak in the Park is Mukshpuri (2813 meters) [17]. The climate of the area is moist temperate with very cold and snowy winters and pleasantly mild summer season. The minimum temperature during winter months falls below freezing points. The mean annual rainfall is well above 1500 mm, most of which is received during monsoon period from July to August, while the month of May, June, September and October are the driest. Rainfall, temperature and humidity conditions of the area are highly conducive for rich vegetation growth [18].

Shafique [19] reported that the Park is settled with 22 species of mammals, 154 species of birds and 08 species of reptilians and amphibians. Mammals in the Park include Asiatic leopard, black bear, yellow throated marten, Kashmir hill fox, red flying squirrel, Himalayan palm civet, masked civet and rhesus monkey. Birds in the park are golden eagle, Himalayan griffon vulture, honey buzzard, peregrine falcon, kestrel, Indian sparrow hawk, hill pigeon, spotted dove and collared dove [20]. According to Shafique [19], the Park is predominantly enriched with

coniferous forest species (*Abie spindrow, Cedrus deodar, Picea smithiana, Pinus wallichiana, and Taxus wallichiana)* mixed with broad leaved evergreen (*Quercus floribunda, Quercus glauca, Quercus incana, Quercus dialatata)* and deciduous broad leaved trees *(Acer caesium, Aesculus indica, Cornus macrophylla, Juglans regia, Prunus padus, Diospyros lotus, Ulmus wallichiana*).

The main objective of this research was to explore the impact of anthropogenic activities on regeneration in the study area and to answer the question that what is correlation between slope and ground aspect on the regeneration of coniferous forest.

2. MATERIALS AND METHODS

Fixed point sampling technique was used to select sample plots in the Park to equally represent the existence and growth of different species regeneration on different forest areas. The sample plots were randomly selected with the similar probabilistic representation of different vegetation type, terrain slope, southern and northern aspects. Besides, due considerations were also made to select the sample plots with the various natural and anthropogenic confronted threats to the regeneration process. Circular plots of an area of about 0.01 hectares were designated around various selected species using a rope to mark a circle of 6 meters diameter.

The study area was further sub divided into six blocks, namely, Bagan, Tajwal, Darwaza, Donga Gali, Kao and Bakot. One hundred sample plots were taken in these forest blocks. However, the number of plots taken in each block was differed due to the area strength. The detail of plots taken in each block is shown in Table 1.

2.1 Regeneration Measurement Standards

The regeneration status was measured through the process of manual enumeration. The circumference of every single tree in the sample plot was measured at the breast height of the observer using a measuring tape. With the application of simple geometric formula, the diameter of the tree at the breast height was ascertained. This was used to group the trees into three categories. The trees were considered as

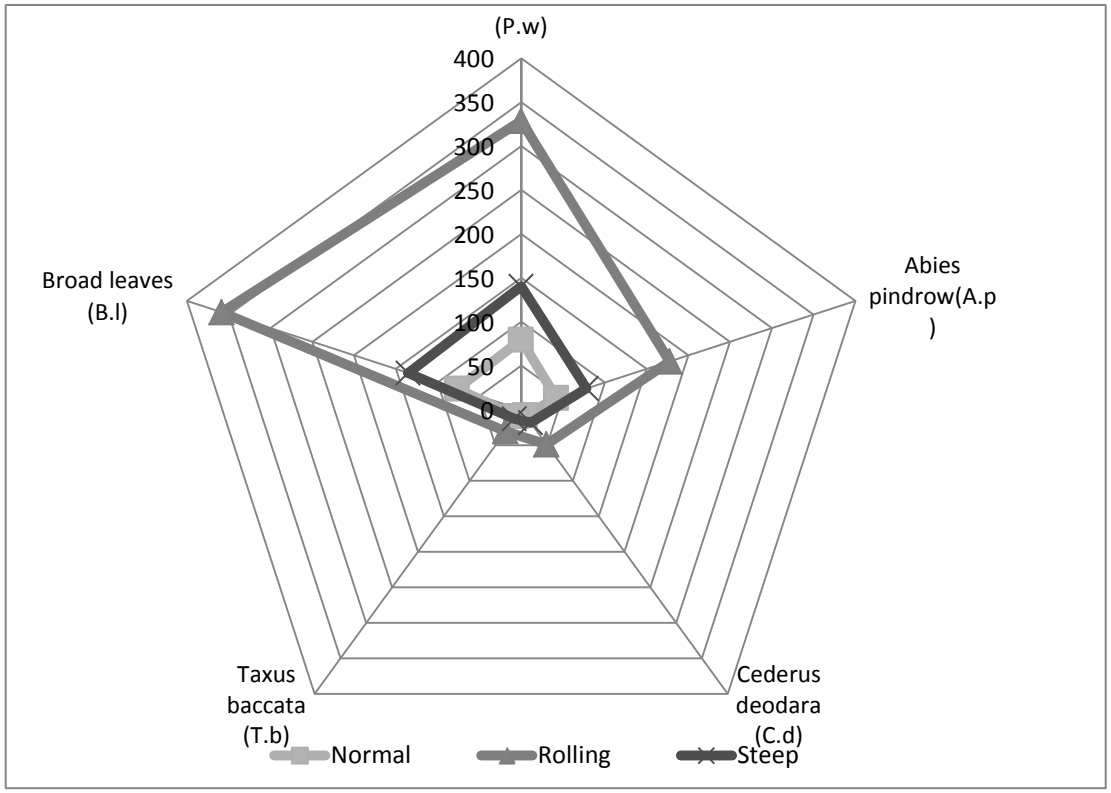

Fig. 3. Number of selected species on various categories of slope.

regeneration with the stand height less than 180 centimeters and diameter at breast height (DBH) less than 20 cm [22]. When height of a tree was greater than 180 cm and its diameter was between 20 cm and 24 cm, this growth stage of various species were labeled as *pole crop* and when diameter of a tree was greater than 24 cm it was categorized as *mother tree* (Table 2) [17].

3 RESULTS AND DISCUSSION

Five species were recorded in the selected sample plots. These species include *Pinus wallichiana* (P.w) *Abies pindrow* (A.p) *Cederus deodara* (C.d), *Taxus baccata* (T.b) and *broad leaves* (B.l). The data for the four selected indicators are presented in Table 3.

3.1 Frequency Ratio

The frequency ratio of regeneration in all 100 sampling plots was found in the range of 16% to 76% (Table 3). Minimum value was recorded for *Taxus baccata* and maximum value of frequency ratio was recorded for the *Pinus wallichiana*.

3.2 Density

The density (species / hectare) of regeneration was ranged from 0.51 to 5.9 ha^{-1}. It is evident from the Table 3 that Broad leaves specie was having a highest density followed by *Pinus wallichiana* (P.w) and *Cederus deodara* (C.d). Minimum value of density was recorded for *Taxus baccata*.

3.3 Abundance

Hubbell [21] was of the view that species abundance is a key indicator for determining biodiversity. Abundance is defined as total number individuals of specie in all sample plots per number of sample plots with that particular specie. According to Hussain [22], relative species abundance refer to how common (or rare) a species is relative to other species in a given location or community. The fields investigations (Table 3) clearly indicated that the regeneration of Broad leaves were in abundance (8.08) as compare to all other species. While the lowest value of abundance was found in *Cedrus deodara*.

3.4 Distribution Pattern

The vegetation in Ayubia National Park was mostly spread away in contiguous and somewhere in random pattern. From the results, it was evident that the *Pinus wallichiana*, *Abies pindrow* and *broad leaves* had the contiguous pattern of

Table 1. Number of plots taken in each forest block.

S. No.	Forest block	Area of each block (hectare)	%age of the total area	Number of selected plots from the block
1	Bagan	1006.83	30.40	31
2	Tajwal	35.21	1.06	1
3	Darwaza	108.87	3.29	3
4	Donga Gali	76.68	2.32	2
5	Kao	1763.27	53.24	53
6	Bakot	321.27	9.70	10
Total		**3312.13**	100	**100**

Table 2. Tree types and their measuring standard.

S. No.	Tree type	Measuring standards (cm)	
		Height	DBH
1	Regeneration	< 180	< 20
2	Pole crop	≥180	≥20 ≤ 24
3	Mother tree	>180	> 24

distribution whereas the *Cedrus deodara* and *Taxus baccata*was distributed in random. All the species were distributed in a random and contiguous pattern and no specie were recorded in regular pattern of distribution.

3.5 Comparison of Regeneration Density with the Densities of Pole Crops and Mother Trees

The regeneration of the forest is strongly correlated with the mother and pole crop trees as evident from Table 4. This correlation coefficient of regeneration density with the densities of pole is 0.6734 and coefficient of determination (R^2) indicates the fraction of the variance in the two variables is 0.4535. The coefficient of determination for the regeneration and mother trees is almost the same as that of pole tree yielding similar 'r' value compares densities of regeneration with pole crops and mother trees of the five selected species. Visual analysis of the table also indicates that the density per hectare of regeneration was significantly high for all type of species in the Park. The higher values of regeneration for broad leaves and *Pinus wallichiana* indicated good regeneration status for these species. The regeneration density of *Cedrus deodara (0.73)* and *Taxus baccata (0.51)* were comparatively lower but on the other hand it was higher than the Pole crops of *Cedrus deodara (0.08)* and *Taxus baccata (0.07). Abies pindrow* regeneration density (3.01) represented a dense canopy cover than density of mother trees (0.61) and Pole crops (0.27). *Cedrus deodara*was normally distributed and having relatively good regeneration (0.73) than pole (0.09) and mother trees (0.08). The regeneration density (0.51) of *Taxus baccata* had no major difference with the Pole crops and the Mother trees in collected densities. But in the overall results the high

Table 3. Scope of regeneration of selected species of coniferous forest in Ayubia National Park.

Species	Regeneration					
	Number of plots in which species occured	Number of individuals in all sample plots	Frequency ratio (Number of plots in which species occurred/ Total sample plots)*100	Density (Total individuals in all sample plots/ Total sample plots)	Abundance (Total individuals in all sample plots/number of sample plots with the species)	Distribution pattern (Abundance / Frequency ratio)
Pinus wallichiana (P.w)	76	530	76	5.3	6.97	0.092
Abies pindrow (A.p)	58	301	58	3.01	5.19	0.089
Cederus deodara (C.d)	24	73	24	0.73	3.04	0.127
Taxus baccata (T.b)	16	51	16	0.51	3.19	0.199
Broad leaves (B.l)	73	590	73	5.9	8.08	0.111

Table 4. Correlation analysis of density of regeneration against pole crop and mother tree.

Species	Regeneration	Pole crop	Mother tree	Correlation coefficient 'r'	
				Pole crop	Mother tree
Pinus wallichiana (P.w)	5.3	0.8	0.79		
Abies pindrow(A.p)	3.01	0.27	0.61		
Cederus deodara (C.d)	0.73	0.09	0.08	0.67	0.66
Taxus baccata (T.b)	0.51	0.07	0.07		
Broad leaves (B.l)	5.9	0.23	0.29		

regeneration status was recorded for Broad leaves (5.9) which were much denser than pole crops (0.23) and mother trees (0.29).

3.6 Impact of Aspect on Regeneration

The natural regeneration of the forest trees has a close relationship with the aspects, i.e., North and South of ground surface. The data were collected at both `North' `South' aspect. Data analysis revealed that the regeneration was slightly more at South aspect (56.61%) than the North aspect (40.38%) of the Ayubia National Park. Out of 40.38% at North aspect, 25.56% of regeneration was conifers and 14.82% were broad leaves. The regeneration of coniferous forest covered 35.73% and broad leaves 23.38% at south aspect out of 59.61% of vegetation density. The enriched natural regeneration of coniferous was observed at both aspects. In winter season, the north aspects are densely covered with snow and due to poor access to the sunlight snow cover melts slowly as compared to the south aspect where the snow layer melts early and rapidly. Hence at the south aspect, the ground became clear and provided a very fertile soil for good regeneration, so the south aspect was highly enriched with natural regeneration.

3.7 Slope and Regeneration

The rolling slope covers a high number of regeneration than normal or steep slopes respectively. The 60.8% of regeneration exists at rolling slope while 25.2% and 14.0%, at the steep and normal slopes respectively. Normally the vegetation grows at rolling slope because of balance water runoff, proper seed germination and control grazing activities. Most of the anthropological activities are concentrated at the normal slopes which is evident from existence of tracks and pathways. The snow accumulated mostly at Normal plains but little at rolling and steep slopes.

4 CONCLUSIONS

The research reveals that natural regeneration of the forest in Ayubia National Park is highly dense, frequent and has contiguous vegetation. All trees type (regeneration, pole crops and mother trees) of *Pinus wallichiana* are remarkably intense in terms of density, frequency and abundance followed by Broad leaves. *Taxus baccata* has measured in significantly poor status of natural regeneration because of the threats like forest fire and other anthropogenic activities. The natural regeneration of all trees of coniferous and broad leaves is good as compared to the growth of its Pole crop and Mother trees. The present natural regeneration is well distributed at South aspects than its growth on North aspects. Besides, a close relation is observed between the regeneration and terrain slope. The regeneration is frequent on the rolling (60.77%) followed by steep (25.24%) and normal slopes (13.98%). Different threats like forest logging and cutting, forest fire, grazing pressure, trampling, fuel wood, and severe climatic condition adversely affect the natural regeneration of Ayubia National Park forest. On these basis it is concluded that the overall status of regeneration hovers between good to moderate though some conifer species are facing various threats to its proper growth and nourishment. As regeneration of coniferous forest was rapid on the southern aspect, therefore anthropogenic activities needs to be monitored so as these does not affect the natural regeneration of the forest cover. The Wildlife and Forest Department must work in collaboration to maintain the existing ecosystem so that natural regeneration is not affected.

5. REFERENCES

1 Chadwick D.O., & B.C. Larson. *Forest Stand Dynamics*. John Wiley and Sons, Turin, Italy (1996).

2 Borghetti, M., & R. Giannini. Natural regeneration in Woodland management. *Encyclopedia of Life Support Systems.* Eolss Publishers, Oxford, UK (2001).

3 GOP. *National Parks of Pakistan*. Wildlife Department of Pakistan Pathway: http://www.wildlifeofpakistan.com/national_parks.html, updated at 05-05-2013 (2013).

4 Hardwick, K., L. Healey, S. Elliott, N. Garwood, & V. Anusarnsunthorn. Understanding and assisting natural regeneration processes in degraded seasonal evergreen forests in northern Thailand. *Forest Ecology and Management* 99:203-214 (1997).

5 Holland, P.G., & D.G. Steyn. Vegetational responses to latitudinal variations in slope angle and aspect. *Journal of Biogeography* 03: 179-183 (1975).

6 Cantlon, J.E. Vegetation and microclimates on north and south slopes of Cushetunk Mountain, New Jersey. *Ecological Monographs* 23: 241-270 (1953).

7 Kutiel, P., & H. Lavee. Effect of slope aspect on soil and vegetation properties along an aridity transect. *Israel Journal of Plant Sciences* 47: 169-178 (1999).

8 Kirkpatrick, J.B., R.J. Fensham, M. Nunez, & D.M.J.S. Bowman. Vegetation-radiation relationships in the wet-dry tropics: granite hills in northern Australia. *Vegetation* 76: 103-112(1988).

9 Vetaas, O.R. Gradients in field-layer vegetation on an arid misty mountain plateau in the Sudan. *Journal of Vegetation Science* 3: 527-534 (1992).

10 Ghimire, B., K.P. Mainali, H.D.Lekhak, R.P. Chaudhary, & A.K. Ghimeray. Regeneration of *Pinuswallichiana*AB Jackson in a trans-Himalayan dry valley of north-central Nepal. *Himalayan Journal of Sciences* 6: 19-26 (2011).

11 Paudel, S., & O.R. Vetaas. Effects of topography and land use on woody plant species composition and beta diversity in an arid Trans-Himalayan landscape, Nepal. *Journal of Mountain Science* 11: 1112-1122 (2014).

12 Pook, E.W. The influence of aspect on the composition and structure of dry sclerophyll forest on Black Mountain, Canberra. ACT. *Australian Journal of Botany* 14: 223-242 (1966).

13 Khattak, G.M. The occurrence of natural regeneration in the Fir (*Abiespindrow*) forets of Kaghan. *Pakistan Journal of Forestry* 20: 157-62 (1970).

14 Walayat. S and Siranjam. *Rapid Vulnerability Assessment of Medicinal and Aromatic Plants of NathiaGali, Galliat district Abbottabad.* Thesis Department of Environment Science, University of Peshawar (2008).

15 WWF.*Boundary Delineation of Ayubia National Par.*, GIS Laboratory, WWF-Pakistan, Peshawar (2008).

16 WWF-P, Peshawar. *Annual Technical Report on Conservation and Training in Applied Ethno Botany*, Project No. 9, zo556 (1997).

17 Shaheen R. K,& N. Asad. *Indigenous Rights and Biodiversity Conservation: A Case Study of Ayubia National Park*. Working Paper 52, Sustainable Development Policy Institute, Islamabad, Pakistan (2000).

18 Haider, S.*Impact Assessment of Interventions Adopted by Resources at Ayubia National Park*, M.Sc. thesis, Department of Environmental Sciences, University of Peshawar, Peshawar(2003).

19 Shafique, C.M.*Some Aspects of Bio-ecology of AyubiaNational Park, NWFP, Pakistan*. Ph.D. thesis, Department of Zoology, University of Karachi, Karachi (2003).

20 GOP (Government of Pakistan). *Regeneration of Mountain Forests and Impact Study of Past Forest Management System in Azad Jammu and Kashmir*. Pakistan Forest Institute, Peshawar (2013).

21 Hubbell, S. P. *The Unified Neutral Theory of Biodiversity and Biogeography (MPB-32),* Vol. 32. Princeton University Press (2001).

22 Hussain, S.K.*Regeneration and Harvest Study of Pinusgeradiana (Chilghoza pine) in Suleiman Mountain Range, District Zhob, Balochistan*. WWF-Pakistan, Peshawar (2006).