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Phyto-sociological study of forest vegetation along an altitudinal gradient in deolsari range, Mussoorie forest division, Uttarakhand

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ABSTRACT

We investigated the phytosociological attributes of tree species along an altitudinal gradient in the Deolsari range, Mussoorie forest division. This area is situated between 30°30'60" and 30°36'00" North latitude and 78°1'80" to 78°18'00" East longitude. The phytosociological analysis of vegetation was conducted between 2021 and 2023. A total of 45 quadrats measuring 0.1 ha^{-1} were designated for the study. During our study, we recorded 21 tree species in the study area, belonging to 17 genera and 13 families. The dominant tree species were Pinus roxburhii at study site I, Cedrus deodara at study sites II, III, IV, and VI, Quercus leucotrichophora at site V, and Q. semecarpifolia at sites VII, VIII, and IX. The Species diversity index was maximum for saplings (1.80) while species richness and evenness were highest for saplings. Simpson's index of dominance was highest for trees. This study provides essential baseline data for the Deolsari range. This information is presumed to be crucial in guiding conservation efforts, implementing effective land management practices, and initiating biodiversity conservation initiatives in the Deolsari Range.

Keywords: Altitudinal, Diversity, IVI, Mussoorie, Phytosociological

INTRODUCTION

Vegetation ecology encompasses the study of species composition and the intricate sociological interactions among species within communities (Mueller-Dombois and Ellenberg, 1974). Central to understanding the structure of these communities is the quantitative analysis of relationships between coexisting species. This quantitative study, known as phytosociology, serves the principal objective of describing vegetation, elucidating, or forecasting its patterns, and organizing it into meaningful classifications (Ilorkar and Khatri, 2003). The vegetation in the Himalayan forests covers a wide spectrum, transitioning from tropical dry deciduous forests in the foothills to moist temperate forests approaching the timberline. More specifically, the temperate forests found in the Western and Central Himalayas usually extend across altitudes ranging from 1200 to 3000 masl. within this region, the Garhwal Himalayan area has served as a focal point for extensive floristic and ecological research over the past century. Its broad altitudinal range, marked by rapid transitions over short distances, coupled with a high degree of endemism, renders it particularly intriguing for floristic investigations (Singh *et al.* 1992; Arora, 1995; Zobel). Characterized by a multitude of forest types distributed across varying altitudes, geological formations, and soil types, the Garhwal Himalaya offers a rich tapestry for ecological exploration (Champion and Seth 1968; Saxena and Singh, 1982). The composition of Himalayan forests is notably diverse and exhibits variations across different topographical features, including plains, foothills, and high mountainous regions (Singh, 2006). This complexity underscores the dynamic interplay between environmental factors and vegetation distribution, providing fertile ground for ongoing scientific inquiry and conservation efforts.

Phytosociology is a quantitative discipline focused on the functioning of plant communities and enhances our understanding of the intricate relationships between plants and their environment (Braun and Blanquet 1932). Climatic and soil variations are recognized as key drivers of plant distribution and diversity (Härdtle *et al.,* 2003 Costa *et al.,* 2006). Campos and Souza (2002) highlight environmental factors influencing species establishment and exclusion, shaping the

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structure, dynamics, and distribution of plant communities. These communities, defined by clear associations among plant species, are essential for biodiversity maintenance, economic significance, and the well-being of ecosystems.

MATERIALS AND METHODS

Study site

The study was conducted in the Deolsari Range Mussoorie Forest Division of Uttarakhand, India. It is located between 30°30'60" and 30°42'00" North latitude and 78°3'00" to 78°13'30" East longitude. The total area covered by the Deolsari range is 5406.00 ha. These regions represent different altitude ranges from 1200 to 3000 (amsl). Based on the objectives the area was divided into 9 different study sites based on altitudinal gradients viz. Site I 1200 -1400 m Site II 1400–1600 m Site III 1600–1800 m Site IV 1800 –2000 Site V 2000-2200 m Site VI 2200-2400m SiteVII 24000- 2600m Site VIII 2600- 2800m and Site IX 2800-3000m.

METHODOLOGY

The phytosociological analysis of vegetation was conducted between the years 2021 to 2023 across the selected study sites. Random sampling was employed to assess vegetation characteristics along different altitudinal gradients. A total of 45 quadrats measuring 0.1 ha^{-1} were designated for tree species, while within each 0.1ha plot, 180 quadrats of sizes $3x3m^2$ and $1x1m^2$ were established for saplings and seedlings, respectively. In each quadrat, the circumference at breast height (CBH) of every individual was measured at 1.37m above the ground level. The classification criteria utilized categorized individuals with a CBH greater than 30 cm as trees, those with a CBH between 10 and 30 cm as saplings, and those with a CBH less than 10 cm as seedlings, (Pande *et al.,*2014). The vegetation data collected underwent quantitative analysis for density, abundance, percentage frequency, relative frequency, and relative density, by Misra 1968. Additionally, the Importance Value Index (IVI) for each species was determined by summing the relative density, relative frequency, and relative dominance, as per Phillips in 1959 and Curtis in 1959.

RESULTS AND DISCUSSION

The Deolsari range is characterized by extensive oak and coniferous forests. These community characteristics exhibit notable variations across different aspects and altitudes. A total of 21 tree species were recorded in the study area, which belonged to 17 genera and 13 families. The most abundant family was Fagaceae with 3 species, Cornaceae, Ericaceae, Pinaceae and Sapindaceae were co-dominant families represented by 2 species each, Aquifoliaceae, Fabaceae, Juglandaceae, Malvaceae, Myricaceae, Phyllanthaceae, Proteaceae, Rosaceae represented by 1 species each.

Tree layer

Tree phytosociological analysis of vegetation at different altitudinal gradients in the Deolsari Range is given in (Table 1). At study site I, the highest importance and frequency was recorded *Pinus roxburhii* was the dominant species (IVI = 240.91) with a frequency of 80 %, and the *Glochidion heyneanum* showed minimum importance value and frequency was recorded (IVI = 28.46) with the frequency 10%. At study site II, III, IV, and VI the highest importance value was recorded for *Cedrus deodara* IVI = 221.18, 157.04, 223.47 and 151.58 with the frequency 73, 52, 74.49, and 50.53 % respectively. At study site V the highest importance value was recorded *Quercus leucotrichophora* (IVI = 112.75) with a frequency 37.58%. At study sites VII, VIII and IX the highest importance value recorded was for *Quercus semecarpifolia* (IVI = 89.35, 213.75, and 231.99) with the frequency 29.78, 71.25, and 77.33% respectively. While the distribution pattern of, *Quercus floribunda, Q. leucotrichophora, Q. semecarpifolia, Lyonia ovalifolia* and *Rhododendron arboreum* was random but *Cedrus deodara* and *Pinus roxburghii*, distributed contiguously.

Table 1: Phytosociological attributes of Trees at different study sites

S.S	Elevation(m)	Botanical Name	RF	RD	RDO	IVI	A/F
I	1200-1400	*Pinus roxburghii* Sarg.	50.00	94.12	96.79	240.91	0.24
		Grevillea robusta A.Cunn. ex R.Br.	25.00	3.92	1.71	30.63	0.04
		Glochidion heyneanum (Wight & Arn.) Wight	25.00	1.96	1.50	28.46	0.04
II	1400-1600	*Cedrus deodara* (Roxb. ex D.Don) G.Don	66.67	72.16	82.35	221.18	0.85
		Pinus roxburghii Sarg.	33.33	27.84	17.65	78.82	0.66
III	1600-1800	*Cedrus deodara* (Roxb. ex D.Don) G.Don	66.66	69.32	21.06	157.04	0.12
		Pinus wallichiana A.B.Jacks.	16.67	29.54	78.54	124.75	0.78
		Ougeinia oojeinensis (Roxb.) Hochr.	16.67	1.14	0.40	18.21	0.03
IV	1800-2000	*Cedrus deodara* (Roxb. ex D.Don) G.Don	37.50	90.00	95.97	223.47	0.24
		Quercus leucotrichophora A.Camus	25.00	6.25	1.91	33.16	0.03
		Lyonia ovalifolia (Wall.) Drude	12.50	1.25	0.79	14.54	0.03
		Ougeinia oojeinensis (Roxb.) Hochr.	12.50	1.25	0.70	14.45	0.03
		Quercus floribunda Lindl. ex A.Camus	12.50	1.25	0.63	14.38	0.03
V	2000-2200	*Quercus leucotrichophora* A.Camus	16.66	81.67	14.42	112.75	0.98
		Quercus glauca Thunb.	16.66	2.50	18.52	37.68	0.03
		Cornus capitata Wall.	5.56	0.83	16.44	22.83	0.03
		Cornus macrophylla Wall.	5.56	0.83	14.26	20.65	0.03
		Lyonia ovalifolia (Wall.) Drude	11.11	5.00	1.29	17.40	0.09
		Cedrus deodara (Roxb. ex D.Don) G.Don	5.55	1.68	9.19	16.42	0.06
		Pyrus pashia Buch.-Ham. ex D.Don	11.10	2.50	1.35	14.95	0.05
		Rhododendron arboreum Sm.	5.56	0.83	8.46	14.85	0.03
		Ilex dipyrena Wall.	5.56	0.83	6.62	13.01	0.03
		Grewia optiva J.R.Drumm. ex Burret	5.56	1.67	3.86	11.09	0.06
		Juglans regia L.	5.56	0.83	4.52	10.91	0.03
		Myrica esculenta Buch.-Ham. ex D.Don	5.56	0.83	1.07	7.46	0.03
VI	2200-2400	*Cedrus deodara* (Roxb. ex D.Don) G.Don	33.34	68.03	50.21	151.58	0.37
		Quercus leucotrichophora A.Camus	11.11	27.05	11.24	49.40	1.32
		Ilex dipyrena Wall.	11.11	0.82	23.77	35.70	0.04
		Aesculus indica (Wall. ex Cambess.) Hook.	11.11	0.82	5.65	17.58	0.04
		Acer caesium Wall. ex Brandis	11.11	1.64	3.59	16.34	0.08
		Cornus capitata Wall.	11.11	0.82	3.36	15.29	0.04
		Pyrus pashia Buch.-Ham. ex D.Don	11.11	0.82	2.18	14.11	0.04
VII	2400-2600	*Quercus semecarpifolia* Sm.	39.45	15.38	34.52	89.35	0.02
		Quercus leucotrichophora A.Camus	40.37	15.38	19.75	75.50	0.02
		Quercus floribunda Lindl. ex A.Camus	6.42	15.38	14.90	36.70	0.02
		Acer caesium Wall. ex Brandis	6.42	15.38	11.40	33.20	0.02
		Lyonia ovalifolia (Wall.) Drude	2.75	15.38	5.84	23.97	0.02
		Aesculus indica (Wall. ex Cambess.) Hook.	0.92	7.70	6.46	15.08	0.03
		Cornus capitata Wall.	2.75	7.70	4.30	14.75	0.03
		Rhododendron arboreum Sm.	0.92	7.70	2.83	11.45	0.03
VIII	2600-2800	*Quercus semecarpifolia* Sm.	50.00	96.47	67.28	213.75	0.27
		Quercus *floribunda* Lindl. ex A.Camus	16.67	1.18	12.57	30.42	0.03
		Lyonia ovalifolia (Wall.) Drude	16.67	1.18	11.38	29.23	0.03
		Acer caesium Wall. ex Brandis	16.66	1.17	8.77	26.60	0.03
IX	2800-3000	*Quercus semecarpifolia* Sm.	60.00	98.24	73.75	231.99	0.37
		Taxus baccata L.	20.00	0.88	13.79	34.67	0.03
		Lyonia ovalifolia (Wall.) Drude	20.00	0.88	12.46	33.34	0.03

S.S = Study site RF= Relative frequency, RD = Relative Diversity, RDO = Relative Dominance IVI = Importance Value Index, A/F = Abundance/ Frequency

Sampling layer

Sampling phytosociological analysis of vegetation at different altitudinal gradients in the Deolsari Range (Table 2). The study site I, the highest importance and frequency were recorded *P. roxburhii* is the dominant species (IVI = 204.59) with a frequency of 68.20%, and the minimum importance value was recorded for *Grevillea robusta* (IVI = 95.4) with the

frequency 28.46 %. Study site II, III, IV, V and VI the highest importance value was recorded for *C. deodara* (IVI = 202.20, 158.39, 156.93 77.39, and 158.67 and frequency of 67.40, 52.80, 52.30, 25.80, and 52.89 % respectively). At study site VII the highest importance value was recorded for *Acer caesium* (IVI = 109.53) with a frequency of 36.51%. At study sites VIII and IX, the highest importance value was recorded for *Quercus semecarpifolia* (IVI = 218.53, and 224.65 and frequency of 72.84 and 74.88% respectively). The distribution pattern of, *P. roxburhii, C. deodara, Q. floribunda, Q. leucotrichophora, Q. semicarpifolia, L. ovalifolia* and *R. arboreum* was random.

Table 2: Phytosociological attributes of sapling at different study sites

S. S	Elevation(m)	Botanical Name	RF	RD	RDO	IVI	A/F
I	1200-1400	*Pinus roxburghii* Sarg.	50.00	66.67	87.92	204.59	0.04
		Grevillea robusta A.Cunn. ex R.Br.	50.00	33.33	12.08	95.41	0.02
II	1400-1600	*Cedrus deodara* (Roxb. ex D.Don) G.Don	66.67	66.67	68.86	202.20	0.02
		Pinus roxburghii Sarg.	33.33	33.33	31.14	97.80	0.03
III	1600-1800	*Cedrus deodara* (Roxb. ex D.Don) G.Don	60.00	60.00	38.39	158.39	0.01
		Pinus wallichiana A.B.Jacks.	20.00	20.00	46.98	86.98	0.01
		Ougeinia oojeinensis (Roxb.) Hochr.	20.00	20.00	14.63	54.63	0.01
IV	1800-2000	*Cedrus deodara* (Roxb. ex D.Don) G.Don	50.00	50.00	56.93	156.93	0.03
		Ougeinia oojeinensis (Roxb.) Hochr.	50.00	50.00	43.07	143.07	0.03
V	2000-2200	*Cedrus deodara* (Roxb. ex D.Don) G.Don	12.50	27.27	37.62	77.39	0.05
		Ilex dipyrena Wall.	25.00	27.27	17.61	69.88	0.02
		Grewia optiva J.R.Drumm. ex Burret	25.00	18.19	9.98	53.17	0.02
		Rhododendron arboreum Sm.	12.50	9.09	18.57	40.16	0.03
		Myrica esculenta Buch.-Ham. ex D.Don	12.50	9.09	8.33	29.92	0.03
		Pyrus pashia Buch.-Ham. ex D.Don	12.50	9.09	7.89	29.48	0.03
VI	2200-2400	*Cedrus deodara* (Roxb. ex D.Don) G.Don	50.00	33.33	75.34	158.67	0.03
		Quercus leucotrichophora A.Camus	50.00	66.67	24.66	141.33	0.05
VII	2400-2600	*Acer caesium* Wall. ex Brandis	33.33	33.33	42.87	109.53	0.03
		Lyonia ovalifolia (Wall.) Drude	33.33	33.33	42.69	109.35	0.03
		Quercus leucotrichophora A.Camus	33.34	33.34	14.44	81.12	0.03
VIII	2600-2800	*Quercus semecarpifolia* Sm.	66.67	75.00	76.86	218.53	0.02
		Lyonia ovalifolia (Wall.) Drude	33.33	25.00	23.14	81.47	0.03
IX	2801-3000	*Quercus semecarpifolia* Sm.	75.00	71.43	78.22	224.65	0.02
		Lyonia ovalifolia (Wall.) Drude	25.00	28.57	21.78	75.35	0.05

Abbreviations are the same as in Table 1

Seedling layer

Seedling phytosociological analysis of vegetation at different altitudinal gradients in Deolsari Range. The study site I, the highest importance and frequency were recorded *P. roxburhii* is the dominant species (IVI = 204.61) with a frequency of 68.20%, and the minimum importance value was recorded for *G. robusta* (IVI = 95.39) with the frequency 31.80%. At study sites II, III, IV, V and VI the highest importance value was recorded for C. *deodara* (IVI = 202.21, 158.39, 156.94, 77.40, and 158.71 and frequency of 67.40, 52.80, 52.31, 25.80 and 52.89% respectively). At study sites VII VIII and IX, the highest importance value was recorded *for Q. semicarpifolia* (IVI = 109.5553, 218.53, and 224.64) with frequency of 36.52, 72.84, and 74.88 %. The distribution pattern of *P. roxburhii, C. deodara, Q. floribunda, Q.leucotrichophora, Q. semicarpifolia, L. ovalifolia* and *R. arboreum* was random (Table 3).

Table 3: Phytosociological attributes of seedlings at different study sites

S.S	Elevation(m)	Botanical Name	RF	RD	RDO	IVI	A/F
I	1200-1400	*Pinus roxburghii* Sarg.	50.00	66.67	87.94	204.61	0.04
		Grevillea robusta A.Cunn. ex R.Br.	50.00	33.33	12.06	95.39	0.02
II	1400-1600	*Cedrus deodara* (Roxb. ex D.Don) G.Don	66.67	66.67	68.87	202.21	0.02
		Pinus roxburghii Sarg.	33.33	33.33	31.13	97.79	0.03
III	1600-1800	*Cedrus deodara* (Roxb. ex D.Don) G.Don	60.00	60.00	38.39	158.39	0.01
		Pinus wallichiana A.B.Jacks.	20.00	20.00	46.95	86.95	0.01
		Ougeinia oojeinensis (Roxb.) Hochr.	20.00	20.00	14.66	54.66	0.01
IV	1800-2000	*Cedrus deodara* (Roxb. ex D.Don) G.Don	50.00	50.00	56.94	156.94	0.03
		Ougeinia oojeinensis (Roxb.) Hochr.	50.00	50.00	43.06	143.06	0.03
V	2000-2200	*Cedrus deodara* (Roxb. ex D.Don) G.Don	12.50	27.27	37.63	77.40	0.05
		Rhododendron arboreum Sm.	12.50	9.09	18.52	40.11	0.03
		Grewia optiva J.R.Drumm. ex Burret	25.00	18.18	9.99	53.17	0.02
		Myrica esculenta Buch.-Ham. ex D.Don	12.50	9.09	8.32	29.91	0.03
		Quercus leucotrichophora A.Camus	25.00	27.28	17.65	69.93	0.02
		Aesculus indica (Wall. ex Cambess.) Hook.	12.50	9.09	7.89	29.48	0.03
VI	2200-2400	*Cedrus deodara* (Roxb. ex D.Don) G.Don	50.00	33.33	75.38	158.71	0.03
		Quercus leucotrichophora A.Camus	50.00	66.67	24.62	141.29	0.05
VII	2400-2600	*Quercus semicarpifolia* sm.	33.34	33.34	14.42	109.55	0.03
		Lyonia ovalifolia (Wall.) Drude	33.33	33.33	42.69	109.35	0.03
		Acer caesium Wall. ex Brandis	33.33	33.33	42.89	81.10	0.03
VIII	2600-2800	*Quercus semecarpifolia* Sm.	66.67	75.00	76.86	218.53	0.02
		Lyonia ovalifolia (Wall.) Drude	33.33	25.00	23.14	81.47	0.03
IX	2800-3000	*Quercus semecarpifolia* Sm.	75.00	71.43	78.21	224.64	0.02
		Lyonia ovalifolia (Wall.) Drude	25.00	28.57	21.79	75.36	0.05

Abbreviations are the same as in Table 1

Diversity Index

Species richness in the tree layer was highest at study site VII (1.40) (Table 4.), for saplings at study site V (1.80) (Table 5.), and for seedlings, at study site V (1.67) (Table 6). The concentration of dominance values ranged from 0.33 to 0.97 for trees (Table 4.), 0.19 to 0.78 for saplings (Table 5.), and 0.21 to 0.63 for seedlings across altitudes (Table 6.). Interestingly, the evenness coefficient (EC) decreased with altitude in both tree and sapling layers but did not follow the pattern in the seedling layer. The Simpson's Diversity Index (SD) showed a reverse relationship with CD across all layers, indicating contrasting patterns of diversity.

Table 4: Diversity index of tree species

Study site	Elevation	H'	CD	1-D	J
I	1200-1400	0.26	0.89	0.11	0.38
II	1400-1600	0.59	0.60	0.40	0.85
III	1600-1800	0.67	0.57	0.43	0.61
IV	1800-2000	0.43	0.81	0.19	0.27
V	2000-2200	0.88	0.67	0.33	0.35
VI	2200-2400	0.84	0.54	0.46	0.43
VII	2400-2600	1.40	0.33	0.67	0.64
VIII	2600-2800	0.19	0.93	0.07	0.14
IX	2800-3000	0.06	0.97	0.03	0.05

H' = Shannon- wiener diversity, D= Simpson's Dominance, 1-D = Simpson's Diversity, J= Pielour Index

The Himalayan region is abundant in various natural resources that have been utilized by humans for centuries. The relationship between managing forests and the welfare of communities living in forested areas has traditionally been linked to employment opportunities within the forest sector, (Sharma and Gairola 2007). Altitude emerges as a

pivotal factor influencing tree distribution, largely due to its pronounced effect on habitat microclimates (Rawal and Pangtey, 1994). In the present study, *Cedrus deodara* thrived within the altitude range of 1400–2000m, while *Quercus semecarpifolia* predominantly occupied elevations between 2401 and 3000m. Similarly, *Pinus roxburhii* exhibited a consistent distribution pattern within the 1200–1400m range. *Lyonia ovalifolia* and *Rhododendron arboreum* were found across the entire study area except for *pinus roxburghii* forest; however, their phytosociological and diversity indices exhibited differences at different altitudes. These species also served as associates to different tree species depending on the altitude variations (Gairola, 2011).

Table 5: Diversity index of sapling

Study site	Elevation	H'	CD	1-D	J
I	1200-1400	0.64	0.56	0.44	0.92
II	1400-1600	0.45	0.72	0.28	0.65
III	1600-1800	0.90	0.47	0.53	0.82
IV	1800-2000	0.61	0.58	0.42	0.38
V	2000-2200	1.80	0.19	0.81	0.93
VI	2200-2400	0.64	0.56	0.44	0.92
VII	2400-2600	1.01	0.39	0.61	0.92
VIII	2600-2800	0.45	0.72	0.28	0.65
IX	2800-3000	0.38	0.78	0.22	0.22

Abbreviations are the same as in Table 4

Generally, in Quercus spp. dominated forests of Uttarakhand Himalaya lots of anthropogenic disturbances such as lopping, stem cutting, grazing, fuel wood collection, etc are prevalent. Although diversity values in the studied forests spanned from 0.6 to 1.4, which is relatively lower compared to reported ranges of 1.16 to 3.40 for the Himalayan region (Pande, 2001; Kunwar and Sharma 2004: Sharma, 2004: Shah *et al.,* 2009;), this disparity could be attributed to varying factors such as species diversity influenced by climate, productivity, biotic interactions, habitat heterogeneity, and historical factors (Willig *et al.,* 2003; Qian and Ricklefs, 2004). Whittaker (1965) observed that the Cd values for certain temperate vegetation ranged from 0.19 to 0.99. The Cd value of the studied forest (0.33-0.97) was slightly lower. At elevations of 2600–3000 m, tree species diversity is notably diminished, possibly due to the presence of the Naag Tibba temple, a religious pilgrimage site, and resting camps for trekking activities. Based on the ecological framework proposed by Odum (1971), the study revealed a predominant contagious distribution pattern among tree species.

Table 6: Diversity index of seedling

Study site	Elevation	H'	CD	1-D	J
I	1200-1400	0.64	0.56	0.44	0.92
II	1400-1600	0.64	0.56	0.44	0.92
III	1600-1800	0.95	0.44	0.56	0.86
IV	1800-2000	0.69	0.50	0.50	1.00
V	2000-2200	1.67	0.21	0.79	0.93
VI	2200-2400	0.64	0.56	0.44	0.92
VII	2400-2600	1.10	0.33	0.67	1.00
VIII	2600-2800	0.56	0.63	0.38	0.81
IX	2800-3000	0.60	0.59	0.41	0.86

Abbreviations are the same as in Table 4

This aligns with previous research conducted in the Garhwal Himalaya by Kershaw (1973) and Kumar and Bhatt (2006). However, trees at elevations ranging from 2401 to 2600 m exhibited a random distribution pattern, indicating uniform environmental

conditions within this elevation band. At 16001-1800 m, saplings and seedlings displayed a regular distribution, which suggests individual competition. Rawat and Chankhok (2009) studied the distribution patterns of tree, sapling, and seedling layers and found that most species in these layers exhibited a random distribution. However, some tree and sapling species demonstrated a regular distribution pattern. Interestingly, in the tree layer, a few species showed a contagious distribution pattern that was absent in the sapling layer. The patterns and breadth of forest use among rural families differ, influencing policies and programs connected to forest conservation and poverty alleviation (Pandey *et al.,* 2024). Pandey *et al.* (2024) examined the floristic composition and biological spectrum of the Raipur forest range in Dehradun, Uttarakhand, noting that therophytes constituted 42% of the 116 plant species analysed. Pandey *et al.,* 2024, documented the comprehensive significance of medicinal flora in the Jaunpur Range, Garhwal Himalaya, Uttarakhand. This research sought to assess the comprehensive importance of medicinal flora in five villages located within the Jaunpur Range of the Mussoorie Forest Division. Seventy plant species were identified across sixty-four genera and forty-three families. Within the 43 families examined, the greatest diversity of species recorded was found in Rosaceae, comprising 8 species. The most frequently identified species comprised herbs (36%), followed by trees (31%), shrubs (20%), climbers (7%), grasses (4%), and ferns (2%). This comprehensive analysis illuminates the intricate relationship between altitude, species distribution, and ecological dynamics in the studied sites, providing valuable insights for conservation and management strategies.

CONCLUSION

The study examined the changes in the variety and population of trees, saplings, and seedlings at different altitudes in the Deolsari Range. This research provides important information for understanding the Deolsari range ecosystem. It is crucial to continually analyse and monitor this initial data to better understand how the ecosystem changes over time. These findings can guide conservation efforts, land management strategies, and initiatives aimed at preserving biodiversity in the Deolsari Range and similar environments.

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