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VEGETATION COMPOSITION OF TWO WATERSHEDS AREAS OF KUMOAN HIMALAYAS, UTTARAKHAND, INDIA

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Abstract

We studied vegetation composition of Dabka and Khulgarh Watershed Areas of Kumoan Himalayas by analyzing 85 and 65 sampling plots of 10 m radius respectively. In Dabka *Q. leucotrichophora* and in Khulgarh *P. roxburghii* was the most dominant tree species. In both the watersheds, density of tree, shrub, and herb was found to be highest in moderate forest. Tree diversity was higher in eastern and density in western aspects in DWA and in Khulgarh tree density was found highest in eastern and diversity in western aspect. Total mean shrub density was higher in Dabka as compared to Khulgarh, where as herb, grass and sapling and seedling density was higher in Khulgarh. In both watersheds, trees showed stunted growth in and around villages. The low regeneration of a plant species in Dabka is a topic of concern for managers as density of some ungulate species was found higher in this area as compared to other protected areas of Kumoan Himalayas.

***Keywords*:** Dabka, Khulgarh, Kumoan Himalayas, Species diversity, Vegetation characteristic, Watersheds

Introduction

Vegetation in the Himalayas is rich and diverse due to varied climatic, altitudinal, geological and topographical conditions. Being a source of primary production, vegetation plays a major role in determining animal abundance and distribution by providing essential habitat components i.e., food and cover.

A useful study is that where vegetation data are collected and analyzed with the aims of providing information of relevance to some ecological problems, often to do with environmental conservation and ecosystem management. The forest resources of the country are under great pressure owing to the increased demands from human and animal populations resulting in degradation of forest ecosystem. This has led to poor productivity and regenerative capacity. Hence, monitoring of our forest resources is of great importance (MOE&F 1997). The collection and organization of existing scattered information with a provision to synthesize and update without much additional effort is needed for optimal resources management (Mukund Rao *et al.,* 1994; Mukund Rao & Jayaraman, 1995). Thus monitoring of vegetation forms an essential component of the management of wildlife areas, since change in vegetation influences the distribution and abundance of animal species (Khan, 1996). Long term monitoring of vegetation, such as in Serengeti National Park, Africa (Sinclair & Norton-Griffiths, 1979), has demonstrated the utility of a habitat-oriented approach to wildlife management. Such studies have been useful particularly in understanding the dynamics of animal population distribution, abundance and habitat use (Dinerstein, 1980). The present study was conducted to understand the vegetation characteristics of the two watershed areas. It was presumed that the vegetation characteristics govern the community structure in an ecosystem.

Study area

The Khulgarh Watershed Area (KWA) lies between 29^0 34” 31’ to 29^0 41” N latitudes and 79^0 32” 15’ and 79^0 37” E latitude in Almora district of Kumaon Himalayas, Uttarakhand (Fig. 1). The area spreads over 32 km^2, and represents middle Shiwaliks. It is situated 15 km west to Almora town and inhabited by 34 villages. There are three distinct seasons, summer, winter and monsoon. The average annual temperature of the watershed is 20 ^{0}C, which varies between 25.2 ^{0}C and 13.6 ^{0}C. The general elevation of the area ranging from 1100 to 2200 meters above mean sea level (msl). The watershed is drained by Khulgarh stream, a tributary of Kosi River which merges with Ramganga River in the plains of Uttar Pradesh. The vegetation of Kumoan Himalayas has been divided into four different zones (Champion & Seth (1968). The most dominating tree species in the study area was *Pinus roxburghii* both in forested and outside forest areas. The other major tree species found in the area were *Quercus incana* and *Lyonia Ovalifolia.* In Khulgarh 102 species of birds, 8 species of mammals, 11 species of reptiles and 4 species amphibians were recorded during the study period.

Dabka Watershed Area (DWA) has an area of about 69.06 km^2 and lies between 79^0 17’ 53” to 79^0 25’ 38” longitude, 29^0 30’ 19” to 29^0 24’ 09” latitudes in the region of lesser Himalayas in the state of Uttarakhand (Figure 1). DWA has several water catchments and several small streams arising from these catchments meet to form the Dabka, a seasonal river. The climate of the area is cold temperate with the temperate vegetation. The monsoon starts at the end of June and ceases by the middle of September. This area falls in different altitudinal ranges from 700-2600 meters. In the lower elevations 600-900 meters near Kotabagh, the mean annual temperature varies from 18.9 ^{0}C to 21.1 ^{0}C with mean annual rainfall of 2860.33 mm. In warm temperate zone 900-1800 meters, the mean annual temperature varies from 13.9 ^{0}C to 18.9 ^{0}C with mean annual rainfall of 3623.33 mm. In cold temperate zone 1800-2500 meters, the mean annual temperature varies from 10.3 ^{0}C to 13.9 ^{0}C with annual rainfall of 1750 mm (Sultana 2002). The study area, though a reserve forest, comprises 33 villages under the category of revenue villages. DWA being a reserve forest is divided into forest ranges Vinayak and Naina. Most of the study area comes under Vinayak forest range of Kumaon division with dominating *Quercus leucotricophora* and few patches of *Pinus roxburgii*, *Taxus baccata*, and *Cedrus deodara* trees are also present. The *Rhododendron arborium* trees are common throughout the area. In total 13 species of mammals, 157 species of birds, 15 species of reptiles, 8 species of amphibians were recorded during the study period.

The Forest Cover map of Dabka was prepared by Forest Survey of India and Khulgarh by Kumoan University, Department of Geology. They classified forest cover of both the watersheds into five categories *viz.* dense forest (>70%), moderately dense forest (40-70%), open forest (10-40%), cropland, and barren area. The forest cover of both the watersheds show that in DWA's 53% area was forested, 16% was barren area and remaining 31 % was under cultivation. However, in KWA only 35% area was forested, 25% was barren and 39% was under cultivation.

Methodology

Overall 150 sampling points, 65 in Khulgarh and 85 in Dabka were established to know the vegetation composition of both the watersheds from October 2008 to March 2009. The sampling points were laid randomly on existing forest trails. A distance of at least 250 meters was maintained between two sampling points. These sampling points covered almost all the habitat types of the study area. Sampling points on trails were taken 10 m inside on either side of the trail to avoid sampling the relatively disturbed vegetation along it (Sultana, 2002).

Sampling plot method following Dombois & Ellenberg (1974) was used for vegetation sampling. At each sampling point, a 10 m radius circular plot was established. Trees < 4 m height were considered as mature trees and different species and their individuals were recorded. Shrub layer was quantified in 3 m radius concentric circular plot within the existing 10 m radius sampling plot. Shrub height was measured using measuring tape and ocular estimation was made for shrub cover. Shrub cover was categorized in to four categories 0 - 25%, 25 – 50%, 50 - 75% and < 75%. To calculate tree species dominance GBH (Girth at Breast Height) in cm, was also recorded in each plot. Regeneration was quantified in terms of seedling and saplings in 3 m radius circular plot within the existing 10 m radius circular plot. Tree species up to 0.50 m was considered as seedling while 0.51 m to 4.0 m was taken as sapling (Sultana 2002). Ground vegetation (herbs and grasses) was estimated in 0.5 m x 0.5 m quadrate in four directions within the 10 m radius circular plot.

Tree cover was measured by using gridded mirror of 10 x 10 inches dimension, divided into 25 equal grids. The mirror was placed horizontally at 1.25 m above the ground touching the body of the observer. Tree cover was measured at 5 m distance from the sampling point in four different directions. Grids covered with more than 50% foliage were counted and expressed in terms of percentage. Average of four recordings was taken for tree cover in each sampling plot. Data pertaining to habitat disturbance such as lopping of trees, fallen trees cattle dung and presence of fire were also recorded in 10 m radius circular plot. Data were also collected on different slope and aspect categories. The importance value index (IVI) was determined as the sum of the relative frequency, relative density, and relative basal area (Curtis 1959). Relative frequency, relative density and relative basal area were determined following Philips (1959)

Results

Trees

Tree species dominance

The Important Value Index (IVI) computed for different tree species to ascertain the dominance and abundance patterns yielded that *Q. leucotrichophora* was the most dominant species with IVI = 128.80 in DWA. On the other hand in KWA, *Pinus roxburghii* was the most dominant species (IVI = 155) (Table 1).

A total of 52 tress species were recorded in both the study sites, of which 34 tree species were identified in DWA and 30 in KWA. The overall tree density (710.93/ha ± 56.86) was higher in KWA as compared to DWA (246.96/ha ± 6.11) and difference was found to be significant (Mann-Whitney U Test, Z = 6.581, P = 0.000).

In different habitats in DWA, tree density was found to be highest in moderate forest and lowest in open forest and difference was found to be significant (ANOVA, F = 3.002, df = 3, P = 0.059) (Table 2) .The overall tree diversity, richness and evenness in DWA was 1.296 ± 0.09, 1.024 ± 0.08 and 0.748 ± 0.04 respectively. Among different habitats in DWA, tree diversity (F = 65.27, df = 2, P = 0.000), richness (F = 36.87, df = 2, P = 0.000) and evenness (F = 34.16, df = 2, P = 0.000) were found to be highest in dense forest (Table 2). Tree diversity was higher in eastern aspects (Fig 2) and density in western aspects in DWA (Fig 3).

Overall diversity, richness and evennes in KWA was 0.645 ± 0.08, 0.731 ± 0.10 and 0.444 ± 0.05 respectively. Tree density was highest in moderate forest and lowest in open forest and the difference was found to be significant (ANOVA, F = 3.63, df = 2, P = 0.034). Among different habitat of KWA, tree diversity (F = 2.028, df = 2, P = 0.14), richness (F = 2.052, df = 2, P = 0.14) and evenness F = 0.694, df = 2, P = 0.504) was found highest in dense forest but difference was not found to be significant (Table 3). Density of trees was found highest in eastern aspect (Fig 3) and diversity in western aspect in Khulgarh (Fig 4).

Shrubs

Total mean shrub density in Dabka was found to be (4600.88/ha ± 843.27). Overall diversity, richness and evenness was 1.097 ± 0.05, 0.777 ± 0.04 and 0.861 ± 0.02, respectively. Moderate forest had highest density followed by dense forest but the difference was not found to be significant. Diversity in different habitats in DWA was found highest in moderate forest and lowest in open forest and here too, the difference was not found to be significant. Richness and evenness was found to be highest in dense and moderately dense forests, respectively, while the lowest values recorded for richness and evenness were both from open forests (Table 4). Shrub density was found highest in southern aspect (Fig 5) and diversity in northern aspect (Fig 6).

Mean shrub density in Khulgarh was found to be (4397.94/ha ± 719.64). Overall diversity, richness and evenness was 0.488 ± 0.06, 0.523 ± 0.07 and 0.411 ± 0.05, respectively. Density was recorded highest in moderate forest and lowest in open forest. The diversity and richness was found to be maximum in the moderate forest in KWA, where as evenness was maximum in the dense forest. Contrary to this the dense forest was also found to least rich in shrubs among all the habitats. On the other hand, shrubs were found to be highly evenly distributed in the dense forest (Table 5). None of the comparisons among the habitats types yielded any significant difference. In different aspects shrub density and diversity was found highest in southern aspects (Fig 7).

Herbs

Overall herb density in DWA was 39.32/m^2 ± 2.75. Overall diversity, richness and evenness were 0.978 ± 2.75, (0.576 ± 0.04 and 0.756 ± 0.04, respectively. Across different habitats density was found highest in moderate forest and lowest in open forest. Moderate forest was found to have maximum herb diversity and to have most evenly distributed herbs among the habitats. While, dense forest was highly rich in herb and the open forest was least rich (Table 6).

Mean herb density was found to be 62.57/m^2 ± 12.02 in KWA. Overall diversity, richness and evenness was 0.518 ± 0.07, 0.802 ± 0.09 and 0.477 ± 0.06, respectively. Density of herbs was found highest in moderate forest (87/m^2 ± 26.61) and lowest in open forest (50.36/m^2 ± 14.87) and the difference was not found to be significant. Diversity too was found to be highest in moderate forest and the difference across habitats was significant ($F = 3.431$, $df = 2$, $P = 0.04$). Dense forest was found to be most rich in herbs, but the herbs were most evenly distributed in the moderate forest, while dense forest was found to be least diverse in herbs (Table 7).

Grasses

Overall grass density in DWA was 93.43/m^2 ± 6.02. The overall diversity richness and evenness was 0.544 ± 0.05, 0.239 ± 0.02 and 0.476 ± 0.05, respectively. In different habitats, density was fond to be highest in open forest and lowest in dense forest and the difference across habitats was significant ($F = 13.59$, $df = 2$, $P = 0.000$). Though the dense forest had the least grass density, the same forest type was found to have highest diversity, richness and evenness (Table 8).

Overall density was found to be 154.09/m^2 ± 17.55. Overall diversity, richness and evenness was 0.919 ± 0.06, 0.653 ± 0.04 and 0.788 ± 0.04, respectively. In different habitats, density and diversity was highest in open forest, richness in dense forest and evenness in moderate forest (Table 9).

Sapling and seedling

The overall sapling and seedling density in DWA was 46.26/ha. ± 6.16 and 27.64/ha ± 4.23, respectively. Sapling density was recorded highest in dense forest and lowest in open forest, where as seedling density was found highest in dense forest but lowest in moderate forest (Table 10).

The overall sapling and seedling density in KWA was 467/ha ± 70.84 and 479.97/ha ± 49.50, respectively. The mean densities of sapling and seedling were recorded highest in moderate forest and dense forest respectively. While the open forest recorded the lowest for both sapling and seedling densities (Table 11)

Human habitation/hamlets

Since thirty three and twenty five villages or hamlets resided within DWA and KWA, respectively, which predominantly depended on natural forest for fodder? As a result vegetation around hamlets showed certain features of anthropogenic pressures. Trees showed stunted growth in and around villages. Tree density and diversity showed increasing pattern and cut tree lopped tree density showed decreasing pattern as one moves away from habitation (Fig. 8, 9 and 10).

Discussion

The vegetation of KWA falls under temperate forest and DWA on the other hand is falls under both sub-tropical as well as temperate zone. Being small in area, no clearly distinct arrangement of tree species in space to form definite vegetation classes was present. However, some poorly distinct classes can be recognized based on the relative dominance of tree species.

The subjective classification of vegetation into different habitat types seemed to be satisfactory in order to discriminate between patches within the mosaic of heterogeneous vegetation. Such classification may not be the best methods, however the aim of this study was to work out vegetation ecology and structure, which may be helpful in explaining animal-habitat inter-relationships and inter-dependencies.

Tree species density was significantly different in both the sites. It was higher in Khulgarh as compared to Dabka. The tree density 715.93 in Khulgarh and 246.96 in Dabka recorded in this study are well within the range of values reported for other forests of different localities of Kumoan Himalayas (Saxena & Singh 1982; Tiwari & Singh, 1985; Upreti *et al.,* 1985; Ilyas, 2001). However Hussain *et al.* (2001) have shown higher tree density in Khunjakharik and Sitlakhet areas. The possible reason for higher tree density estimates could be due to small proportion of sampling area. Moreover, that study was conducted in 1998 and since then onwards frequent fires and high anthropogenic pressure in both the areas have changed the forest composition. The tree diversity and richness found during this study, in both the areas, are similar to those reported by Sultana (2002). However, these values are quite low (all values < 2.0) as compared to values (2.63 and 2.28) recorded by Saxena *et al.* (1985), who found maximum tree diversity in middle Himalayas concluding that harsh climate was responsible for the development of dominance while moderate climate *i.e.* high rainfall and moderate temperature for diversification closely supporting that tropical forests are more diverse than temperate ones (Khan, 2004). Shrub density was low compared to values reported by Sultana (2002) & Hussain *et al.* (2008) in the same area. Shrub diversity range (0.448 in Khulgarh and 1.097 in Dabka) reported was well within the range of (0.6 - 1.1) reported by Hussain *et al.* (2008) in the same area but lower (1.36) than what was reported by Dhar *et al.* (1997) in other regions of Kumoan Himalayas.

In our study, Oak (*Q. leucotricophora*) forest represented the elevation range 1800 - 2300 m (1200 - 2300 m by Singh & Singh 1987, 1700 – 2100 m by Singh *et al.,* 1994), while *Q. semecarpifolia* forest was present between 2200 - 3000 m altitude range (2400 - 3600 m by Singh & Singh 1987, 2366 - 3000 m by Singh *et al.,* 1994) and *Shorea robusta* forest reported below 900 m (<800 m by Ahmed *et* *al.,* 2009). The diversity values were also similar to those reported by (Singh *et al.* 1994). These values were also similar to those reported for temperate communities in adjacent Nepal Himalayas (Ohsawa *et al.,* 1975) and elsewhere (Monk 1967). As reported by Dhar *et al.* (1997), more than 50% species of this region are non-native species. The area has received plant elements from adjoining regions of tropical Asia (Indo-China and Indo- Malaya (Mani, 1974) and Indo-Gangetic plains (Spate, 1957). Though, the data were not collected and analyzed keeping in mind native species but, the distribution of non-native species is known from the Himalaya (Maheswari, 1962). However, the change in native flora because of non-native species could lead to long-term changes in ecosystem processes.

The *P. roxburghii* poses serious threat to native Oak (*Q. leucotricophora* and *Q. floribunda*) in whole of the Kumaon, as it has been reported earlier also (Singh & Singh, 1987). The ecological nature of *P. roxburghii* does not allow other broad-leaf species to replace it, and *P. roxburghii* will continue to hold a site indefinitely once it occupies it (Singh *et al.,* 1984). All Oak species are facing severe threats because of the demand for fodder and fire-wood. This has led to reduction in seed production (Saxena & Singh, 1984). Other valuable tree species such as *A. pindrow, T. baccata* and *C. deodara* are felled because of their timber value. *A. pindrow* and *C. deodara* had a good population size in Vinaiyak reserve forest falling under DWA. Protection of this community is necessary. The density of regenerating species was highest in Khulgarh as compared to Dabka. In Dabka extensive summer forest fires are very frequent which is perhaps responsible for low density of regenerating species. Shrub and herb density was found highest in moderate forest indicating that open canopy provides better opportunity for the recruitment of shrubs and herbs (Khera *et al.,* 2001). Although, in open forest these values were found to be lowest. The possible reason for this could be that the open forest in the study area mainly consisted of pine forest, and the acidic nature of *Pinus roxburghii* does not allow any broad-leaf species to survive (Singh *et al.,* 1984).

The southern and eastern aspects are comparatively more dense and diverse than other aspects. Low density and diversity in other aspects is due to high anthropogenic pressure on these aspects. Khera *et al.* (2001) also found that low density and diversity of vegetation in one or other aspects was due to anthropogenic pressure. In the complex Himalayan forest ecosystem chronic form of disturbances exists in which people remove only a small fraction of forest biomass in the form of grazing, lopping, surface burning and litter removal at a given time. These disturbances are affecting the stability of the ecosystem and retarding the successional process in the area. Moreover, the broad overlapped scattered centers of species population along a gradient imply that most of the communities integrate continuously along environmental gradients, rather than forming clearly distinct zones (Mishra *et al.,* 2000). The total number of species in any physiographic aspects reflects the adaptation potential of the community. The physiographic features such as aspects and elevation have profound influence on the distribution, growth, form and structure of vegetation, as result of which the individual species has different values for density at various aspects and altitudes (Wikum & Wali, 1974). The diversity is also variable on different geographical locations (Baduni, 1996).

The low tree and shrub density and highest lopped and cut tree density in and around villages is the result of human dependency on forest. Human interference causes great impact on forest structure (Tyser & Worley, 1992). In Kumoan, most of the lower altitude and middle altitude forests are densely populated as compared to high altitude forests (Sultana, 2002). So, the chances of destruction of forest and invasion of non-native species are more as seen in *Quercus leucotricopphora* and *Quercus semecarpifolia* forests. Disturbances may interact in complex ways to affect composition (Collins & Barber, 1985, Steuter *et al.,* 1990, Noy-Meir, 1995). The shrub diversity was found highest near human habitations, similar observation has also been made by Khan (1996) in Gir Lion Sanctuary, whereby controlling vegetation from livestock grazing led to a considerable increase in shrub densities and decrease in species richness and diversity. The high species diversity in shrubs near human habitation is contrary to expectations, as one would expect higher regeneration and species richness as we move away from habitation. While moderate grazing favors high species diversity in grasses (Mc-Naughton, 1983), it needs to be empirically tested by enclosure experiments whether moderate grazing by domestic livestock leads to better regeneration and high species richness of trees and shrubs in Kumoan Himalayas. Pandey & Singh (1985) have also reported an increase in species diversity in disturbed ecosystem of Kumoan Himalayas. While in alpine meadows of the Himalayas, the impact of livestock grazing has been a subject of considerable debate among ecologists (Ram *et al.,* 1989; Negi *et al.,* 1993; Rawat & Uniyal, 1993; Kala *et al.,* 1995; Sundriyal, 1995; Kala *et al.,* 1997). Based on intermediate disturbance hypothesis, a few authors (Kumar & Joshi, 1972) have argued that moderate level of grazing may enhance herbaceous species diversity in alpine meadows. While Singh (1991) & Kala *et al.* (1997) found higher species diversity in ungrazed sites as compared to grazed sites indicating that livestock grazing may not be crucial for maintaining species diversity but certain abiotic factors such as soil depth, snowfall, water movement, wind and soil erosion seem to influence the structure and composition of alpine meadows (Kala *et al.,* 1995). Kala & Rawat (1999) also found that heavy grazing reduces the species diversity, and promotes ruderal and weedy species.

The low regeneration of a plant species in Dabka is a topic of concern for managers. All the species occur in extremely low densities in tree layer and large scale mortality in plant population (Ahmed *et al.,* 2009) would further affect their regeneration. The repeated fires in Dabka cause retrogression in vegetation and reduction in tree cover. This area needs an urgent attention as density of some ungulate species in this area (Ahmed, 2010), was found higher than other protected areas of Kumoan Himalayas.

Table 1 : Tree density (/ha) along with Important Value Index (IVI) in Dabka and Khulgarh Watershed Areas

Tree species	DWA	IVI	KWA	IVI
Abies pindrow	13.23	7.03	-	-
Acer oblongum	10.21	6.08	-	-
Adina cordifolia	7.81	12.72	-	-
Brassaiopsis mitis	0.60	1.08	-	-
Briedelia retusa	-	-	2.38	0.92
Cedrus Deodara	42.75	11.59	-	-
Cornus macrophylla	-	-	4.85	1.43
Cupressus torulosa	1.20	2.87	-	-
Cassia fistula	10.22	14.79	-	-
Euonymus sp.	-	-	14.54	3.11
Ficus benghalensis	3.00	5.34	-	-
Ficus religiosa	1.20	1.55	-	-
Ficus hispida	1.20	1.45	-	-
Grewia optiva	0.60	0.87	0.80	0.95
Grewia asiatica	-	-	0.80	0.96
Ilex dyperina	13.87	10.37	1.01	1.34
Litsia umbrosa	23.32	11.98	12.65	5.35
Lyonia ovalifolia	11.21	9.08	45.54	9.54
Madhuca longifolia	3.61	3.95	3.98	4.16
Myrica esculenta	4.81	6.27	60.51	35.73
Machilus odoratissima	-	-	17.52	-
Malus sp.	-	-	2.11	2.98
Murrya sp.	4.81	6.28	-	-
Mallotus philippinensis	5.41	8.53	-	-
Magnifera indica	3.61	5.34	-	-
Millettia auriculata	-	-	1.59	1.22
Nerium indicum	0.60	0.56	-	-
Persea duthiei	9.21	2.34	8.43	7.23
Pinus roxbughii	4.40	3.85	531.01	155.23
Pinus wallichiana	10.41	7.58	21.23	20.21
Pyrus pashia	-	-	2.39	1.23
Pieris avalifolia	-	-	31.05	25.51
Phyllanthus indica	1.20	2.81	-	-
Premma latifolia	-	-	0.80	0.96
Phoebe lanceolata	-	-	0.80	0.92
Quercus incana	-	-	110.46	42.65
Quercus floribunda	13.82	17.04	-	-
Quercus leucotrichophora	117.77	128.80	23.46	13.23
Quercus semecarpifolia	18.43	-	-	-
Rhododendron arboreum	20.43	29.79	44.59	23.63
Symplocos theifolia	4.31	1.22	-	-
Syzygium cumini Skeels	6.61	11.30	-	-
Sapium insigne	1.80	3.16	-	-
Shorea robusta	11.42	16.05	-	-
Swida oblonga	-	-	20.97	11.23
Taxus baccata	43.21	10.21	-	-
Viburnum cotinifolium	27.85	11.21	4.54	3.21
Villebrunea frutescens	-	-	2.39	2.91
Wrightia tomentosa	-	-	0.80	1.05
Unidentified1	-	-	3.00	3.45

Table 2 : Tree density, diversity, richness and evenness in different habitats in DWA

Habitat	Density(/ha) ±	Diversity	Richness	Evenness
Open forest	210 ± 16.23	1.538±0.14	1.302±0.17	0.857±0.03
Moderate forest	264 ±16.23	0.477±0.09	0.335±0.06	0.403±0.08
Dense forest	243 ± 9.51	1.706±0.06	1.356±0.08	0.919±0.01

Table 3 : Tree density, diversity, richness and evenness in different habitats in KWA

Habitat	Density(/ha)	Diversity	Richness	Evenness
Open forest	505.57±72.20	0.427±0.10	0.472±0.08	0.383±0.08
Moderate forest	915±61±157.60	0.543±0.18	1.640±0.21	0.366±0.12
Dense forest	769±80±79.90	0.641±0.13	0.928±0.17	0.504±0.07

Table 4 : Shrub density, diversity, richness and evenness in different habitats in DWA

Habitat	Density(/ha)	Diversity	Richness	Evenness
Open forest	2480.21±1149.58	1.087±0.06	0.643±0.08	0.847±0.03
Moderate forest	5914.94±1424.62	1.175±0.14	0.777±0.04	0.936±0.01
Dense forest	3981.05±1309.08	1.092±0.10	0.815±0.08	0.866±0.05

Table 5 : Shrub density, diversity, richness and evenness in different habitats in KWA

Habitat	Density(/ha)	Diversity	Richness	Evenness
Open forest	2213±628	0.431±0.09	0.528±0.53	0.364±0.08
Moderate forest	5657±1224	0.603±0.11	1.670±0.36	0.526±0.10
Dense forest	3547±848	0.497±0.13	0.412±0.40	0.533±0.11

Table 6 : Herb density, diversity, richness and evenness in different habitats in DWA

Habitat	Density(/m^2)	Diversity	Richness	Evenness
Open forest	36.80±5.98	0.972±0.08	0.551±0.05	0.716±0.07
Moderate forest	40.12±3.62	0.1.071±0.30	0.606±0.07	0.781±0.05
Dense forest	38.58±5.37	0.958±0.11	0.624±0.18	0.719±0.18

Table 7 : Herb density, diversity, richness and evenness in different habitats in KWA

Habitat	Density(/m^2)	Diversity	Richness	Evenness
Open forest	50.36±14.87	0.419±0.12	0.766±0.21	0.418±0.12
Moderate forest	87.00±26.61	0.676±0.10	0.953±0.12	0.581±0.08
Dense forest	59.50±27.65	0.219±0.09	1.453±0.17	0.278±0.12

Table 8 : Grass density, diversity, richness and evenness in different habitats in DWA

Habitat	Density(/m^2)	Diversity	Richness	Evenness
Open Forest	129.64±12.06	0.619±0.42	0.266±0.18	0.537±0.36
Moderate forest	79.61±5.08	0.474±0.30	0.214±0.14	0.409±0.29
Dense forest	56.00±7.37	0.712±0.21	0.297±0.08	0.682±0.19

Table 9 : Grasses density, diversity, richness and evenness in different habitats in KWA

Habitat	Density(/m^2)	Diversity	Richness	Evenness
Open forest	177±41.41	1.047±0.09	0.650±0.03	0.789±0.09
Moderate forest	172±27.67	0.848±0.16	0.517±0.09	0.795±0.11
Dense forest	134±22.98	0.875±0.09	0.704±0.06	0.785±0.07

Table 10 : Mean sapling and seedling density in different habitats in DWA

Habitat	Sapling density(/ha)	Seedling density(/ha)
Open forest	13.94±12.46	28.08±24.87
Moderate forest	46.83±11.29	22.48±8.53
Dense forest	51.36±8.04	30.81±5.99
Overall	46.26±6.16	27.64±4.23

Table 11 : Mean sapling and seedling density in KWA

Habitat	Sapling density(/ha)	Seedling density(/ha)
Open forest	347±67.96	441±110
Moderate forest	720±255	480±78
Dense forest	517.51±122	493±76
Overall	457±70.84	479±48

Legends to Figures

Figure 1 Map showing location of study area
Figure 2 Diversity, richness and evenness of trees on different aspects in DWA
Figure 3 Variation of tree density on different aspets in Dabka and Khulgarh Watershed Areas
Figure: 4 Diversity, richness and evenness of trees on different aspects in KWA
Figure 5Variation of shrub density on different aspects in Dabka and Khulgarh Watershed Areas
Figure 6 Diversity, richness and eveness of shrubs on different aspects in DWA
Figure 7 Diversity, richness and evenness of shrubs on different aspects in KWA
Figure 8 Tree, cut tree & lopped tree density (/ha) in relation to human habitation in DWA
Figure 9 Tree, cut tree & lopped tree density (/ha) in relation to human habitation in KWA
Figure 10 Tree diversity in relation to human habitation in Dabka and khulgarh Watershed Areas of Kumoan Himalyas

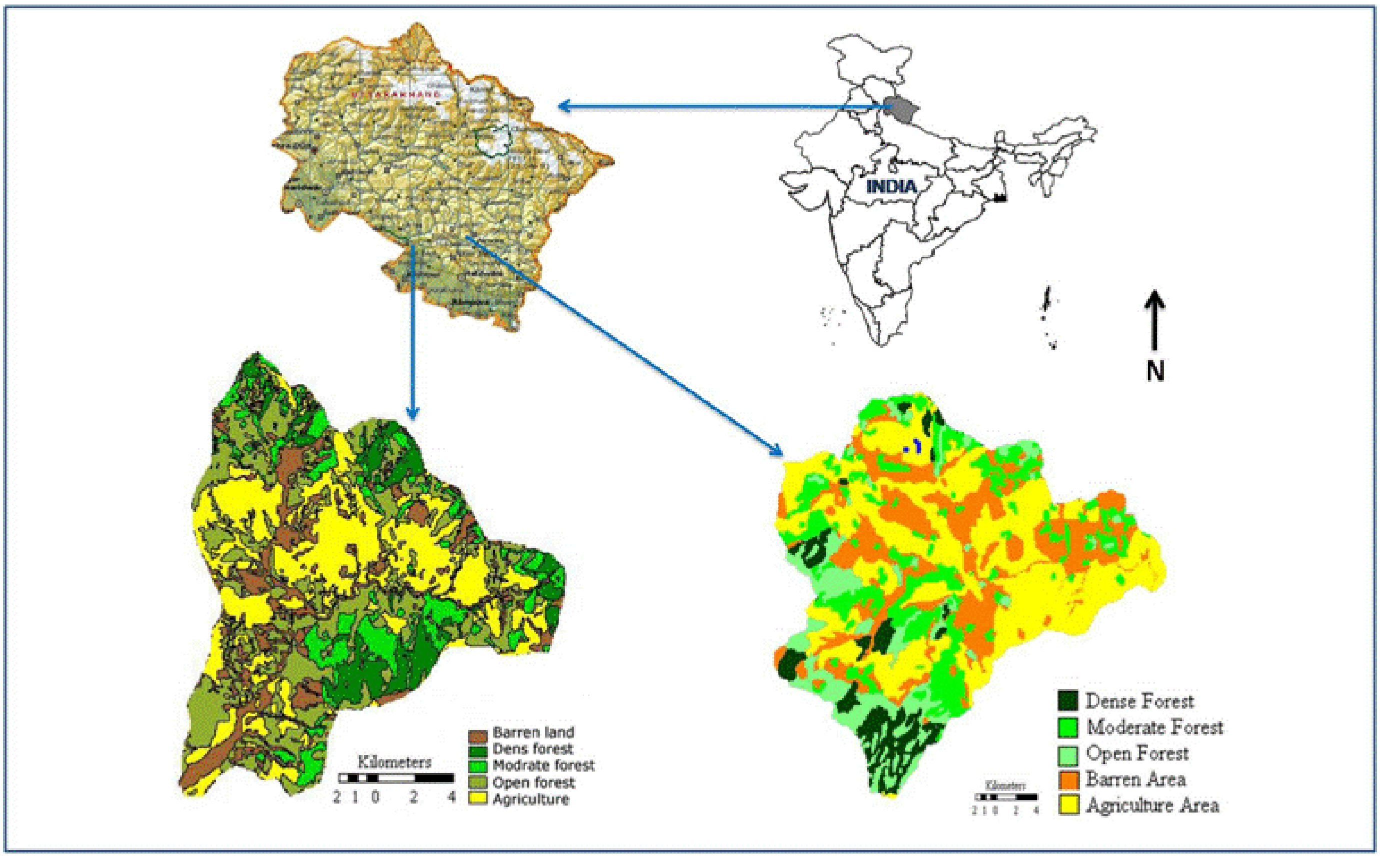

Fig. 1 : Map showing location of study area

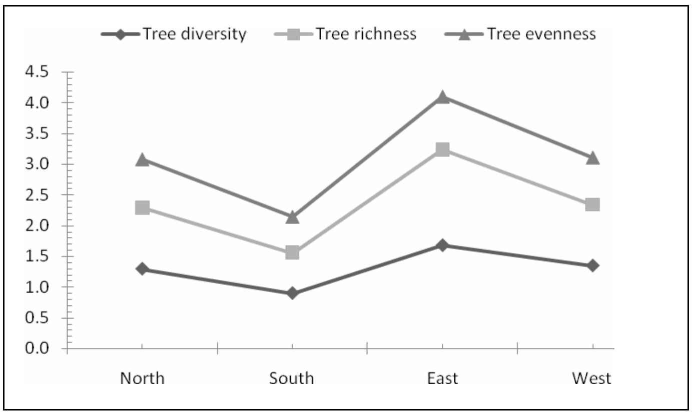

Fig. 2 : Diversity, richness and evenness of trees on different aspects in DWA

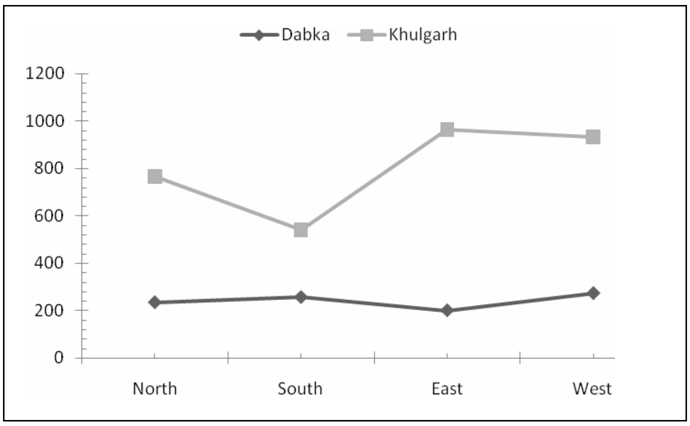

Fig. 3 : Variation of tree density on different aspets in Dabka and Khulgarh Watershed Areas

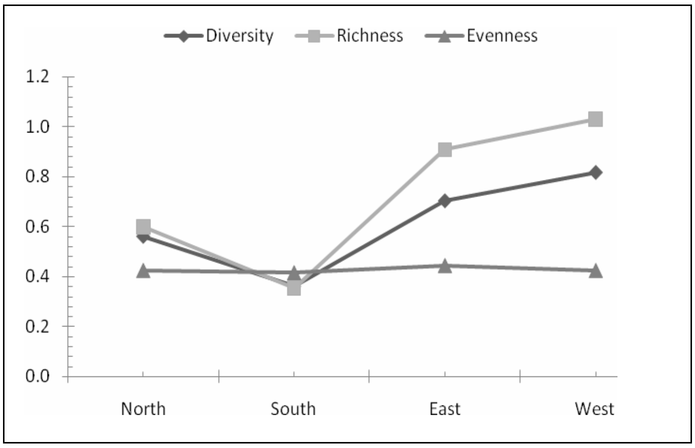

Fig. 4 : Diversity, richness and evenness of trees on different aspects in KWA

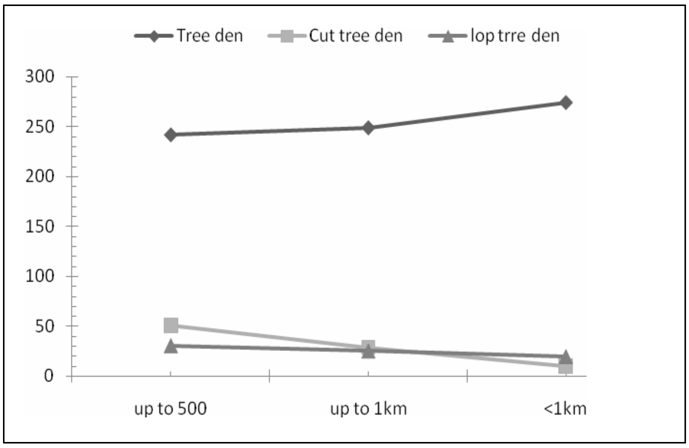

Fig. 8 : Tree, cut tree & lopped tree density (/ha) in relation to human habitation in DWA

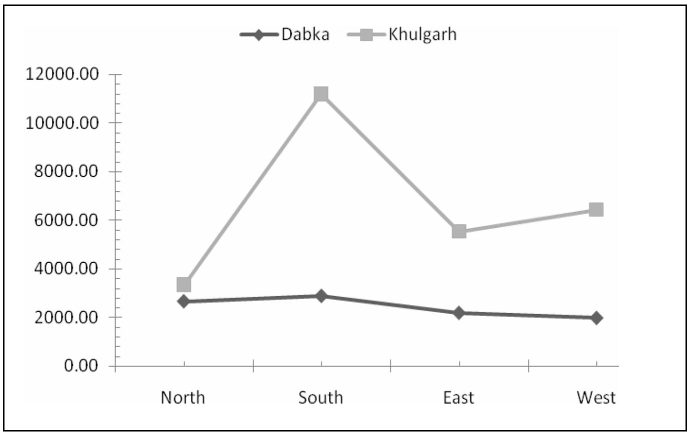

Fig. 5 : Variation of shrub density on different aspets in Dabka and Khulgarh Watershed Areas

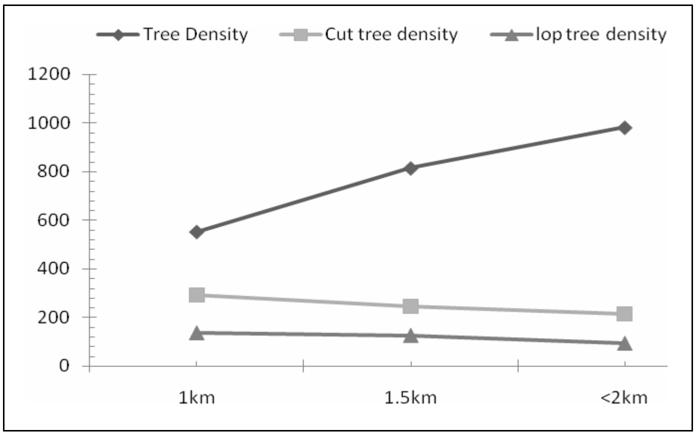

Fig. 9 : Tree, cut tree & lopped tree density (/ha) in relation to human habitation in KWA

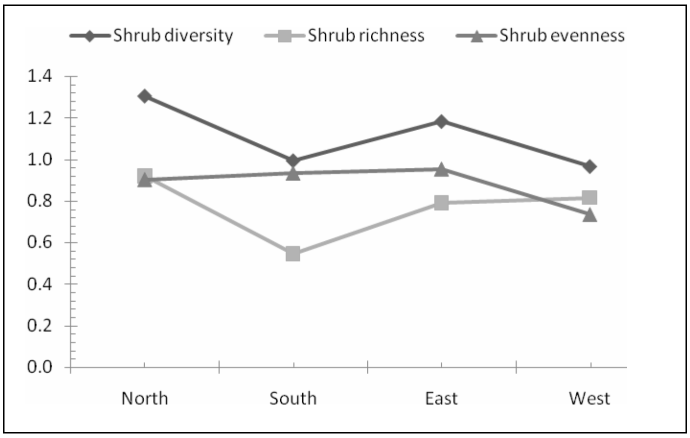

Fig. 6 : Diversity, richness and eveness of shrubs on different aspects in DWA

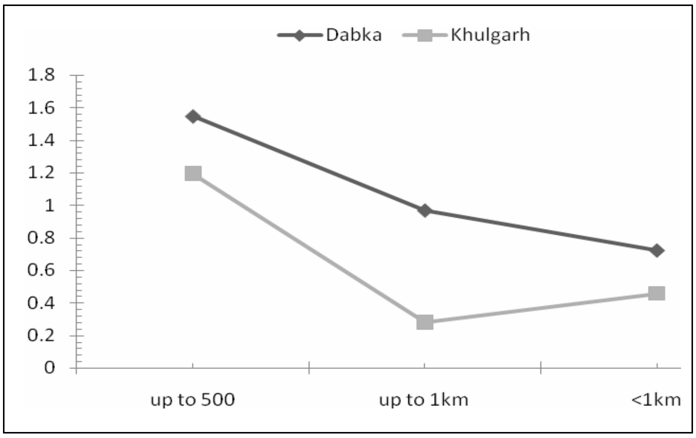

Fig. 10 : Tree diversity in relation to human habitation in Dabka and khulgarh Watershed Areas of Kumoan Himalyas

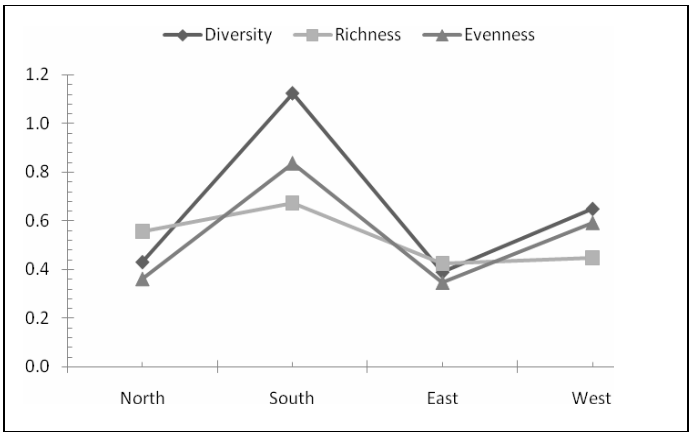

Fig. 7 : Diversity, richness and evenness of shrubs on different aspects in KWA

Acknowledgments

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