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Assessing Tree Diversity And Phytosociological Attributes: A Comparative Study In Madhyamaheshwar Valley Of Kedarnath Wildlife Sanctuary, Uttarakhand

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Abstract: Trees are the main component of the forest structure and are regarded as an indispensable necessity for various purposes, including environmental conservation, managing forest ecosystems, and biodiversity research. Target of this study is to identify the diversity and also quantification of tree species in the temperate forest of the Madhyameshwar area, focusing on two sites on the basis of altitudinal gradient (ranging 1550 to 2600 meters above sea level i.e., m asl). Twenty quadrats of 10m×10m for tree species, were laid down along the altitudinal gradient in each site. Ecological data were used for the analysis of tree diversity and phytosociological attributes and there was regular distribution found. Two selected sites were visited, broadly 17 species from 15 genera and 12 families were observed. *Alnus nepalensis* was recorded as dominant species at the site-I, with a maximum density of 350/hectare(ha) and an IVI of 61.81/ha. *Quercus leucotrichophora* was found dominant species in the site-II with the highest values of density (190/ha), and IVI of 46.63/ha. In the present study, ample population of old trees was recorded and hence new growth was affected. Therefore, the study recommended some measures to protect the forest ecosystem.
Keywords: Madhyamaheshwar • Western Himalaya • phytosociological attributes • diversity • altitudinal gradient

Introduction

The Himalayas are among the biggest and newly borne mountain ranges in the entire universe. It is recognized as a tremendous depository of biological and cultural diversity (Negi and Dhyani 2012). There is alpine grassland above the timberline and tropical dry deciduous woodland in the Himalayan foothills (Bhatt and Bankoti 2016). More than one-third of the world is made up of forests, which are home to a diverse range of habitats and species that support a substantial population (Ao et al 2021). The Himalayan forests are the most fascinating and amazing places on earth because of their unique ecology and fluctuating temperature patterns (Tiwari et al 2018). Since ages, scientists have been interested in evaluating species diversity; nevertheless, given the dire circumstances, it is now imperative to protect and conserve it (Soboleski et al 2017). There is a mutual relationship between the diversity of distinct species, forest production, and climate (Rahbek 2005). A vital element of ecosystems, tree diversity promotes the general resilience and well-being of natural settings. It is regarded as a decisive component of the forest's ecology (Rennolls and Laumonier 2000; Pala et al 2016; Bhat et al 2020). Furthermore, it is essential to the overall biodiversity of the landscape (Huang et al 2003). Forest cover acts as a carbon sink and adds to the global carbon cycle because trees absorb carbon dioxide during photosynthesis. In doing so, impacts generated by climate change are mitigated. Ecologists and biogeographers are worried about the elevation gradient. Diversity is dispersed over multiple spatial scales in a gradient fashion (Field et al 2009). Variations in elevation change various environmental factors, such as precipitation, temperature, soils, and humidity (Oliveira-Filho et al., 1998; Homeier et al., 2010; Chang et al., 2015). Additionally, effective quantitative indicators of forest architecture are tree diversity indices (Aguirre et al 2003; Lexerød and Eid 2006; Pommerening 2002; 2006a) which is a crucial prerequisite for comprehending how patterns and processes interact in forest environments. Quantifying

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the tree vegetation is the current study's purpose in order to ascertain the forest's present structure and provide early intervention to maintain its health.

Material and Methods

Study area: The assessment was done in the Madhyamaheshwar Valley of Kedarnath Wildlife Sanctuary (KWS), Uttarakhand (India). The area located between 30°35'40.00" N; 79°09'55.37" E and 30°37'10.40" N; 79°12'09.27" E, within the KWLS. The study site experiences an average annual temperature in summer of (15°C), & in winter (-10°C), with an average annual precipitation (1550mm). The area comprises temperate, sub-alpine, and alpine zones, home to sub-alpine meadows and Oak-*Rhododendron* mixed broad-leaf forest stands, with moderate to heavy snowfall in low-altitude areas. The unique combination of plant species in this area has developed due to variations in climate and landscape. The area harbours two beautiful rivers namely Morkanda and Madhuganga which are snow-fed rivers. Morkanda originates from Morkanda hills (near Chaukhamba massif mountain) and Madhuganga from Nandikund. Both sources are at more than 5500 m asl. The two rivers meet at Bantoli village which is at 1650 m asl. The selected sites were named as, site-I (1550-2050) at Gaundar and site-II (2100-2600) at Khadara. Figure 1. shows the vegetation, and Figure 2. depicts the map (along the altitudinal gradient) of the survey sites

Figure 1. Tree vegetation of the area

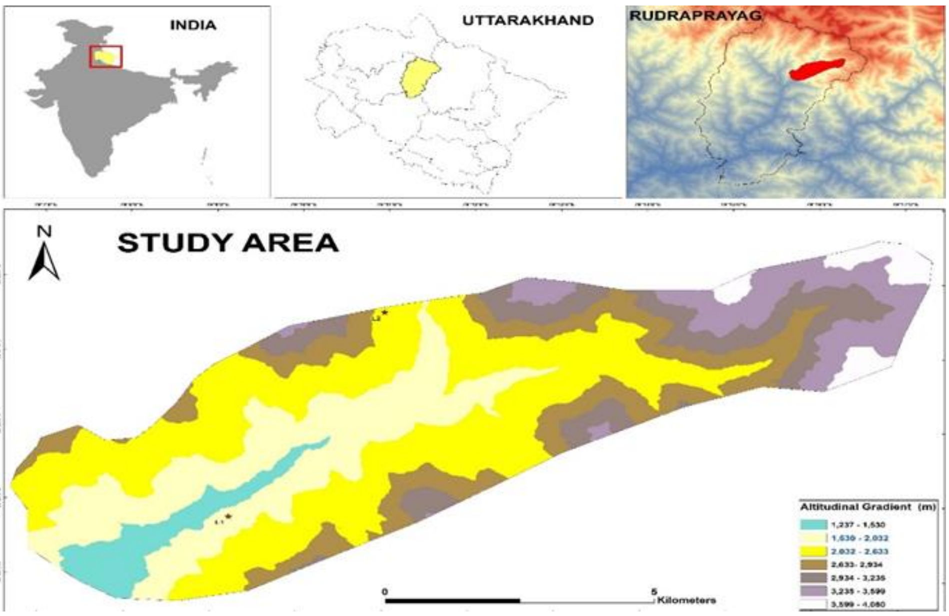

Figure 2. Map of the study area and study site, L1(1530-2032m asl) and L2 (2032-2633m asl

Methods

Tree species quantification was conducted by random quadrat method, following Misra (1968). Twenty 10m x 10m quadrats (encompassing 1000m^2) were placed in every selected site for the quantification of different tree species and their individuals. Individuals with girth at breast height (GBH) more than 31.5 cm above the ground, were classified as trees. We examined the density, frequency, and abundance of the obtained vegetational data (Curtis and McIntosh 1950). Calculation of relative values was done by following Phillips (1959). Sum of relative values of frequency, density, and dominance gives IVI (Curtis 1959). Total basal cover of the tree species was calculated following Misra (1968). Distribution pattern of the species was examined through abundance to frequency ratio. Less than 0.025 was deemed regular, 0.025 to 0.050 was deemed random, and a greater than 0.050 ratio was deemed contagious (Whitford 1949). The Important value index (IVI) was used to build the dominance-diversity curve for tree species. The Shannon-Wiener diversity index (SWI), denoted by H, was employed to assess tree species diversity determined using a specific formula (Shannon and Wiener 1963).

$$H = -\sum_{i=1}^{s} pi \ \ln pi$$

Simpson concentration of dominance (SI), denoted by Cd, was determined using a specific formula (Simpson 1949).

$$Cd = \sum_{i=1}^{s} (pi)^2$$

pi=proportion of individual=n/N; 'n' is the total individuals in one species, whereas 'N' represents the overall individuals of all species. Cd focuses on the most dominating species in the ecosystem and it represents the probability of a species found at the time of sampling, and its value ranges from 0 to 1.

ln pi=Log natural of pi

Σ=sum of calculations.

Results

A total of 17 tree species were found, associated with the 12 families and 15 genera, mostly showed regular distribution (Table 3). Several structural attributes of the forest showed variation along the altitudinal gradient. Site-I had the highest tree density measured, and TBC exhibited a same pattern. Overall values of the species, genera, and families were high in site-II as compared to site-I (Table 3). The Shannon-Wiener diversity index (H) was observed higher in site-II while Simpson index (Cd) was shown higher in site-I (Table 3).

Site-I Generally, 9 tree species (which were categorized into 8 genera and 6 families) found in the site-I (1550-2050m asl) out of which 5 species showed random distribution and 4 existed in regular distribution (Table 3). This site had higher tree density (143/ha) and higher TBC (53.06/ha) as compared to site-II. The values of Shannon-Weiner (H) and Simpson index (Cd) were recorded as 1.95 and 0.16 (Table 3).

Site-II: Overall, 15 tree species (associated to 14 genera and 12 families) were observed from the site-II (2100-2600) out of which 5 were recorded randomly distributed, 9 were regularly distributed and 1 had shown contagious distribution (Table 3). Total tree density (1090/ha) and TBC (33.02/ha) were recorded in the site-II. The values of Shannon-Weiner index(H) and Simpson index (Cd) were found as 2.42 and 0.11 (Table 3) that represented that this site showed more tree diversity than site-I.

Table 1. Phytosociological parameters of tree species in Site-I

Species name	D	TBC	RF	RD	Rd	IVI	A/F	Dist.
Alnus nepalensis D. Don	350	17.67	14.93	24.48	22.41	61.81	0.04	Random
Betula alnoides Buch. -Ham. ex D. Don	40	0.19	4.48	2.80	0.25	7.52	0.04	Random
Ficus auriculata Lour.	70	0.79	10.45	4.90	1.00	16.34	0.01	Regular
Ficus neriifolia Sm.	60	0.25	8.96	4.20	33.03	46.18	0.02	Regular
Juglans regia L.	30	0.28	4.48	2.10	0.35	6.93	0.03	Random
Lyonia ovalifolia (Wall.) Drude.	190	1.54	14.93	13.29	1.95	30.16	0.02	Regular
Pinus roxburghii Sarg.	280	10.64	13.43	19.58	13.50	46.51	0.03	Random

Quercus leucotrichophora A. Camus	190	12.25	14.93	13.29	15.54	43.75	0.02	Regular
Rhododendron arboreum Sm.	220	9.45	13.43	15.38	11.98	40.80	0.03	Random
	1430	**53.06**	**100**	**100**	**100**	**300**		

Note: D=Density, TBC=Total basal cover, RF=Relative frequency, RD=Relative density, Rd=Relative dominance, IVI=Important value index, A/F= Abundance frequency ratio; Dist.= Distribution.

Table 2. Phytosociological parameters of tree species in Site-II

Species name	**D**	**TBC**	**RF**	**RD**	**Rd**	**IVI**	**A/F**	**Dist.**
Albizia chinensis (Osbeck) Merr.	30	0.54	4.41	2.75	2.75	9.92	0.03	Regular
Alnus nepalensis D. Don	150	8.14	10.29	13.76	13.76	37.82	0.03	Regular
Betula alnoides Buch. -Ham. ex D. Don	30	0.66	4.41	2.75	2.75	9.92	0.03	Regular
Cornus macrophylla Wall.	40	0.57	5.88	3.67	3.67	13.22	0.03	Regular
Falconeria insignis Royle	20	0.31	2.94	1.83	1.83	6.61	0.05	Random
Juglans regia L.	40	0.79	2.94	3.67	3.67	10.28	0.10	Contagious
Lyonia ovalifolia (Wall.) Drude.	140	3.16	11.76	12.84	12.84	37.45	0.02	Random
Morus serrata Roxb.	40	0.60	5.88	3.67	3.67	13.22	0.03	Regular
Myrica esculenta Buch. -Ham. ex d. Don	50	0.62	5.88	4.59	4.59	15.06	0.03	Regular
Pinus roxburghii Sarg.	160	5.99	11.76	14.68	14.68	41.12	0.03	Regular
Quercus floribunda Lindl. ex A. Camus	50	1.42	5.88	4.59	4.59	15.06	0.03	Regular
Quercus leucotrichophora A. Camus	190	5.78	11.76	17.43	17.43	46.63	0.03	Regular
Rhododendron arboreum Sm.	110	3.80	10.29	10.09	10.09	30.48	0.02	Random
Symplocos paniculata (Thunb.) Miq.	20	0.18	2.94	1.83	1.83	6.61	0.05	Random
Zanthoxylum armatum DC.	20	0.45	2.94	1.83	1.83	6.61	0.05	Random
	1090	**33.02**	**100.00**	**100.00**	**100.00**	**300.00**		

Table 3. Overall values of phytosociological parameters and diversity indices

Parameters	**Site-I (1550-2050m)**	**Site-II (2100-2600m)**
Density/ha	1430	1090
TBC/ha	53.06	33.02
No. of Species	9	15
No. of Genera	8	14
No. of Families	6	12
Distribution pattern		
Random	5	5
Regular	4	9
Contagious	0	1
Diversity indices		
SWI (H)	1.95	2.42
SI(Cd)	0.16	0.11

Note: SWI= Shannon-Wiener index, SI= Simpson index, No.=Number

Table 4. Table showing phytosociological parameters and diversity indices of the current study with earlier studies

S.No.	Study area	Altitude	D	TBC	H	Cd	Reference
1	Madhyamaheshwar*	1550-2050	1430	53.06	1.95	0.16	Present study
2	Madhyamaheshwar	2100-2600	1090	33.02	2.42	0.11	Present study
3	Madhmeshwar *	1500-1700	530±36	37.96±2.95	4.209	0.07	Bhat et al (2020)
4	Madhmeshwar	2000-2200	285±26	14.71±1.43	3.146	0.135	Bhat et al (2020)
5	Madhmeshwar	2450-2650	425±35	32.37±6.14	4.148	0.073	Bhat et al (2020)
6	Kukrani Band Forest	1650-1750	410±20	20.40±1.24	3.02	0.9	Malik et al (2015)
7	Triyuginaryan forest 1	2300-2600	465±13	31.51±1.86	3.53	0.94	Malik et al (2015)
8	Triyuginaryan forest 2	2250-2400	505±21	42.92±2.57	3.34	0.91	Malik et al (2015)
9	KWLS	1400-2200	433.72	88.06	2.66	–	Singh et al (2012)
10	KWLS	2201-2700	433.15	110.5	2.53	–	Singh et al (2012)
11	Tangsa	1200-1600	1020	19.42	0.949	0.2857	Khali and Bhatt (2014)
12	Devkhal	1600-2000	1140	18.57	0.8098	0.2438	Khali and Bhatt (2014)
13	Bamyala	2000-2500	940	17.79	0.8173	0.246	Khali and Bhatt (2014)
14	Guptkashi Range	1700-2100	807.59	62.47	2.22	0.14	Dhyani et al (2019)
15	Guptkashi Range	1900-2100	736.7	59.12	1.76	0.22	Dhyani et al (2019)
16	Guptkashi Range	2400-2700	1152.31	101.28	1.98	0.25	Dhyani et al (2019)
17	Sari	2100	740	76.27	3.59	0.56	Pushpan and Pandey (2011)
18	Krokhi	1900	690	46.94	1.96	0.44	Pushpan and Pandey (2011)
19	Makkumath	1700	740	56.042	3.21	0.14	Pushpan and Pandey (2011)
20	Kailakhan	1750-1950	672	51.58	2.04	0.42	Joshi et al (2023)
21	Kilbury	2050-2250	884	33.42	2.31	0.24	Joshi et al (2023)
22	Dhanaulti	2350	850	137.4	0.84	0.69	Saha et al (2016)
23	Dhanaulti	2200	850	57.78	2.13	0.29	Saha et al (2016)
24	Dhanaulti	2050	1210	43.68	2.13	0.26	Saha et al (2016)
25	Gharsaari	1005	37.39	–	3.14	0.135	Sharma et al. (2009)
26	Bammana	1470	84.29	–	3.09	0.1389	Sharma et al (2009)
27	Khalla	330	36.32	–	2.1	0.3213	Sharma et al (2009)
28	Ramganga valley, Chamoli	1400-2000	1170	39.05	1.69	0.27	Rawat et al (2020)
29	Ramganga valley, Chamoli	1350-2250	840	23.01	1.78	0.29	Rawat et al (2020)
30	Ramganga valley, Chamoli	1800-2300	1140	54.18	2.49	0.14	Rawat et al (2020)
31	Ramganga valley, Chamoli	1800-2300	570	23.9	2.13	0.14	Rawat et al (2020)
32	Ramganga valley, Chamoli	2500-3000	830	55.99	2.21	0.17	Rawat et al. (2020)
33	Ramganga valley, Chamoli	2100-2700	540	29.79	2.21	0.15	Rawat et al (2020)
34	Guptkashi Range	1900-2100	880	78.59	1.326	0.385	Misra et al (na)
35	Guptkashi Range	1700-2100	536.13	44.62	1.037	0.523	Misra et al (na)
36	Guptkashi Range	2400-2700	1058.94	84.6	1.631	0.31	Misra et al (na)
37	Narayanbagar, Chamoli	1200–1800	1166–1826	–	1.00–2.07	0.13–0.40	Devlal and Sharma (2008)
38	Kumaon Himalaya	1500–2600	370–1140	–	0.0–6.2	0.3–1.0	Kharkwal (2009)
39	Chaurangikhal	1850–2800	–	–	0.99–2.37	–	Sharma et al (2009)
40	KWS	900–2600	235–505	10.49–42.92	2.3–3.53	0.06–0.1	Malik and Bhatt (2015)

41	Uttarkashi	2010–2565	35–930	2.21–87.07	1.27–1.86	–	Singh et al (2016)
42	Mandal-Chopta	2500-2100	1390	84.03	3.19	0.1442	Gairola et al (2011)
43	Mandal-Chopta	2400-2150	1200	76.83	3.33	0.1289	Gairola et al (2011)
44	Mandal-Chopta	2150-1900	1007	37.37	3.14	0.135	Gairola et al (2011)
45	Mandal-Chopta	1900-1600	1470	84.25	3.09	0.1389	Gairola et al (2011)
46	Mandal-Chopta	1650-1500	990	35.08	2.43	0.253	Gairola et al (2011)

Note: D=Density per hectare, TBC=Total basal cover/hectare, H =SWI; Cd=SI, * Madhyamaheshwar and Madhmeshwar are the same.

Discussion

In this study, values recorded for density and total basal cover (TBC) were somewhat different from previously reported values. There was lower TBC found in the site-II than estimated and was more random distribution of species recorded in the site-I. These deviated values might be due to more anthropogenic disturbances because although, the area comes under KWLS but is more prone to tourism as it is one of the parts of Panch Kedar (holy shrines of lord Shiva). Plant degradation is one of the most important effects of human activity (Baithalu et al 2013; Dias and Melo 2010). Mountain communities often face lower wealth and poverty compared to their lowland counterparts, even in first world countries (Godde et al 2000; Messerli and Ives 1997). According to recent studies on recreational ecology, mountain tourism negatively impacts wetlands, natural areas, and protected areas in developing nations (Stevens 2003; Bautaine et al 2007). Policies pertaining to tourism are often out-of-date, deficient, or improperly implemented in developing nations (Singh 2002). Trees with high total biomass (TBC) reflect optimal species performance in certain environmental conditions, whereas reduced TBC indicates the possibility of species existence or previous biotic disturbances (Saxena et al 1978).

Diversity indices: A diversity index is a quantitative indicator of the species diversity present in a certain community. In the current study, there are low values of diversity (1.95-2.42 for trees), as given by Bhat et al (2020) for Garhwal Himalayan forests (3.15-4.21). These lower values of diversity may be due to road construction work (part of anthropogenic activity) in the forest. Anthropogenic influences have been linked to the population growth of *Pinus* spp. in many parts of the world, whether they are native or invasive species (Richardson and Bond 1991; González-Espinosa et al 1995; Schneider 1996; Savage 1997; Richardson 2000b; Stapanian and Cassel 1999). Tropical lowland and Montane Rain Forests' structure, floristic composition, and regeneration dynamics may be regulated in part by anthropogenic disturbances (Ewel et al 1981; Gómez-Pompa and Vázquez-Yanes 1981; Horne and Hickey 1991; Hong et al 1995). According to Kim et al (2017), a useful tool for estimating species richness and evenness, especially species evenness, is Simpson's index (Cd). The site with the greatest Cd value in the current study is site-I, which may be because this zone has a lower species richness. Less weight is assigned to rare species and more weight is given to abundant species in the Simpson's diversity index (Geleta 2023).

Conclusion

In this study, good diversity and density were observed in both zones. But mostly these trees were of old age. This indicates that new growth is affected. This can be due to anthropogenic pressure. Therefore, the present study recommends some measures to sustain forest health in the Western Himalayas. Some of them are: a) tourism should be controlled, as the study area is ecologically rich. b) The government must launch awareness programs to teach the local inhabitants as they are the main stakeholders of the forest.

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