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Variation in Tree Layer Composition Across Mid and Higher Elevation Forest Sites in Kumaun Himalayan Region, Uttarakhand

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Abstract

The Himalayan forests are rich in biodiversity and distributed over a large extent from lower to higher elevations. The dependence of the locals for their daily requirements of fuel, fodder and medicinal plants is high on these forests. The study was conducted at altitude varied between 1725 and 3250 masl (above sea level) in Kumaun region. The study deals with the comparison of tree layer vegetation in higher elevation sites (HES) and mid elevation sites (MES) with reference to Diversity, Richness, Basal area (BA), Dominance and Important Value Index. The MES were dominated by mixed *Quercus leucotrichophora* and *Pinus roxburghii* forests where as HES sites were dominated by *Quercus semecarpifolia* and *Aesculus indica* forests and *Rhododendron campanulatum* in the understory. Across all the sites the tree species richness ranged between 9 and 15. Tree density was maximum (1400 trees/ha) at MES. Tree diversity and total basal area were maximum at HES. The study will be useful in developing baseline data for carrying out future studies. The data generated will be helpful for the conservation of biodiversity of the region.

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Introduction

The Himalaya among global mountains is most complex, vast and diversified and produce a distinct climate.[1] The Himalayan forests are very diverse ranging from Shorea robusta dominated foothill forests to the alpine meadows above the treeline.[2] The Himalayan forests are equally important for millions of people residing in the adjoining plain areas due to the various ecosystem services they provide. The regeneration ability of a species is chiefly dependent on biotic pressure and community dynamics.[3] Various aspects of biodiversity, its

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compilation and structure of these forests have been studied.[4,5,6,7 and 8] For socioeconomic development and betterment of soil, livestock and human, the conservation of biodiversity is of special importance for socioeconomic development of local population9. Vegetation within forest is greatly affected by differences in the microclimate, aspect and altitude.[10] The chronic disturbance and destruction, both natural and man- made are the major threats to biodiversity.[11] The forest resources of the Himalaya are shrinking in size due to over exploitation. The rich plant diversity of IHR has been utilized by the local communities in various forms such as medicine, fuel, fodder, timber, agricultural implements and small scale enterprises and in religious ceremonies.[12] The recent phenomenon of climate change is also influencing the composition and regeneration of many plant species.[11] Young individuals grow within the most severe micro environment in a forest. Regeneration in the forest is dependent on the capacity of mature trees to produce seeds, seed germination capacity and viability.[13] The focus of present study was to compare the forest composition and tree diversity of selected forest areas of Uttarakhand region located at mid altitude sites (MES) and high altitude sites (HES). The baseline data generated in the current study would be useful for future studies on forests. The paper has a huge scope for young researchers and scientists working in related field as the study will provide baseline data for future referencing.

Material and Methods

Study Site

Two sites located in Ranikhet mid elevation sites (MES) between an altitude 1725 m and 2000 m between 29º 37´ N latitude 79º 27´ E longitudes at northern aspect of the lesser Himalayan zone in Kumaun were selected. The climatic data were taken from Kalika Research Range, Ranikhet. The mean maximum and minimum annual temperature ranged from 13.02°C to 28.05°C and 3.6°C to 17.32°C respectively. The average annual precipitation was 1347 mm14 (Table 1).

Two sites located in Munshiyari high elevation sites (HES) between an altitude 3000 m and 3250 m between 30º, 03´ N latitude 80º, 13´ E longitudes at North eastern aspect were selected. Mean monthly maximum and minimum temperature range from 12°C to 26°C and -1°C to 12°C respectively. The mean annual total rainfall is 1959 mm (more than half occurring during the rainy season – about 400 mm in the month of August itself) 15 (Table 1).

Table 1: Site characteristics of different forests located at mid elevation and high elevation sites

Sites	Altitudes (m)	Latitude	Longitude	Aspect
Mid elevation sites (MES)				
Site I	2000	29º37´ N	79º27´ E	Northern
Site II	1725	29º37´ N	79º27´ E	Northern
High elevation sites (HES)				
Site I	3250	30º03´ N	80º13´ E	North –eastern
Site II	3000	30º03´ N	80º13´ E	North –eastern

Tree Layer Analysis

Total of 2 ha area was selected at each site for placing ten quadrats of 10 m x 10 m for determining the vegetational parameters following.[2,3,16, and 17]

Equitability (EC) or species evenness was calculated following.[18] Species diversity (H) for each species was determined by using Shannon- Weiner index.[19] Concentration of Dominance (CD) was calculated by Simpson's index[20]

Result and Discussion

Tree Layer Analysis

In MES (Site I) The total density of trees was 1400 trees/ha. The density of trees ranged between 10 and 490 trees/ha. The basal area was 46.30

m^2/ha. The basal area ranged between 0.004 and 13.05 m^2//ha. Least important species was *Prunus cerasoides* (5.9) in terms of IVI. The forest was *Quercus leucotrichophora, Rhododendron arboreum* and *Pinus roxburghii* mixed forest. (Table 2).

Table 2: Vegetational parameters of tree species in mid elevation site I (MES I) at Ranikhet

Species	Density (trees/ha)	Frequency (%)	Abundance	A/F	Basal area (m^2/ha)	IVI
Pinus roxburghii	160	70	2.2	0.03	13.05	62.9
Quercus leucotrichophora	490	80	6.1	0.07	9.33	58.4
Rhododendron arboreum	260	90	2.8	0.03	12.52	58.4
Myrica esculenta	240	80	4.6	0.05	9.95	51.9
Quercus glauca	10	50	2	0.04	0.40	18.9
Cedrus deodara	70	40	1.7	0.04	0.37	15.3
Cupressus torulosa	80	30	2.6	0.08	0.51	14.4
Fraxinus micrantha	70	40	1.7	0.04	0.17	13.9
Prunus cerasoides	20	20	1	0.05	0.004	5.9
Total	**1400**				**46.30**	**300.00**

In MES (Site II) Total tree density was 1300 trees/ ha. The density of trees ranged between 20 and 250 trees / ha. The basal area was 49.37m^2/ha. The basal area ranged between 0.59 and 13.69 m2/ha. Least important species observed was *Myrica esculenta* (12.2) in terms of IVI. The forest was *Quercus leucotrichophora* and *Rhododendron arboreum* mixed forest. (Table 3). Across both the sites at mid elevation tree richness ranged between 9 and 14 (Table 6).

Table 3: Vegetational parameters of tree species in mid elevation site II (MES II) at Ranikhet

Species	Density (trees/ha)	Frequency (%)	Abundance	A/F	Basal area (m^2/ha)	IVI
Quercus leucotrichophora	250	80	3.1	0.03	10.71	43.65
Rhododendron arboreum	220	70	3.1	0.04	13.69	43.5
Pinus roxburghii	190	50	3.8	0.07	8.86	33.97
Cedrus deodara	140	50	2.8	0.05	3.48	25.62
Pinus petula (Planted)	100	50	2	0.04	3.12	23.87
Acacia menenzi	60	50	1.2	0.02	1.82	20.69
Aesculus indica	20	20	1	0.05	1.06	16.65
Quercus glauca	20	20	1	0.05	0.85	15.83
Acer oblongum	80	20	4	0.2	1.74	14.55
Pinus gragaii	20	20	3.5	0.17	0.84	14.20
Cupressus torulosa	50	20	2.5	0.12	1.03	12.02
Robinia pseudoacasia	40	30	1.3	0.04	0.59	11.86
Fraxinus micrantha	60	20	3	0.15	0.89	11.58
Myrica esculenta	50	20	2.5	0.12	0.69	12.2
Total	**1300**				**49.37**	**300.0**

In HES (Site I) The total tree density was 1040 trees/ ha. The density of trees ranged between 20 and 190 trees / ha. The basal area was 68.56 m^2/ha. The basal area ranged between 1.24 and 9.41 m^2/

ha. Least important species observed was *Fraxinus floribunda* (11.7) in terms of IVI. *Rhododendron campanulatum* dominated the under canopy species whereas the canopy vegetation was dominated by *Quercus semecarpifolia* (Table 4).

Table 4: Vegetational parameters of tree species in high elevation site I (HES I) at Munshiyari

Species	Density (trees/ha)	Frequency (%)	Abundance	A/F	Basal area (m^2/ha)	IVI
Rhododendron campanulatum	190	80	2.3	0.02	2.21	35.2
Quercus semecarpifolia	50	30	1.6	0.05	9.41	25.4
Betula utilis	110	50	2.2	0.04	6.01	24.7
Betula alnoides	90	40	2.2	0.05	6.45	22.2
Juglans regia	30	20	1.5	0.07	5.51	21.1
Cupressus torulosa	80	40	2	0.05	5.21	20.8
Taxus baccata	40	20	2	0.1	6.15	19.7
Lyonia ovalifolia	20	20	1	0.05	3.36	19
Carpinus veminia	70	30	2.3	0.07	5.45	18.7
Cedrus deodara	70	30	2.3	0.07	4.53	17.7
Abies spectabilis	70	40	1.7	0.04	2.43	17.5
Alnus nepalensis	70	30	2.3	0.07	4.24	17.4
Rhododendron arboretum	60	30	3	0.1	4.38	17.3
Pyrus pashia	40	20	2	0.1	1.98	11.6
Fraxinus floribunda	50	20	2.5	0.1	1.24	11.7
Total	**1040**				**68.56**	**300.0**

Table 5: Vegetational parameters of tree species in high elevation site II (HES II) at Munshiyari

Species	Density (trees/ha)	Frequency (%)	Abundance	A/F	Basal area (m^2/ha)	IVI
Aesculus indica	20	10	0.2	0.02	20.44	48.8
Rhododendron campanulatum	150	70	2.1	0.03	2.43	42.4
Carpinus veminia	80	50	1.6	0.03	5.59	28.5
Cedrus deodara	50	40	1.2	0.03	9.12	26.5
Taxus baccata	60	30	2	0.06	8.91	23.4
Cupressus torulosa	60	30	2	0.06	5.97	21.3
Quercus semecarpifolia	10	10	0.1	0.01	4.05	21.4
Abies spectabilis	50	40	1.2	0.03	1.50	19.5
Betula utilis	30	30	1	0.03	1.75	14.8
Betula alnoides	40	20	2	0.1	2.18	13.7
Alnus nepalensis	40	20	2	0.1	2.18	13.8
Lyonia ovalifolia	0.2	10	0.2	0.02	3.86	13.8
Fraxinus micrantha	30	20	1.5	0.07	0.94	12.1
Total	**640**				**68.92**	**300.0**

In HES (Site II) The total tree density was 640 trees/ha. The density of trees ranged between 20 and 150 trees / ha. The basal area was 68.92 m^2/ha. The basal area ranged between 20.44 nd 0.94 m^2/ha. Rhododendron campanulatum dominated the under canopy species whereas the canopy vegetation was

dominated by Aesculus indica. Least important species observed was Fraxinus micrantha (12.1) in terms of IVI (Table 5). The tree richness ranged between 13 and 15 across both the sites at high elevation.

Table 6: Variations in tree evenness, diversity and concentration of dominance

(CD) at MES and HES sites					
Site	**Elevation (m)**	**Evenness**	**Diversity(ΣH)**	**Richness**	**ΣCD**
MES(Site I)	2000	0.91	2.49	9	0.04
(Site II)	1725	0.39	2.60	14	0.1
HES (Site I)	3250	0.61	7.10	15	0.04
(Site II)	3000	0.34	7.69	13	0.87

Tree Diversity and Evenness

In MES across both elevations species evenness ranged between 0.39 and 0.91. Tree diversity ranged between 2.49 and 2.60. Tree richness ranged between 9 and 14. The concentration of dominance ranged between 0.04 and 0.1. (Table 6).

In HES across both elevation species evenness ranged between 0.34 and 0.61. Tree diversity ranged between 7.10 and 7.69. Tree richness ranged between 13 and 15. The concentration of dominance ranged between 0.04 and 0.87. (Table 6).

The vegetation of Himalaya varies due to different physiognomic conditions and altitudinal range coupled with different climatic and biotic factors.[21] The forest sustainability highly depends upon regeneration potential of various species composition in Himalayan region.[2] The dominated forests at MES sites were of *Quercus leucotrichophora* and Pinus roxburghii mixed forests. At HES site II *Rhododendron campanulatum* dominated the undercanopy vegetation where as the canopy vegetation was dominated by *Aesculus indica*. Certain species of Ericaceae yield toxic diterpenes, named grayanotoxins. It causes various livestock poisoning and food intoxication. Due to toxic nature of some *Rhododendron* species, animal avoid grazing them or it is non-palatable. This can be a major cause of higher density of *R. campanulatum* in higher altitudes.[22] Forest ecosystem diversity is directly linked to tree species diversity and differs very much.[23,24] HES showed high species richness than MES. Low anthropogenic disturbance can be related to higher species richness.[7] As a result certain MES forest areas have decreased, modified and developed dry conditions.[25] Negative correlation has been reported between elevation and tree species diversity.[26] In present study the pattern was different. Across MES and HES sites the highest tree diversity (7.69) was observed at HES. The forests of this area showed less or no anthropogenic disturbances. This reason has been instrumented in enabling many tree species to form stable communities.[27] Basal area was found maximum (68.92) at HES sites. The range of basal area was 56-126m^2/ha at Garhwal Himalaya.[28] Forest plots with higher basal area have been reported at higher elevation by various researchers. For Q. semecarpifolia forest high value of Basal area (72.90) has also been reported earlier. The tree species richness was higher at HES sites than MES sites. High species richness in broad leaved forest of Garhwal Himalaya has also been reported earlier. The highest CD 0.87 was recorded at HES (SiteII). Increase in dominance has been related with increase in altitude.[26] The maximum concentration of dominance might be due to the lesser rate of development and diversification of the communities.[29,2] The concentration of dominance for tree layer was 0.1 - 0.99 at Okalhoma upland forest.[30] Concentration of dominance (0.1-0.5) has also been reported earlier in Nainital forest area of Kumaun.

Conclusion

Assessment of tree vegetation and diversity is important for management, sustainable use and conservation of forests. Baseline data is essential for carrying out future studies on forest vegetation particularly in a changing climate regime. There are several researches to indicate that already certain

tree and shrub species like *R. campanulatum* (which are non palatable) are marching into the alpine meadows which are repositories of important Himalayan medicinal plants. The present study clearly indicates the domination of *R. campanulatum* at sites adjacent to these alpine areas. It is essential to concentrate and carry on such studies to further investigate such movements.

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Conflict of Interest

The authors do not have any conflict of interest.

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