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STRUCTURAL DIVERSITY, VEGETATION DYNAMICS AND ANTHROPOGENIC IMPACT ON LESSER HIMALAYAN SUBTROPICAL FORESTS OF BAGH DISTRICT, KASHMIR

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Abstract

Patterns of species composition and diversity in the lesser Himalayan subtropical forests of Kashmir were studied in relation to environmental variables and underlying anthropogenic influence. Simpson's diversity ranged from 0.85 to 1.96; Menhinick's diversity, 1.49 to 1.37; evenness, 0.23 to 0.61; average species richness per site, 36 to 40 and maturity index, 41 to 44. Deterrended correspondence analyses (DCA) revealed the altitude as the most influential factor controlling species distribution pattern. Diversity values were similar to the other Himalayan forests, whereas density, basal area and seedling count were very low. 89.6% of the human population was dependent on forest resources for fuel and energy requirements. Annual fuel wood consumption was 6.7 metric tons, 2.2 kg $capita^{-1}day^{-1}$. High deforestation and disturbed regeneration patterns were indicated by a stem/stump ratio of 1.9; a tree density of $344ha^{-1}$; tree basal area of $69.3m^2ha^{-1}$ and only 212 seedlings ha^{-1}. A sharp decline in forest vegetation attributes occurred with increased levels of human and livestock interference.

Introduction

Forest composition, community structure and diversity patterns are important ecological attributes significantly correlated with prevailing environmental as well as anthropogenic variables (Gairola *et al.*, 2008; Timilsina *et al.*, 2007; Ahmad *et al.*, 2010). The lesser Himalayan region, with a 900-1800m altitudinal range, is colonized by subtropical broadleaved forests, mainly dominated by Chir pine (*Pinus roxburghii*) and Oak (*Quercus*) species (Kharakwal & Rawat, 2010). The forest diversity patterns and governing environmental as well as anthropogenic variables in the Himalayan subtropical region have been studied in the past by Phytosociologists (Todoria *et al.*, 2010; Kharakwal *et al.,* 2009; Gairola, 2008; Ahmed *et al.*, 2006; Kunwar & Sharma, 2004). Himalayan forests are considered to be among the globe's most depleted forests (Duke, 1994; Schickhoff, 1995; Shaheen *et al.*, 2011); this has been attributed to the high population increase, associated with land use changes, socio-economic transformations and unsustainable exploitation of natural forest resources (Nayar & Sastry, 1990; Ghosh, 1994; 1981; Myers, 1986).

Three quarters of the western Himalayan forest cover have been lost in last century (Joshi *et al.,* 2001). Eight percent loss in the Eastern and 23% in the western Himalayas has been occurred in last three decades (FSI, 2005), or 17% (2364 x 10^3ha) for the two halves between 1975 and 2000 (Conservation International, 2005). In Pakistan overall only 4.8% of land remains covered with forest, with an annual deforestation rate of more than 3% (FAO, 2005; Cronin & Pandya, 2009). Pakistan lost 24.7% of its forest cover in just 15 years, from 1990 to 2005 (Abbasi, 2006). Oza, 2003 has discussed the destruction of forests in Kashmir valley. A 27% (821 x 10^3 ha) loss of forest cover was recorded in Jammu & Kashmir by using satellite imagery from 1970 to 2000 (Valdiya, 2002). The impacts of timber harvesting on forest biodiversity and ecosystem functioning have been subject to research (Putz *et al.*, 2001; Meijard *et al.*, 2005; Asner *et al.,* 2006). The variations in community attributes are directly correlated with the intensity of variables like geographical location, productivity, evolutionary competition and human-forest interaction (Eriksson, 1996; Criddle *et al.*, 2003; Ahmad *et al.*, 2011).

In the present study we have analyzed forest harvest and wood extraction scenarios under varying intensities of anthropogenic pressure as well as environmental variables. The changes in diversity and composition of forest stands under these conditions have also been assessed. Our aim was to develop a better understanding of long term forest harvest impacts leading to a sustainable use of local forests reserves in Himalayas.

Materials and Methods

Bagh district lies between 73° - 75° East and 33° - 36° North having sub tropical to moist temperate vegetation, with 54.58% area under forest cover. It is located in the Pirpanjal sub range of the western Himalayan foothills. The total area of the district is 1368Sq.Km, which is about 10% of total land area of Azad Jammu & Kashmir (Anon., 1998). Population of Bagh is about 0.434 million, with an annual growth rate of 2% (Anon., 2007). Some 94% of the population lives in rural areas. The elevation is between 1000 and 2200 m.a.s.l. Average annual temperature is 21°C, ranging from 2°C in January to 40°C in July. The annual precipitation is about 1500 mm (Anon., 2005, 2008).

The study was carried out during June 2008 to March 2009 starting with a preliminary survey in the 9 village communities to collect data about their socio-economic indicators and dependency on forest resources. The data about family size, land holding, herd size and available grazing area was obtained through the field survey questionnaire method (Ogunkunle & Oladele, 2004). A total of 180 questionnaires (20 /site) were administrated in the study area. The quantity of fuelwood consumption was measured over a period of 24 hrs using a weight survey method (Mitchell, 1979; Bhatt *et al*., 1994). Each sampled household was visited randomly round the year to record the firewood consumption. Initially, a wood lot was weighed and left in the kitchen and the household was requested to burn wood only from this bundle. After 24 hrs, the actual fuelwood consumption was measured. From this value, fuelwood consumption in kilogram/capita/day was calculated for each site.

Expeditions to the three subtropical forest sites were conducted during spring and summer 2008-9 using extensive and detailed surveys in accordance with specific locality procedures (Cox, 1967; Ford, 1978). Quadrat method was used for sampling vegetation. Quadrat sizes of 30 x 30 m (900m^2) were used for trees; 5 x 5 m (25m^2) for shrubs; and 1 x 1 m (1m^2) for herbs and grasses. Sampling was started at each site from the beginning of forest, at an average distance of 100 m from the edge. Then onwards, quadrats were laid at every 250 m distance, until the vegetation climax was reached. Co-ordinates recorded were altitude, longitude and latitude of each site using a Garmin 2000 global positioning system (GPS). Seedling and stump count per ha were calculated synchronized with the laid quadrats after every 250 m distance.

Simpson's (1949), Menhinick's (1964) and Shannon-Weiner's (1948) indices of diversity were calculated. Simpson's diversity index gives the probability that two individuals selected at random will belong to the same species. It was calculated as:

$$D = 1 - \frac{N(N-1)}{\Sigma n(n-1)},$$

where D = Diversity index; n = Number of individual of a species; N = Number of individual of all the species. Shannon's index is a measure of the amount of information needed to describe every member of the community, where p_i is the proportion of individuals (from the sample total) of species i, and diversity (H') is:

$$H' = -\sum_{i=1}^{s} p_i p_i l_n p_i$$

Species evenness was calculated using the Shannon evenness index: **E = H'/ln S**; where H' is the Shannon–Wiener diversity index and S is species number. The Shannon evenness index ranges from zero (when one species is dominant) to one (when all species are equally abundant). Menhinick's (1964) index was calculated as:

$$d = \frac{S}{\sqrt{N}}$$

where d 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 after Pichi-Sermollis method (1948) as:

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

The index of similarity was calculated after Sorenson (1948) by using importance values. The lowest values in two communities were considered for comparison.

$$IS_s = \frac{2C}{A+B} \times 100$$

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. The CANOCO version 4.5 was used to carry out Detrrended correspondence analyses (DCA) of studied forest vegetation (ter Braak & Smilauer, 2002).

Results

A total of 72 species belonging to 31 families were recorded from the area. These communities were dominated by *Pinus roxburghii* (18.53%), *Quercus ilex* (6.57%0 and *Quercus dilatata* (6.41%) respectively. Co dominant tree species included *Pinus wallichiana* (5.11%), *Olea cuspidata* (2.34%) and *Punica granatum* (2.21%). *Pinus wallichiana* was found in upper limits of only one subtropical site (Saiyagalla) in 45000-5500 feet a.s.l. altitudinal range. Shrub layer was dominated by *Dodonea viscosa* (4.22%), *Sarcococca saligna* (4.04%) and *Berberis lycium* (1.15%). The ground stratum in subtropical communities comprised mainly of *Arthraxon prionodes* (2.29%), *Micromeria biflora* (1.56%), *Dactylis glomerata* (1.51%) and *Ajuga bracteosa* (1.43%).

Average land holding in the area was found to be 2.54 acres per family. Herd size was 3 with an average available grazing area of 0.55 acres unit^{-1}. An average amount of 6.7 metric tons of fuelwood was measured to be consumed per house hold annually. Average per capita fuelwood consumption was calculated to be 2.2 kg^{-1} (Table 3). 89.6% population of village communities was found dependent on forest wood for their fuel and energy requirements. Out of 180 surveyed households in lower Bagh zone, 103 (57.3%) were found completely dependent on forest wood; 19 (10.5%) used Liquid Propane gas where as remaining 58 (32.3%) used both the forest wood and LPG gas as fuel source for cooking and heating. Recorded tree density for the Subtropical zone in Bagh was 344 ha^{-1}, tree basal area of 69.31 m² ha^{-1}; average stem/stump ratio of 1.62 and an average seedling count of 211ha^{-1} (Tables 2, 3). Nampra showed the maximum seedling count of 311 ha^{-1}whereas Saiyagalla had the lowest of 123ha^{-1}. Shannon-Wiener's diversity value for the subtropical forests was 1.3 with a minimum of 0.83 at Nampra and maximum of 1.77 at Maira sites. Simpson's diversity value in subtropical zones was 0.91. The study sites showed very low species richness values in a range of 0.9-1.8. The average species richness at the sites ranged from 36-40 (Table 4). The Maira and Nampra sites were the low altitudinal (1000-1500 m) sites in the study area dominated by *Pinus wallichiana, Quercus dilate* and *Olea cuspidata,* showing significantly similar (59.6%) to each other. However they showed a striking dissimilarity of 12.32% and 2.9% with the Saiyagalla site, located at relatively higher (1400-1800 m) range dominated by *Quercus ilex* and *Pinus wallichiana*.

DCA analyses generated three clearly differentiated species clusters. Altitude appears to be the main limiting factor determining the species distribution at studied sites. The lower Nampra & Maira site's (1000-1500 m), vegetation is grouped at the left most of ordination axis (Fig. 1). This group is dominated by typical subtropical species like *Pinus roxburghii, Q. dilatata, Olea cuspidata* and *Dodonea viscosa*. The higher Saiyagalla site's (1400-1800 m) species are grouped at the right most. This zone behaves like an ecotone between subtropical and moist temperate zones indicated by the presence of some moist temperate members like *P. wallichiana, Q. Ilex, Viburnum grandiflorum* and *Poa alpina*. The central cluster is composed herbaceous flora having broad ecological amplitude, common in upper and lower subtropical limits. Altitudinal based temperature and moisture gradient is the most probable reason for this sub grouping of subtropical vegetation. This clustering is also supported by Sorenson's similarity tests showing high (60%) similarity of lower, Nampra & Maira, sites among themselves whereas strong (85-88%) dissimilarity with upper Saiyagalla sites.

Discussion

Present study revealed alarmingly high level of fuelwood consumption in the western Himalayan communities of Bagh. Area showed an annual fuelwood consumption of 6.7 metric tons per household. In terms of kg capita^{-1} day^{-1}, fuelwood consumption was 2.19 in lower Bagh (Table 3). Results of similar investigations in other Himalayan regions show that consumption level in study area is considerably higher than those like 1.5 kg capita^{-1} day^{-1} in rural and tribal communities of the western Himalayas (Bhatt *et al*., 1994); 1.9–2.1 kg capita^{-1} day^{-1} in Southern India (Hedge, 1984); 1.6–2.4 kg capita^{-1} day^{-1} in South-East Asia (Donovan, 1981) and 1.24 kg capita^{-1} day^{-1} in trans-Himalayan Nepali communities (Mahat *et al*., 1987). In present study stem/stump ratio was used to estimate the degree of tree felling and logging. Immense, unchecked and horrible deforestation phenomenon is represented by a terribly small stem/stump ratio of 1.9 (Table 1). A strong correlation was observed between tree felling intensity and population density, fuelwood consumption level as well as ease of access in the area (Shinwari, 2003). The forest sites surrounded by larger villages and having easy road access represented lower stem/stump values. The lowest values were observed in initial 1000 meters forest margins while maximum tree/stump ratios were recorded at the forest centre, fairly away from the settlements. The very initial forest margins within 1st 500 meters showed relatively higher values than the latter 500 meters. It is due to the fact that people usually try to mask and hide tree felling from the authorities which often pay visits for the forest inspection, but usually restricted to the margins. So the people mostly exploit the latter 500 meter zone with some camouflage provided by initial forest margin (Butt, 2006).

Table 1. Stem/stump ratio & seedling count along the distance gradient at studied sites.

Site name↓	Distance from disturbance stimuli (Meters) →								→		→	
	100	350	600	850	1100	1350	1600	1850	2100	2350	Av/900m²	Av/ha
	Number of seedlings/quadrate↓								↓		↓	
Maira	29	21	23	17	12	29	33	29	41	45	28	313
Nampra	41	32	17	23	12	12	3	7	12	14	18	201
Saiyagalla	0	2	13	11	22	9	16	11	13	9	11	124
Av(900m²)	23	18	17	17	15	16	17	15	22	22	19	212
Av/ha	256	199	190	188	167	177	191	165	243	238	212	212
Site name↓	Distance from settlements (Meters)								→		→	
	100	350	600	850	1100	1350	1600	1850	2100	2350	Av/900m²	Av/ha
	Stem/stump ratios ↓								↓			
Maira	0.79	1.24	0.69	0.44	2.13	3	1.52	1.59	2.04	2.45	1.6	1.6
Nampra	1.81	1.83	1.06	1.41	1.62	1.59	2.29	1.34	4	2.24	1.9	1.9
Saiyagalla	0.86	0.64	0.47	0.57	0.67	0.87	2.64	3.1	5.15	6.6	2.2	2.2
Average	1.15	1.23	0.74	0.81	1.47	1.82	2.15	2.01	3.73	3.76	1.9	1.9

Table 2. Comparison of tree density values in study area with different Himalayan regions.

Forest type	Density ha^{-1}	Geographic region	Source
Quercus dilatata-P. roxburghii	**344**	**Kashmir, Western Himalayas**	**Present study**
Q. semecarpifolia -P. roxburghii	530-940	Kumaun, Central Himalayas	Kharkwal *et al*., 2009.
Q. leucotrichophora	790-1059	Gharwal, Himalayas	Todoria *et al*., 2010.
Q. lanuginosa- P. roxburghii	341-462	Nepal, Trans Himalayas	Subedi & Shkya, 1988.
Q. leucotrichophora	1158	Himachel, western Himalayas	Sharma *et al*., 2008.

Table 3. Village wise fuelwood consumption, land holding, herd size and grazing area.

Village name	Elevation m.a.s.l.	Av. family size	Fuelwood consumption		Land holding/ family (acres)	Herd size	Av grazing area/unit (acres)
			Metric tons (annual)	Kg capita^{-1} day^{-1}			
Kafalgarh	151 ± 60	10 ± 3	8.4 ± 1.5	2.25 ± 0.9	06 ± 20	4 ± 2	0.88
Channala	1395 ± 90	8 ± 2	7.8 ± 1.0	2.6 ± 0.9	1.8 ± 0.5	3 ± 1	0.26
Kaila	1450 ± 11	10 ± 4	6.22 ± 0.8	1.63 ± 0.4	2.2 ± 0.3	3 ± 2	0.34
Gahlan	1345 ± 40	8 ± 3	6.6 ± 1.2	2.15 ± 0.9	1.2 ± 0.5	4 ± 2	0.12
Bhagloor	1180 ± 50	8 ± 2	7.16 ± 0.9	2.5 ± 0.6	3.9 ± 0.9	3 ± 1	0.84
Sahlian	1175 ± 70	7 ± 1	6.7 ± 0.7	2.8 ± 0.9	2.05 ± 0.3	2 ± 1	0.54
Nindhrai	1205 ± 90	8 ± 1	2.2 ± 0.3	0.7 ± 0.05	1.23 ± 0.4	1	0.58
Nampra	1020 ± 11	7 ± 3	8.03 ± 2.3	3.3 ± 0.6	2.4 ± 10	2 ± 1	0.52
Patrata	1100 ± 10	9 ± 2	6.8 ± 1.8	2.02 ± 0.2	2.2 ± 0.7	1	0.8
MEAN	1270	8	6.7	2.2	2.6	3	0.55

Table 4. Quantitative phytosociological attributes of subtropical forest communities.

Forest type	Site name	"N"	"D"	"H'"	"J"	"M"	"S"
Q. ilex-P. Wallichiana	Saiyagalla	40	0.92	1.96	0.61	42.82	1.37
Q. dilatata-P. roxburghii	Maira	37	0.91	1.77	0.49	44.45	1.22
P. roxburghii-Dodonea viscosa	Nampra	36	0.93	0.83	0.23	40.71	1.49

(**N:** Species number, **D:** Simpson's diversity, **H**: Shannon's diversity, **J**: Evenness, **M**: Maturity index, **S**: Richness)

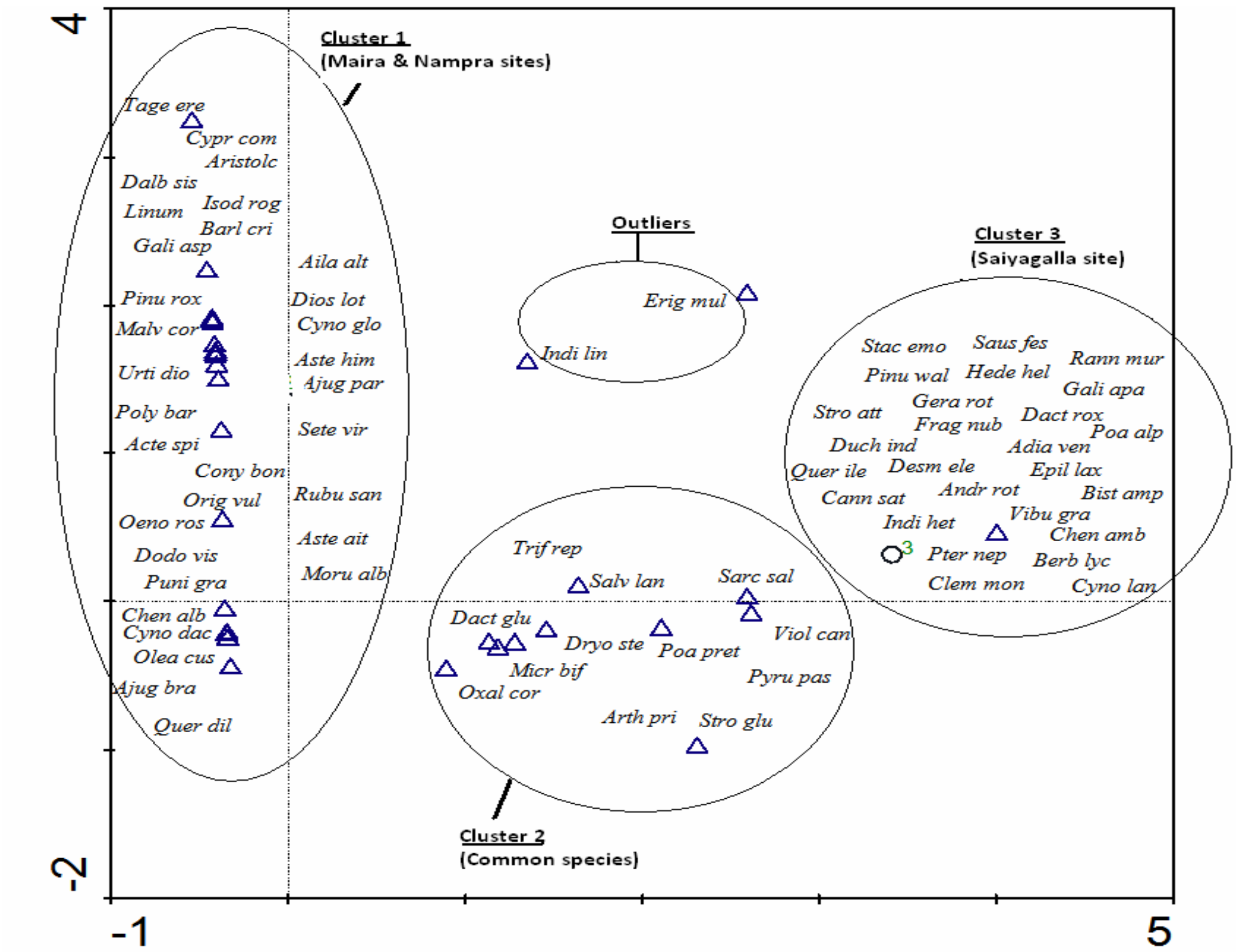

Fig. 1. DCA diagram of species distribution pattern in subtropical forest stands of Bagh Himalayas.

Recorded tree density was 344 ha^{-1}in the subtropical forests showing deteriorated forest structure (Table 2). This value is far less than the subtropical forest investigations in other Himalayan regions like 534-620 ha^{-1} in lesser Himalayas (Ahmed *et al*., 2006); 1158 in Himachel Pradeh, western Himalayas (Sharma *et al*., 2008, Sundriyal *et al*., 1994); 530-940 ha^{-1} in Kumaun Himalayas (Kharkwal *et al*., 2009, Hussain *et al*., 2008); 790-1059 ha^{-1} in Gharwal Himalayas (Kusumlata & Bisth, 1991; Todoria *et al*., 2010) and 341-462 ha^{-1} in Nepal broadleaved forests (Subedi & Shakya, 1988). The recorded diversity values of 0.83 to 1.96 lie more or less within the reported range of 0.91 to 3 for Himalayan range (Pande, 2001; Mishra *et al*., 2003; Sharma *et al.,* 2009). A slow rate of evolution and community stabilization along with relatively drier climatic conditions can also be responsible for the low diversity values of subtropical forest as compared to highly diverse tropical and temperate vegetation (Conell & Oris, 1964). Recorded species richness in the range of 36-40 is in accordance with the results of several related phytosociological investigations in Himalayas (Behra *et al*., 2005; Kharakwal *et al*., 2009).

Identified vegetation communities in the study area showed maturity index scores less than 50 indicating the unbalance and immaturity and heterogeneity within communities due to a lesser adaptation to the ecological conditions of area. The high intensity of anthropogenic disturbances regularly disturbs the natural balance of forest and alpine vegetation communities, thus preventing them to reach a climax stage of community maturity (Saxena & Singh, 1984). This phenomenon is evident from the heavy grazing and tree felling in studies sites. The non timber forest products including medicinal Plants etc are also over collected and being utilized by various industries (Shinwari, 2010) though they are source of cure to many diseases and have high quality micronutrients (Hussain *et al*., 2009).

Average herd size recorded in the area was 3 with an average grazing area of 0.41acres/cattle, about 20 times lesser than the ecologically permissible limit of 8.51 acres/grazing unit/year for Himalayan region (Singh *et al*., 1984). Consequently the grazing pressure shifts to the surrounding forest reserves creating a massive stress on forest ground flora, shrubs and most important, the seedlings (Negi, 2009). This was evident from the observed heavy grazing activity at the sites. The forests showed regeneration rate of 212 seedlings ha^{-1}. Highest seedling concentrations (230-250 ha^{-1}) were recorded in the lower and upper forest margins as compared to centre (Table 1). The high seedling density in very initial forest margins is possibly due to some of departmental plantation schemes. Higher seedling count in upper forest margins away from settlements b is because of lesser intensity of human and live stock disturbances (Dalling *et al*., 1996).

Preferred fuel wood tree species including *Quercus ilex, Quercus dilatata, Pinus wallichiana and Pinus roxburghii* are under immense pressure**.** On one hand due to fuel wood and timber demands, very heavy extraction is going on in the local forest reserves. While on the other hand due to limited grazing area available for the livestock, over and illegal grazing of demarcated forest areas is threatening the growing seedlings of these tree species (Oza, 1980, 2003; Alam & Ali, 2010). Himalayan people have to think seriously to protect their vital, overexploited and rapidly dying forest resources (Oza, 1985; Kharakwal *et al*., 2009). Forests reserves are the only fuel wood and timber source for poor mountain people. There is an urgent need to develop a conservation management policy for the sustainable use of local forest lands which should include improving the socio-economic status of locals; providing them alternative fuel/timber sources.

References

Abassi, A. 2006. deforestation & drought, www.chowki.com.

Ahmad, I., M.S.A. Ahmad, M. Hussain and M. Ashraf. 2011. Spatiotemporal variations in soil characteristics and nutrient availability in open scrub type semi-arid rangelands of typical sub-mountainous Himalayan tract. *Pak. J. Bot.*, 43(1): 565-571.

Ahmad, I., M.S.A. Ahmad, M. Hussain, M. Ashraf, M.Y. Ashraf and M. Hameed. 2010. Spatiotemporal aspects of plant community structure in open scrub rangelands of sub-mountainous Himalayan plateaus. *Pak. J. Bot.,* 42(5): 3431-3440.

Ahmed, M., T. Husain, A.H.S. Heikh, S.S. Hussain and M Siddiqui. 2006. Phytosociology and structure of Himalayan forests from different climatic zones of Pakistan *Pak. J. Bot*., 38(2): 361-383

Alam, J. and S.I. Ali. 2010. Contribution to the red list of the plants of Pakistan. *Pak. J. Bot*., 42(5): 2967-2971, 2010.

Anonymous. 1998. District census report Bagh, AJ& K.

Anonymous. 2005. FAO News room, News stories. Deforestation continues.

Anonymous. 2005. FSI (Forest Survey of India). The State of Forest Report 2003. Dehradun, FSI, Ministry of Environment and Forests, Government of India

Anonymous. 2005. Pakistan Meteorological Dept. Islamabad

Anonymous. 2007. AJK at a glance, P &D dept. Govt. of AJ & K

Anonymous. 2008. www.pm.ajk.gov. Official website of AJ& K Government.

Asner, G.P., E.N. Broadbent, P.J.C. Oliveira, M. Keller, D.E. Knapp and J.N.M. Silva. 2006. Condition and fate of logged forests in the Brazilian Amazon. *Proc Natl Acad Sci USA*., 103: 12947-12950.

Behera MD and PS Roy, 2005, Assessment of biological richness in different altitudinal zones in the Eastern Himalayas, Arunachal Pradesh, India. *Current Science*, 88(2): 25.

Bhatt, B.P., A.K. Negi and N.P. Todaria. 1994. Fuelwood consumption pattern at different altitudes in Garhwal Himalaya. *Energy*, 1994 19(4): 465-8.

Butt, T.M. 2006. Sustainable forest management: A case study on Machiara national park in district Muzaffarabad, state of Azad Jammu and Kashmir, Pakistan, A thesis for the degree of MPhil in development studies (specializing in geography) department of Geography Norwegian University of science and technology.

Conell, J.H. and E. Oris. 1964. The ecological regulation of species diversity. American Naturalist 1964; 48: 399-414.

Cox, W.G. 1967. *Laboratory Manual of General Ecology*. WMC Brown Co. Dubuque, IA.

Criddle, R.S., J.N. Church, B.N. Smith and L.D. Hansen. 2003. Fundamental causes of the global patterns of species range and richness. *Russ. J. Plant Physiol*., 50: 192-199.

Cronin, R. and A. Pandya. 2009. Eds, exploiting natural resources, growth, instability, and conflict in the middle east and Asia. The Henry L. Stimson Center, ISBN: 978-0-9821935-0-1

Dalling, J.W., S.P. Hubbel and K. Silvera 1998. Seed dispersal, seedling establishment and gap partitioning among tropical pioneer trees. *J. Ecol*., 86: 674-689.

Donovan, D.G. 1981. Fuelwood: How Much Do We Need? Institute of Current World Affairs, Hanover, N.H., p. 23.

Duke, G. 1994. A participatory approach to conservation safeguarding the Himalayan forests of the Palas valley, District Kohistan. In: Asian Study Group (Afghanistan Circle), editors. The Destruction of the Forests and Wooden Architecture of Eastern Afghanistan and Northern Pakistan: Nuristan to Baltistan. Islamabad, Pakistan: Asian Study Group, pp. 40-48.

Eriksson, O. 1996. Regional dynamics of plants: Review of evidence for remnant, source-sink and meta-populations. *Oikos*, 77: 248-258.

Ford, R.L. 1978. The nature and status of ethnobotany. In: Ford RL, editor. Anthropological Papers. Museum of Anthropology, University of Michigan, USA; 1978.

Gairola, S., R.S. Rawal and N.P Todaria. 2008. Forest vegetation patterns along an altitudinal gradient in sub-alpine zone of west Himalaya, India. *African Journal of Plant Science*, 2(6): 042-048.

Ghosh, P.K. 1994. The red data book on Indian animals (Part I Vertebrata). Zoological Survey of India, Calcutta.

Hegde, M.S. 1984. Fuel problem in villages: challenges and opportunities. *Bulletin of Science*, 8: 8-13.

Hussain, J.A., L. Khan, N. Rehman, M. Hamayun, Z.K. Shinwari, W. Malik and I.J. Lee. 2009. Assessment of herbal products and their composite medicinal plants through proximate and micronutrients analysis. *Journ. Med. Pl. Res*., 3(12): 1072-1077.

Hussain, M.S., A. Sultana, J.A. Khan and A. Khan. 2008, Species composition and community structure of forest stands in Kumaon Himalaya, Uttarakhand, India. *Tropical Ecology*, 49(2): 167-181.

Joshi, P.K., S. Singh, S. Agarwal and P.S. Roy. 2001. Forest cover assessment in western Himalayas, Himachal Pradesh using IRS 1C/1D WiFS data. *Curr Sci*., 80: 941-947.

Kharkwal, G. 2009. Qualitative analysis of tree species in evergreen forests of Kumaun Himalaya, Uttarakhand, India. *African Journal of Plant Science*, 3(3): 049-052.

Kharkwal, G. and Y.S. Rawat. 2010. Structure and composition of vegetation in subtropical forest of Kumaun Himalaya. *African Journal of Plant Science*, 4(4): 116-121.

Kunwar, R.M. and S.P. Sharma. 2004. Quantitative analysis of tree species in two community forests of Dolpa district, mid-west Nepal. *Him J Sci*., 2(3): 23-28.

Kusumlata and N.S. Bisht. 1991. Quantitative analysis and regeneration potential of moist temperate forest in Garhwal Himalaya. *Indian Journal of Forestry*, 14(2): 98-106.

Mahat, T.B.S., D.M. Grigffin and K.P. Shepherd. 1987. Human impact on some forest of the middle hills of Nepal. Part 4: A detailed study in Southeast Sindhu Palanchock and Northeast Kabhere Palanchock. *Mountain Research and Development*, 7: 114-134.

Meijard, E., D. Sheil, R. Nasi, D. Augeri, B. Rosenbaum, D. Iskandar, T. Setyawati, M. Lammertink, I. Rachmatika, A. Wong, T. Soehartono, and T. O'Brien. 2005. Life after logging: reconciling wildlife conservation and production forestry in Indonesian Borneo. Bogor, Indonesia: Center for International Forestry Research.

Menhinick, E.F. 1964. A Comparison of some species diversity indices applied to samples of field insects. *Ecology*; 45: 859-861.

Mishra, C., H.T. Prins and Van Wieren. 2003. Diversity, Risk Mediation, and Change in a Trans-Himalayan Agropastoral System, *Human Ecology*, 31(4): 595-609.

Mitchell, R. 1979. An Analysis of Indian Agro-ecosystem. Interprint, New Delhi, India, p. 180.

Myers, N. 1986. Environmental repercussions of deforestation in the Himalayas. *Journal of World Forest Resource Management*, 2: 63-72.

Nayar, M.P. and A.R.K. Sastry. 1990. Red data book of Indian plants. vol. III. Botanical Survey of India, Calcutta

Negi, S.P. 2009. Forest Cover in Indian Himalayan states, An Overview. *Indian Journal of Forestry*, 32(1): 1-5.

Ogunkunle and Oladele. 2004 Ethnobotanical study of fuelwood and timber wood consumption and replenishment in Ogbomoso, Oyo state, Nigeria *.Environmental Monitoring and Assessment*, 91: 223-236.

Oza, G.M. 1980. Threat to the Chir and Fir Forests of Kashmir. *Environmental Conservation*, 7(1): 31-32.

Oza, G.M. 1985. Human Impact on Kashmir Himalayan Bird Populations. *The Environmentalist*, 5(4): 293-296.

Oza, G.M. 2003. Destruction of Forests and Wildlife in the Kashmir Wilderness. *The Environmentalist*, 23: 189-192.

Pande, P.K. 2001. Quantitative vegetation analysis as per aspect and altitude, and regeneration behaviour of tree species in Garhwal Himalayan forest, *An For*., 9(1): 39-52.

Putz, F.E., G.M. Blate, K.H. Redford, R. Fimbel and J. Robinson. 2001. Tropical forest management and conservation of biodiversity: an overview. *Conserv Biol*., 15: 7-20.

Rodolfo, E. Pichi-Sermolli. 1948. An index for establishing the degree of maturity in plant communities author(s): source. *Journal of Ecology*, 36(1): 85-90.

Saxena, A.K. and J.S. Singh. 1984. Tree population structure of certain Himalayan forests and implications concerning the future composition. *Vegetatio*, 58: 61-69.

Schickhoff, U. 1995. Himalayan forest-cover change in historical perspective: A case study from the Kaghan Valley, Northern Pakistan. *Mountain Research and Development*, 15(1): 3-18.

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

Shannon, C.E. 1948. A mathematical theory of communication. *Bell System Technical Journal*, 27: 379-423 and 623-656.

Sharma, C.M., S.K. Ghildiyal, S. Gairola and S. Suyal. 2009. Vegetation structure, composition and diversity in relation to the soil characteristics of temperate mixed broad-leaved forest along an altitudinal gradient in Garhwal Himalaya, *Ind. J. Sci. Technol*., 2(7): 39-45.

Sharma, R.K., PL Sankhayan and Ole Hofstad. 2008. Forest biomass density, utilization and production dynamics in a western Himalayan watershed. *Journal of Forestry Research*, 19(3): 171-180.

Shinwari, Z.K. and Syed Shahinshah Gilani. 2003. Sustainable harvest of medicinal plants at Bulashbar Nullah, Astore (Northern Pakistan). *Journal of Ethnopharmacology*, 84(2-3): 289-298.

Shinwari, Z.K.2010. Medicinal Plants Research in Pakistan. *Journ. Med. Pl. Res*., 4(3): 161-176.

Simpson, E.H. 1949. Measurement of Diversity. *Nature*, 163-688.

Singh, J.S., U. Pandey and A.K. Tiwari. 1984. Man and forest: a central Himalayan case study. *Ambio*, 13(2): 81, 87.

Subedi, M.N. and P.R. Shakya. 1988. Above ground biomass and productivity studies of Q. semicarpifolia forest in Nepal, presented in CHEA, INTACH workshop on Biomass, production and utilization strategies, Nainital India. p. 381-385.

Sundriyal, R.C., E. Sharma, L.K. Rai and S.C. Rai. 1994 Tree structure, regeneration and woody biomass removal in a sub-tropical forest of Mamlay watershed in the Sikkim Himalaya. *Vegetatio*, 113: 53-63.

ter Braak, C.J.F. and P. Šmilauer. 2002. CANOCO Reference manual and canodraw for windows user's guide: software for canonical community ordination (version 4.5). Microcomputer Power (Ithaca NY, USA), 500 pp.

Timilsina, N., M.S. Ross and J.T. Heinen. 2007. A community analysis of sal (*Shorea robusta*) forests in the western Terai of Nepal, Forest *Ecology and Management*, 241: 223-234.

Todaria, N.P., Prerna Pokhriyal, Pooja Uniyal and D.S. Chauhan. 2010. Regeneration status of tree species in forest of Phakot and Pathri Rao watersheds in Garhwal Himalaya. *Current Science*, 98(2): 171-175.

Valdiya, K.S. 2002. Emergence and evolution of Himalaya: reconstructing history in the light of recent studies. *Prog Phys Geogr*, 26: 360-399.

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