INTERNATIONAL JOURNAL OF CONSERVATION SCIENCE

ISSN: 2067-533X Volume 5, Issue 1, January-March 2014: 61-68 www.ijcs.uaic.ro

SPECIES COMPOSITION AND DIVERSITY OF SIX FOREST STANDS AT ALMORA AND AROUND THE TOWN AREA FORESTS OF KUMAUN HIMALAYA

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Abstract

The present study was carried out in two major contrasting aspects (north-south) at and around the town area forests of Almora Kumaun Himalaya. Three stands on both the Northern and the Southern aspects were studied for their species composition and diversity, considering the microclimatic conditions and altitudinal gradient between 1500 - 1900msl. The study reveals that Pinus roxburghii was the dominant species on the Southern aspect, as well as on the lower altitude of the Northern aspect, while Cedrus deodara was the most dominant species on the Northern aspect. The total tree density varies from 300 to 420ind·ha^{-1}; sapling density from 30 to 130ind·ha^{-1}; seedling density from 100 to 1550ind·ha^{-1} and shrub from 609.98 to 3265.33ind·ha^{-1}. The result on the basal area of trees ranges between 34.14 - 96.79m^{2}ha^{-1} and the species diversity indices vary from 0.13 to 1.39.

Keywords: *Species composition; Diversity; Regeneration; Kumaun Himalaya; India*.

Introduction

The Himalaya forest ecosystem has a major contribution to the mega-biodiversity of India. Therefore, the conservation and scientific management of that biodiversity for the socio-economic development, betterment of soil, live stock and human life assumes a great significance for various aspects of the biodiversity of those forests [1-4]. Mountain vegetation is affected by several factors, such as altitude, slope, soil, canopy cover and microclimate, as they modify the regimes of moisture and the exposure to the sun. Although, anthropogenic disturbances play an important role in the change, loss or maintenance of plant biodiversity the more recent phenomenon of climate change is also responsible for the changes in species composition and other ecosystem activities [5].

The Himalayan forest vegetation ranges from tropical, dry, deciduous forest in the foothills, to alpine meadow above timberline [6]. The composition of the forest is diverse and varies from place to place, because of the varying topography, such as plains, foothills and upper mountains [7]. Economically and environmentally, the natural resources are the main source of income for people in this region [8]. In addition, environmental problems are particularly noticeable in this region, as a form of degradation and depletion of the forest resources [9]. Earlier studies done in the Kumaun region explored various aspects of the forest vegetation [1, 10], altitudinal variation [11-13], phytosociology [14, 15] and population

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structure [10, 16]. The main objectives of the present paper was to describe the species composition, species diversity and regeneration status of six forest stands in Kumaun Himalaya, in relation to natural and anthropogenic disturbances in two major contrasting aspects (north and south) respectively.

Materials and Methods

The study area, located in and around the town area forests of Almora, forms a large (17.8×10^4ha [17], prestigious and botanically valuable reserve complex (Almora forest division) in the Kumaun region (Central Himalaya). It lies between 29°30'N to 30°20'N latitudes and 79°20'E to 80°20'E longitudes. The study area is divided into two major contrasting aspects (Lodhiya to Simtola in the Northern aspect and the Dolidana to the Zoo forest site in the Southern aspect) along an altitudinal gradient of 1500-1900m. Attitudinally these forest sites are located in the temperate zone, although the lower area falls under the tropical belt. These sites recorded tree major species, such as *Pinus roxburghii, Cedrus deodara, Quercus leucotrichophora*, *Alnus nepalensis* and *Planted Acacia sp.*

The temperature ranged between 16 and 24°C and the mean annual rainfall was 1040mm. In the area under study there are humid outer mountain ranges and dry internal mountains, as well as temperate valleys. This area was hot during the six months of summer and cold during the six months of winter. The south-east monsoon commences towards the end of June and lasts until the middle of September.

A *vegetational analysis* was carried out for all the four, layers of forests (i.e. trees, saplings, seedlings and shrubs) in the year 2012 (Feb-March). The phytosociological analysis was done by assigning 10 randomly $100m^2$ circular areas (radius 5.65m) [18-20]. *Circumference at breast hight* (*cbh*) of trees was measured at 1.37m from the ground. The importance value for each tree species was calculated as the sum of its relative basal cover by *J.T. Curtis* [20]. Trees were considered to be the individuals with *cbh* 31.5cm, saplings 10-30cm *cbh* and over 30cm in height and seedling those with their circumference < 10cm [15]. The shrubs layer was set by 40 areas of 2x2m. The vegetational data was assessed for density, frequency [18]. *Importance Value Index* (*IVI*) for tree and sapling were determined as the sum of their relative density, relative frequency and relative dominance [20]. The diversity index for the all four layers at each stand was calculated by using the *Shannon-Weiner index* [21], the concentration of dominance by *Simpson's index* [22] and evenness or equability by *log cycle index* respectively [23].

Results and discussion

Evaluation of the Tree Layer

The *Total Tree Density* ranges from 320 to 420 ind·ha^{-1} with a *Total Basal Area* (*TBA*) of 58.20 to 96.97m^2ha^{-1} and *Total Importance Value Index* (*TIVI*) of 299.93 to 299.96% on the Northern aspect, while the total density ranges from 300 to 360ind·ha^{-1} with a *TBA* of 34.14 to 78.48m^2ha^{-1} and a *TIVI* of 299.06 to 299.97% on the Southern aspect. *Pinus roxburhii* (330ind ha^{-1} and *TBA* 40.42m^2ha^{-1}) and *Cedrus deodara* (190 and 240ind·ha^{-1} with *TBA* 20.90 and 52.20m^2ha^{-1}) were the most dominant species with a *TIVI* of 130.57; 151.12 and 267.41% on all stands of the Northern aspect whereas *Pinus roxburghii* (180; 300 and 340ind·ha^{-1} and *TBA* 23.36; 63.0 and 77.52m^2ha^{-1}) was also the most dominant species with a *TIVI* of 181.75; 220.13 and 260.39% on all stands of the Southern aspect and the lowest density was that of *Acasia sp*, *Alnus nepalensis*, *Myrica esculenta*, *Prunus cerasoides* and *Quercus leucotrichophora* (10ind·ha^{-1} each) on both aspects (Table 1). The values of the present tree densities are lower than the earlier reported values (1103-2460ind·ha^{-1}) in five Panchayat forests [24]; 280-1680ind·$ha^{-1}$from Kumaun Central Himalaya [25-28] and comparable with the 193 to

324ind·ha^{-1} values reported for different Central Himalayan oak and pine forests [29], while the total basal area of the present study varied from 34.14 to 96.79m^{2}ha^{-1}. These values are comparable with the values reported earlier, 25.97 -55.95m^{2}ha^{-1}[30]; 3.74-80.36m^{2}ha^{-1}[27, 31]. The species diversity range varied from 0.13 to 1.39 in the Northern aspect and 0.21 to 1.06 in the Southern, whereas the concentration dominance range varied from 0.38 to 0.94 in the Southern and 0.44 to 0.89 in the Southern aspects. Evenness (Pielou's equitability index) ranged from 0.10-0.24 in the Northern aspects and 0.10-0.21 in the Southern aspects (Table 3). These values are generally comparable with the values reported earlier by different workers in sub-tropical forests [27, 29, 32-34]. The evenness values for trees varied from 0.10 to 0.24 in both of the aspects, which was lower than the 0.4 in Meghalaya, north east India [35] and 0.9 in an average reported for Western Ghats India [36].

Table 1. Result table for tree, sapling and seedling layers

Stand	Forest name	Species	Tree layer			Sapling layer			Seedling layer
			Density (ind ha^{-1})	**TBA (m^{2}ha^{-1})**	**IVI (%)**	**Density (ind ha^{-1})**	**TBA (m^{2}ha^{-1})**	**IVI (%)**	**Density (ind ha^{-1})**
					Northern Aspect				
1-	Lodhiya	*Acasia sp*	10.0	0.32	32.52	20.0	0.08	175.87	260.0
		Pinus roxburghii	330.0	40.42	267.41	10.0	0.05	124.10	260.0
		Total	**340.0**	**41.24**	**299.93**	**30.0**	**0.13**	**299.97**	**320.0**
2-	Cant area	*Aesculus indica*	40.0	11.60	50.07	-	-	-	-
		Alnus nepalensis	10.0	3.30	14.67	-	-	-	20.0
		Cedrus deodara	190.0	20.90	130.57	10.0	0.01	65.73	50.0
		Celtis australis	20.0	8.20	32.09	-	-	-	-
		Cupressus torulosa	30.0	6.30	31.95	-	-	-	-
		Pinus roxburghii	10.0	3.30	14.67	-	-	-	-
		Prunus cerasoides	10.0	0.80	14.67	20.0	0.06	131.73	30.0
		Quercus leucotrichophora	10.0	3.80	10.37	10.0	0.05	102.52	-
		Total	**320.0**	**58.20**	**299.06**	**40.0**	**0.12**	**299.98**	**100.0**
3-	Simtola	*Aesculus indica*	20.0	11.05	24.18	30.0	0.09	69.09	-
		Cedrus deodara	240.0	52.20	151.12	40.0	0.14	97.55	150.0
		Cupressus torulosa	40.0	2.40	24.0	30.0	0.03	38.68	70.0
		Myrica esculeta	50.0	2.0	25.96	10.0	0.12	42.86	20.0
		Pinus roxburghii	70.0	29.04	74.69	20.0	0.08	50.95	140.0
		Total	**420.0**	**96.79**	**299.95**	**130.0**	**0.46**	**299.13**	**380.0**
					Southern Aspect				
4-	Doli dana	*Pinus roxburghii*	340.0	77.52	260.39	10.0	0.02	104.23	860.0
		Sapium insigne	20.0	0.96	39.38	20.0	0.08	195.74	40.0
		Total	**360**	**78.48**	**299.97**	**30.0**	**0.10**	**299.97**	**900.0**
5-	Karbala	*Acasia sp*	10.0	0.01	21.55	-	-	-	90.0
		Cedrus deodara	30.0	2.60	57.88	-	-	-	-
		Pinus roxburghii	300.0	63.0	220.13	-	-	-	79.66
		Sapium insigne	-	-	-	-	-	-	30.0
		Total	**340.0**	**66.03**	**299.06**	**-**	**-**	**-**	**199.96**
6-	Zoo forest	*Acasia sp*	20.0	0.01	20.01	40.0	0.14	131.60	800.0
		Cedrus deodara	80.0	9.96	75.83	-	-	-	20.0
		Myrica esculeta	10.0	0.73	12.12	10.0	0.04	42.95	60.0
		Pinus roxburghii	180.0	23.36	181.75	30.0	0.11	125.43	600.0
		Quercus leucotrichophora	10.0	0.08	10.22	-	-	-	70.0
		Total	**300.0**	**34.14**	**299.93**	**80.0**	**0.29**	**299.98**	**1550.00**

Sapling layer

Total sapling density ranged from 30 to 180ind ha^{-1} with a TBA of 0.12 to 0.46m^{2}ha^{-1} in the Northern aspect and 30 to 80ind·ha^{-1}, with a TBA of 0.10 to 0.29m^{2}ha^{-1} in the Southern aspects, while the total IVI ranged from 299.13 to 299.98 in both aspects. The highest sapling density was that of *Cedrus deodara* in the Northern and *Acasia sp* in the Southern aspects (40ind·ha^{-1} with TBA of 0.14m^{2}ha^{-1}, each) and an IVI of 97.55 and 131.60% respectively. The lowest density was that of *Myrica esculenta*, *Pinus roxbrughii* and *Quercus leucotrichophra* (10ind·ha^{-1} each) in both aspects (Table 1). These density and TBA values were lower than the earlier reported values of 260-610ind·ha^{-1} and 119-258.6ind·ha^{-1} and 0.45-0.98m^{2}ha^{-1} [28, 29]. Species diversity values for sapling varied from 0.63 to 1.52 in the Northern and 0.63 to 0.97 in the Southern aspects, while the concentration dominance ranged from 0.23 to 0.37 in the Northern and 0.40 to 0.55 in the Southern aspects. Evenness ranged from 0.21 to 0.34 in the Northern and 0.31 to 0.32 in the Southern aspects respectively (Table 2).

Table 2. Result table for shrub layer

Species	Density ind/ha					
	Northern Aspect			Southern Aspect		
	Lodhiya	**Cant area**	**Simtola**	**Dolidana**	**Karbala**	**Zoo forest**
Asparagus racemosus	-	93.75	15.63	15.63	-	96.75
Berberis asiatica	265.63	-	234.38	109.38	125.0	218.75
Cotoneaster sp.	328.13	515.63	1937.50	1843.75	687.50	2546.88
Desmodium elegans			250.0	15.63	-	-
Pyrecantha crenulata	15.63	-	140.63	46.88	187.50	46.88
Rubus ellipticus	-	15.63	140.63	15.63	203.13	359.38
Total	**609.38**	**625.01**	**2718.75**	**2046.88**	**1203.13**	**3265.63**

Seedling layer

Total seedling density ranged from 100 to 180ind·ha^{-1} in the Northern and 199.96 to 1550ind·ha^{-1} in the Southern aspects respectively. The highest density was that of *Acasia sp* and *Pinus roxburghii* (260ind·ha^{-1} each) in the Northern and *Acasia sp* also registered the highest density (800ind·ha^{-1}) in the Southern aspects, whereas the lowest density was that of *Cedrus deodara* and *Myrica esculenta* (20ind·ha^{-1} each) in both aspects. These values were higher than the earlier reported values 249.98 to 845ind·ha^{-1} and 260-970ind·ha^{-1} [29, 37]. Seedling density alone is a good indicator of regeneration potential, because the probability of establishment of an individual seedling is closely related to its regeneration [38].The species diversity value varied from 0.48 to 1.20 in the Northern and 0.18 to 1.10 in the Southern aspects, while the concentration dominance range varied from 0.33 to 0.70 in the Northern and 0.32 to 0.92 in the Southern aspects. Evenness ranged from 0.30 to 0.34 in the Northern and 0.09 to 0.20 in the Southern aspects, respectively (Table 3).

Shrub layer

Total shrub density ranged from 609.98 to 3265.63ind·ha^{-1} in both Northern and Southern aspects. Among all six stands in both aspects *Cotoneaster sp* was the most dominant shrub with the highest density, which ranged from 328.13 to 2546.88ind·ha^{-1}, whereas the lowest density (15.63ind ha^{-1} each) was that of *Pyrecantha crenulata* and *Rubus ellipticus* in the Northern aspect and that of *Asparagus recemosus* and *Desmodium elegans* in the Southern aspect, respectively (Table 2). Present shrub density ranges were higher than the earlier reported values of 199.32 to 406.32ind·ha^{-1} [29] and lower than 1475 to 112.28ind·ha^{-1} [39]. Species diversity values varied from 0.53 to 1.26 in the Northern and 0.44 to 1.15 in the Southern aspect, while the concentration of dominance varied from 0.48 to 0.70 in the Southern aspects and evenness ranged from 0.17 to 0.26 in the Northern and 0.07 to 0.28 in the Southern aspects, respectively (Table 3).

Regeneration

The population structure of dominant and co-dominant species for the all stands of the Northern and Southern aspects is presented in Figure 1. The number of seedlings and saplings of *Pinus roxburghii* was mostly present in both of the aspects and they were absent only in one stand, the 5th in the Southern aspect, while seedlings and saplings of *Cedrus deodara* were present in two stands (2nd and 3rd) of the Northern aspect. The majority of trees were the older size class 121-150, followed by younger size class 51-120cm (Fig. 1).

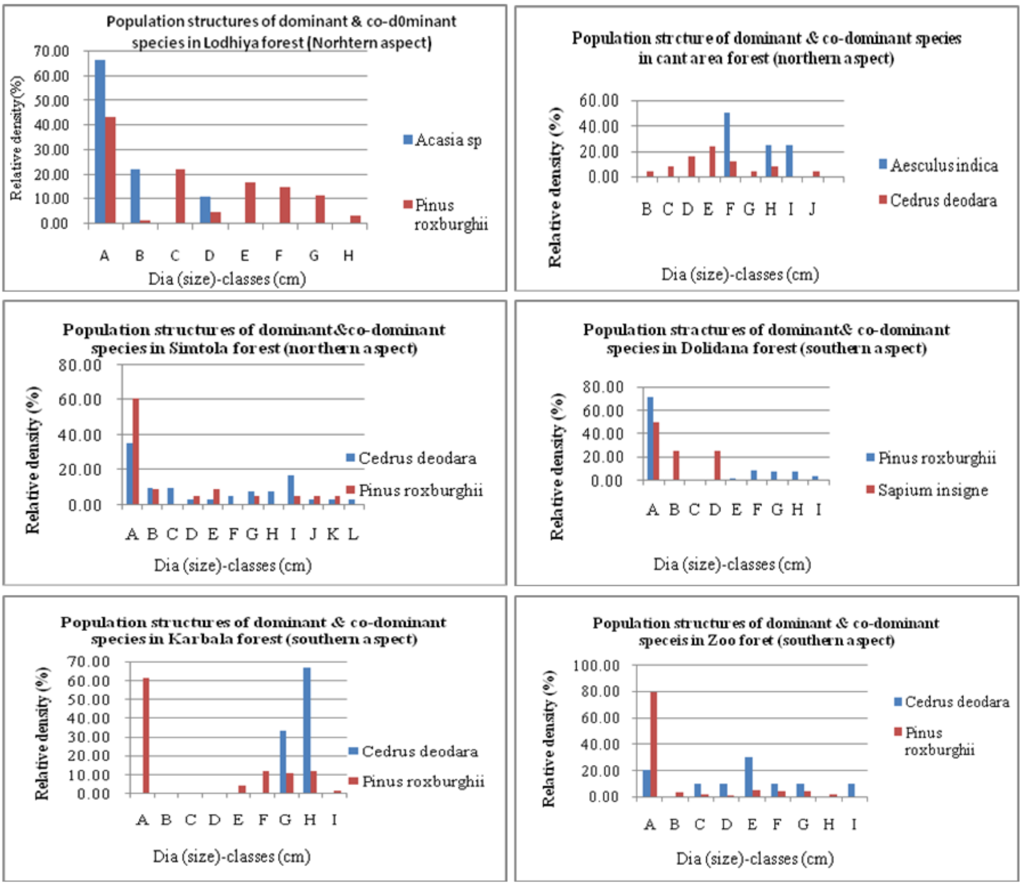

Fig. 1. Population structures of dominant and co-dominant species in different stands in two aspects (Northern and Southern); relative density (%) is on *y* axis and diameter classes on *x* axis; 0-10(A) = seedling, 11-30(B)cm = sapling, Trees: C = 31-60, D = 61-90, E = 91-120, F = 121-150, G = 151-180, H = 181-210, I = 211-240, J = 241-270, K = 271-300, L=301-340

Table 3. Species richness (SR), Species diversity (SD), Concentration of dominance (CD) and Evenness (EN) in the Northern and Southern aspect

Forest Name	Parameters	Vegetation layer			
		Tree	Sapling	Seedling	Shrub
		Northern Aspect			
Lodhiya	SR	2.00	2.00	2.00	3.00
	SD	0.21	0.63	0.48	0.78
	CD	0.89	0.31	0.70	0.48
	EN	0.10	0.21	0.24	0.26
Cant area	SR	8.00	3.00	3.00	3.00
	SD	1.39	1.03	1.03	0.53
	CD	0.38	0.37	0.38	0.70
	EN	0.19	0.34	0.34	0.17
Simtola	SR	5.00	5.00	4.00	6.00
	SD	1.24	1.52	1.20	1.26
	CD	0.38	0.23	0.33	0.52
	EN	0.24	0.30	0.30	0.21

		Southern Aspect			
Dolidana	SR	2.00	2.00	2.00	6.00
	SD	0.21	0.63	0.18	0.44
	CD	0.89	0.55	0.92	0.81
	EN	0.10	0.31	0.09	0.07
Karbala	SR	3.00	-	3.00	4.00
	SD	0.42	-	0.62	1.15
	CD	0.69	-	0.66	0.39
	EN	0.14	-	0.20	0.28
Zoo-forest	SR	5.00	3.00	6.00	5.00
	SD	1.06	0.97	1.10	0.78
	CD	0.44	0.40	0.32	0.63
	EN	0.21	0.32	0.18	0.15

Conclusions

Overall 11 tree and 6 shrub species were recorded in six forest stands in the Northern and Southern aspects. Among these tree species, *Pinus roxbrughii* was the dominant species in the Southern aspect, as well as in the lower stand of the Northern aspect, while *Cedrus deodara* was the dominant species in two stands of the Northern aspect. *Cotoneaster sp*. was the dominant species, followed by *Berberis asiatica*, as shrub stages in all stands of both aspects. Therefore, the present study revealed a great variation in species composition, richness and diversity in the six stands along an altitudinal gradient in both aspects. Moreover, a considerable variation was noted in species composition and richness. The lower altitude (chir pine forest) featured low species richness, which increased with altitude (oak-pine forest). Some stands had a good regeneration status of seedlings of *Pinus roxburghii*, followed by *Acasia sp.* and *Cedrus deodara*, whereas seedling and sapling layers were completely absent in the Karbala forest stand, which indicated a higher human influence, forest fires and grazing pressure.

Acknowledgments

The authors would like to thank to all the staff members from the Department of Botany, Kumaun University, S.S. J. Campus, Almora, for their valuable suggestions and comments.

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Received: May, 24, 2013
Accepted: December, 15, 2013