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Research Article

Phytosociological assessment of *Juniperus macropoda* dominated forest stands in the Gurez valley of Kashmir Himalaya, India

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Abstract

The present study entitled "Phytosociological assessment of *Juniperus macropoda* dominated forest stands in the Gurez valley of Kashmir Himalaya" was carried out to access the ecological status of this important species in the high-altitude landscapes of Gurez valley in Kashmir Himalaya, India. For a better understanding of these stands, the area was divided into three sites namely Kanzalwan, Dawar, and Burnai based on the standard sampling procedure. The results revealed that these three different sites harbor a total of 80 plant species representing 72 genera and belonging to 38 families. Of these reported 80 plant species, 6 species were trees, representing 4 genera under 3 families and 4 species of shrubs belonging to 4 genera from 4 families. The number of herbaceous species was 71 representing 64 genera under 31 families. *Juniperus macropoda* was dominant in all the sample sites with IVI of 205.57, 279.62, and 239 in Kanzalwan, Dawar, and Burnai forests respectively. Among shrubs, *Rosa webbiana* with IVI value of (114.5) was the dominant species followed by *Hippophae rhamnoides* (34.6) in Dawar only. Among the herbs, *Stipa sibirica* was dominant with IVI values of 20.08, 9.78, and 16.23 in Kanzalwan, Dawar, and Burnai forest stands respectively. Out of these three sites, Dawar reported the highest number of species followed by Kanzalwan and Burnai. The study is a baseline and will be of high significance in formulating conservation and sustainable management practices of this important Himalayan species.

Keywords altitude, conservation, forest, Himalaya, management, sampling

Introduction

Juniperus macropoda Boiss. commonly known as Himalayan Pencil Cedar is coniferous tree in the genus Juniperus of the cypress family Cupressaceae. In the temperate and cold regions of the northern hemisphere, it is generally located in dry river valleys and distributed almost across the Western Himalayan temperate and alpine regions at an altitude of 2400-4300 m amsl. This species is economically significant in terms of providing fuel wood, fencing equipment, construction, control of soil erosion and underground water table recharge. This is a cold-resistant species, but its seedlings require a significant amount of humidity and shady conditions to flourish [1-2]. It can thrive in severe

abiotic environments such as shallow and stony soils, cold, hot and dry climates, and also has the potential to grow in severe biotic conditions such as grazed areas [3-5]. The species is highly resistant to cold weather, able to protect the soil, and can thrive in areas where the minimum temperature is -35°C [6-7].

Juniperus macropoda is distributed from westwards Nepal to Uttrakhand, Himachal, Jammu & Kashmir, Pakistan, Afghanistan, and in the inner arid regions of the Himalayas [8]. The bark is reddish-brown, with long fibrous streaks of exfoliation. In cold arid regions of Kinnaur, Lahaul, and Spiti districts of Himachal Pradesh the species is known as "Shur," "Shukpa," "Surge" or "Shuru," It is one of the important indigenous Junipers found in the sub-alpine and cold desert areas of Ladakh and Jammu & Kashmir having ecological, socio-cultural and religious significance. In Gurez Valley of Jammu & Kashmir, it is locally known as "Chilli. The Juniper wood is also used for making pencils. This species is one of the important contributors to the greenery in the barren landscapes of Gurez valley having social, and religious significance apart from being used in domestic utility. The threat status of *Juniperus macropoda* was assessed during the CAMP workshop organized at Himalayan Forest Research Institute, Shimla in 2003 and it was categorized as endangered species in the North-Western Himalayan region [9]. Keeping in view the importance of this species in the Indian Himalayan region especially Gurez valley, the present study was carried out to assessment of this *Juniperus macropoda* dominated forest for phytosociological assessment of flora for further sustainable conservation and management strategies.

Methodology

Study area

The present study was carried out in three *Juniperus macropoda* dominated stands of Gurez forest range (Kanzalwan 34 39 56. 71 N, 74 43 9.59 E; Dawar 34 38 13.71 N, 74 49 4.07 E; Burnai 34 36 38.79 N, 74 57 10.92 E). Gurez Valley (also known as Gurais) is situated on the banks of the Kishenganga River, northeast of Srinagar, and falls under Kashmir division. The Gurez main valley stretches between latitudes (34˚ 30'to 34˚ 41' N) and longitudes (74˚ 37 'to 74˚ 46' E) at an average altitude of about 2370 masl. It is surrounded by Ladakh to the north, Bandipora to the south, Ganderbal to the southeast, and Kupwara to the west. Normally, the climate of the region is temperate but varies due to various altitudes. In October or even earlier in the higher reaches, the first snowfall can occur. Frequent heavy snowfalls are experienced and are very extreme, the winters last for a long time from November to April, with temperatures falling to -20˚C [10].

Methodology

Vegetation sampling was done by the quadrat method, and quadrates were laid down by systematic random sampling methods along the three (3) vertical transects running parallel to each other which were 200-300m apart. In each transect, quadrates were laid down at definite intervals. The trees were recorded from 10 m × 10 m quadrant samples across the selected sites. Each quadrate was divided into two quadrates of 5 m × 5 m size, for sampling shrubs and four quadrates of 1 m × 1 m for the herbs. The available plant specimens were mostly identified on the spot and unidentified ones were collected by preparing herbarium specimens and were identified at the Centre for Biodiversity and Taxonomy center, University of Kashmir.

Vegetation Study/Phyto-Sociological Analysis

Frequency

The frequency expresses the percentage and represents the chance of occurrence of species in a given habitat.

$$frequency = \frac{Number\ of\ quadrates\ in\ which\ a\ species\ occurs}{Total\ number\ of\ quadrates\ studied} \times 100$$

Relative frequency
Relative frequency was determined by the following formula

$$Relative\ frequency = \frac{Number\ of\ occurrence\ of\ a\ species}{Number\ of\ occurrence\ of\ all\ species} \times 100$$

Density
Density expresses the numerical strength and is an indicator of the standing biomass and productivity of the region.

$$Density = \frac{Total\ number\ of\ individuals\ of\ a\ species}{Total\ number\ of\ quadrates} \times 100$$

Relative density
Relative density shows the percentage of representation of the species in terms of the number of individuals in comparison to all other species in a community.

$$Relative\ density = \frac{Number\ of\ individuals\ of\ the\ species}{Number\ of\ individuals\ of\ all\ species} \times 100$$

Abundance
It is the number of individuals of a species occurring in all the sampled areas of a particular vegetation type.

$$Abundance = \frac{Number\ of\ individuals\ of\ the\ species}{Number\ of\ quadrates\ in\ which\ a\ species\ occurs} \times 100$$

Relative abundance
Relative abundance is the ratio of the species to the number of quadrants studied.

$$Relative\ abundance = \frac{Abundance\ of\ a\ species}{Sum\ of\ the\ abundance\ of\ the\ species} \times 100$$

Important value index
IVI is the sum of relative frequency, relative density, and relative abundance (IVI = RF+RD+RA) as suggested by [11, 12, 13, 14].

Diversity Indices
Shannon-Wiener diversity index was calculated as per Shannon and Wiener [15] and Concentration of dominance CD was calculated as per Simpson [16].

Results and Discussion

Floristic composition
A total of 80 plant species representing 72 genera belonging to 38 families were recorded from all three sites. Out of these 6 species were trees, representing 4 genera under 3 families. Four species were shrubs belonging to 4 genera from 4 families. The number of herbaceous species was 71 representing 64 genera under 31 families (Figure 1). Asteraceae with 12 species was the dominant family followed by Apiaceae (6 species), and Lamiaceae (5 species). Among tree species, the dominant family was Salicaceae, representing four species and for shrub families viz; Rosaceae,

Elaeagnaceae, Caprifoliaceae and Adoxaceae were represented by one species each. Family Asteraceae with 12 species was the dominant family among herbs. Despite a relatively small geographical area and high livestock grazing pressure, the species richness of the study area is fairly high.

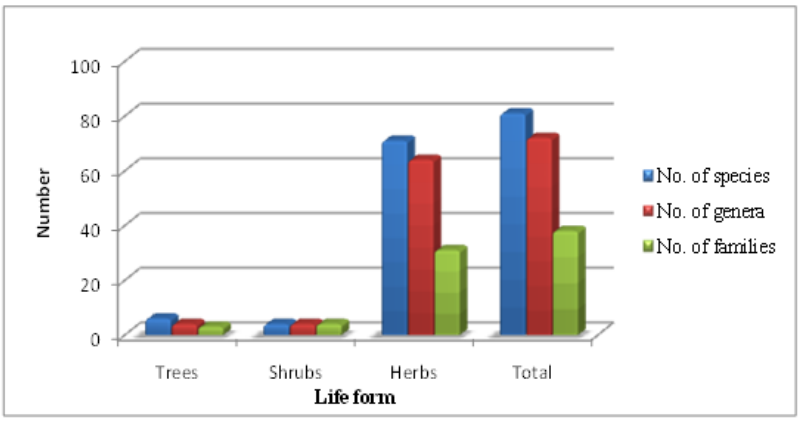

Figure 1. Status of total species, genera and families of different life forms

Site/stand wise distribution of Flora

Kanzalwan forest

A total of 49 plant species representing 49 genera belonging to 27 families were recorded from Kanzalwan site. Out of these 5 species were trees, representing 4 genera under 3 families. The number of herbaceous species was 44 representing 43 genera under 24 families (Figure 2).

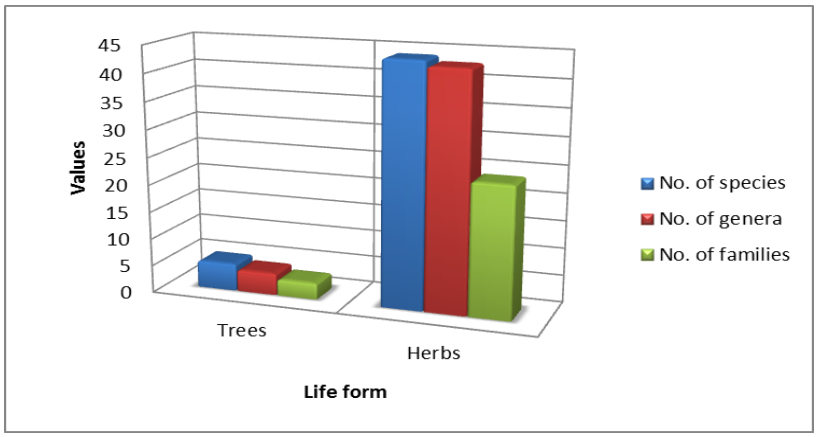

Figure 2. Status of flora at Kanzalwan forest stand

Among tree species, *Juniperus macropoda* was dominant with IVI (205.57) followed by *Juglans regia* with IVI (47.21), *Populus ciliata* with IVI (21.43), and *Salix denticulate* with IVI (15.07). The maximum value for frequency (50%), density (1.36 trees/100m2), and abundance (2.61) were also recorded for *Juniperus macropoda* followed by *Juglans regia* with frequency (16%), density (0.46 trees/100m^2) and abundance (2.87). The highest value for the basal area (15.87m^2/ha) was again observed for *Juniperus macropoda* followed by *Juglans regia* (1.59m^2/ha) and the lowest for *Populus ciliata* (0.40m^2/ha) (Table 1). The overall density and TBC were recorded as 2.22 tree/100m^2 and 18.34m^2/100m^2 respectively. The phytosociological data related to shrubs is also depicted (Table 2). Within the sampled site, *Juniperus macropoda* was recorded for maximum density and frequency. This may be because of the high altitude and acidic nature of soil in Gurez valley. The study by Dad

and Reshi [17] also revealed that there was a positive effect of soil acidity on distribution of Juniperus species in Gurez.

Table 1: Phytosociological data of tree species in *Juniperus macropoda* dominant tree stands at Gurez forest range.

Species	Kanzalwan					Dawar					Burnai				
	F	D	A/F	TBCm ²/ha	IVI	F	D	A/F	TBCm ²/ha	IVI	F	D	A/F	TBCm ²/ha	IVI
Juniperus macropoda	52	1.36	0.05	15.872	205.57	80	3.6	0.05	51.168	279.62	36	0.92	0.07	2.368	239.00
Juglans regia	16	0.46	0.17	1.599	47.21	12	0.24	0.16	0.561	20.37	-	-	-		-
Populusciliata	10	0.18	0.18	0.406	21.43	-	-				-	-	-		-
Salix wallichiana	4	0.10	0.62	0.321	10.69	-	-				-	-	-		-
Salix alba	-	-	-		-	-	-				10	0.22	0.61	0.243	60.99
Salix denticulate	8	0.12	0.18	0.144	15.07	-	-				-	-	-		-
Total		2.22		18.342			3.84		51.729			1.14		2.611	

F=Frequency (%); D=Density/100m²; A/F= Abundance to Frequency, IVI =Important Value Index

Table 2: Phytosociological data of shrub species in *Juniperus macropoda* dominant tree stands at Gurez Forest Range.

Species	Kanzalwan				Dawar				Burnai			
	F	D	A/F	IVI	F	D	A/F	IVI	F	D	A/F	IVI
Rosa webbiana	-	-	-	-	12	0.31	0.21	114.5	-	-	-	-
Hippophae rhamnoides	-	-	-	-	3	0.11	1.22	34.65	-	-	-	-
Lonicera quinquelocularis	-	-	-	-	4	0.08	0.5	33.86	-	-	-	-
Viburnum grandiflorum	-	-	-	-	2	0.04	1	16.93	-	-	-	-

F=Frequency (%); D=Density/25m²; A/F= Abundance to Frequency Ratio,IVI =Important Value Index

Out of forty-four herbaceous species, *Stipa sibirica* with IVI value of (20.08) was dominant species followed by *Poa annua* (13.33), and *Persica alpina* with IVI value of (7.24). *Dioscorea deltoidea* with IVI value of (1.07) was found least dominant followed by *Mentha longifolia* and *Scabiosa speciosa* with IVI values of (01.52) and (1.59) respectively (Table 3).

Table 3. Phytosociological status of herbs species in *Jumiperus macropoda* dominant tree stands at Gurez Forest Range.

Species	Kanzalwan				Dawar				Burnai			
	F	D	A/F	IVI	F	D	A/F	IVI	F	D	A/F	IVI
Achillea millefolium	-	-	-	-	9	0.29	0.35	1.74	8.5	0.25	0.35	5.53
Aconitum heterophyllum	6.5	0.27	0.65	3.73	10.5	0.55	0.49	2.58	-	-	-	-
Aconogonon molle	-	-	-	-	8	0.43	0.67	2.01	1.5	0.05	2.22	1.02
Anaphalis virgata	-	-	-	-	11	0.37	0.30	2.18	5.5	0.27	0.89	4.61
Androsace sarmentosa	5.0	0.33	1.34	3.76	12.5	0.33	0.21	2.22	-	-	-	-
Angelica archangelica	4	0.17	1.06	2.30	-	-	-	-	-	-	-	-
Angelica glauca	-	-	-	-	14	0.48	0.24	2.78	-	-	-	-
Anthemis cotula	-	-	-	-	9.5	0.33	0.36	1.90	5	0.22	0.88	3.94
Arctium lappa	-	-	-	-	14	0.75	0.38	3.49	-	-	-	-
Artemisia absinthium	-	-	-	-	44.5	1.77	0.08	9.49	-	-	-	-
Artemisia maritima	5	0.21	0.84	2.85	46.5	1.79	0.08	9.76	-	-	-	-
Aster flaccidus	5.5	0.24	0.80	3.24	15.5	0.62	0.25	3.31	12.5	0.40	0.25	8.43

Atropa acuminate	-	-	-	-	7.5	0.49	0.88	2.11	-	-	-	-
Bunium persicum	3	0.11	1.27	1.63	16	0.59	0.23	3.29	5.5	0.22	0.72	4.12
Campanula cashmiriana	4	0.18	1.15	2.41	14.5	0.82	0.39	3.73	12	0.38	0.26	8.06
Carum carvi	6	0.21	0.58	3.12	-	-	-	-	-	-	-	-
Chenopodium album	8	0.28	0.44	4.20	41	1.62	0.09	8.72	3.5	0.11	0.89	2.32
Chenopodium botrys	-	-	-	-	14	0.49	0.25	2.81	1.5	0.05	2.44	1.07
Cichorium intybus	6	0.28	0.77	3.63	11	0.24	0.19	1.82	7.5	0.37	0.66	6.36
Clinopodium umbrosum	-	-	-	-	9	0.36	0.44	1.92	8.5	0.32	0.44	6.22
Codonopsis ovata	9	0.29	0.35	4.50	17.5	0.42	0.13	3.01	-	-	-	-
Corydalis govaniana	14.5	0.28	0.13	5.93	16.5	1.04	0.38	4.54	5	0.18	0.72	3.55
Cotoneaster cashmiriensis	-	-	-	-	13	0.57	0.33	2.91	4.5	0.16	0.81	3.22
Crepis fleurosa	7.5	0.27	0.48	3.99	9.5	0.44	0.48	2.18	2	0.06	1.5	1.30
Crepis sancta	4.5	0.16	0.81	2.39	6.5	0.16	0.39	1.14	5	0.22	0.9	3.99
Dioscorea deltoidea	2	0.07	1.87	1.07	5.5	0.29	0.97	1.37	2.5	0.12	2	2.12
Dracocephalum heterophyllum	-	-	-	-	17	0.12	0.04	2.17	4	0.18	1.15	3.24
Dryopteris barbigera	-	-	-	-	10.5	0.46	0.41	2.35	7	0.27	0.56	5.20
Epilobium hirsutum	7.5	0.28	0.49	4.03	6.5	0.175	0.41	1.16	5.5	0.16	0.52	3.53
Fragaria nubicola	5.5	0.18	0.59	2.77	33	1.125	0.10	6.54	-	-	-	-
Fritillaria roylei	-	-	-	-	13	0.26	0.15	2.09	-	-	-	-
Gentiana moorcroftiana	-	-	-	-	8	0.53	0.82	2.26	9	0.33	0.41	6.50
Geranium wallichanium	8.5	0.18	0.25	3.60	20	0.60	0.15	3.76	9.5	0.29	0.32	6.23
Heracleum candicans	-	-	-	-	-	-	-	-	4	0.11	0.71	2.55
Hypericum perforatum	7	0.31	0.64	4.15	8	0.27	0.42	1.59	9.5	0.35	0.39	6.87
Inula racemosa	-	-	-	-	9	0.50	0.62	2.30	-	-	-	-
Ligularia fischeri	-	-	-	-	18	0.61	0.18	3.57	-	-	-	-
Lindelofia stylosa	8.5	0.38	0.53	5.06	9.5	0.29	0.32	1.80	3.5	0.17	1.42	2.97
Lychnis coronaria	-	-	-		20.5	1.03	0.24	4.95	9.5	0.33	0.36	6.63
Malva neglecta	8	0.24	0.38	3.91	15	1.29	0.57	5.03	7.5	0.22	0.39	4.83
Malva verticillate	-	-	-	-	11	0.25	0.21	1.86	-	-	-	-
Medicago lupulina	-	-	-	-	12.5	0.59	0.38	2.92	8	0.34	0.53	6.19
Medicago polymorpha	-	-	-		19.5	1.12	0.29	5.07	4	0.12	0.78	2.65
Medicago sativa	14	0.23	0.11	5.43	18	0.72	0.22	3.86	6	0.20	0.56	4.15
Mentha longifolia	3	0.1	1.11	1.52	7.5	0.49	0.88	2.11	-	-	-	-
Myosotis sylvatica	6.5	0.23	0.54	3.40	17.5	0.87	0.28	4.20	4	0.24	1.53	3.84
Persica riaalpina	14.5	0.46	0.22	7.24	4	0.17	1.09	0.89	-	-	-	-
Plantago lanceolata	-	-	-	-	9.5	0.50	0.55	2.36	-	-	-	-
Poaannua	25.5	0.9	0.13	13.33	28.5	1.37	0.16	6.71	11	0.42	0.35	8.10
Podophyllum hexandrum	3.5	0.16	1.30	2.09	2.5	0.09	1.52	0.52	-	-	-	-
Prangos pabularia	-	-	-	-	22.5	0.66	0.13	4.18	-	-	-	-
Primula macrophylla	6	0.22	0.61	3.19	4.5	0.26	1.28	1.17	10.5	0.30	0.27	6.73
Prunella vulgaris	14.5	0.42	0.19	6.91	7	0.52	1.06	2.12	-	-	-	-
Prunus cornuta	3.5	0.11	0.93	1.76	10	0.4	0.4	2.13	5	0.12	0.5	3.00
Rumex nepalensis	11	0.34	0.28	5.43	7.5	0.62	1.11	2.45	-	-	-	-
Sambucus wightiana	12.5	0.46	0.29	6.71	4	0.14	0.87	0.80	10.5	0.27	0.24	6.44
Saussurea costus	6.5	0.21	0.49	4.31	12.5	0.41	0.26	2.43	-	-	-	-
Scabiosa speciosa	3	0.11	1.22	1.59	8	0.42	0.66	1.98	10	0.33	0.33	6.80
Setaria viridis	10	0.33	0.33	5.06	5	0.25	1.02	1.21	7.5	0.28	0.49	5.42
Sisymbrium officinale	3	0.1	1.11	1.52	5.5	0.16	0.52	1.01	1.5	0.06	2.66	1.12
Solidago virgaurea	-	-	-	-	11	0.52	0.43	2.57	-	-	-	-
Stipa sibirica	29	1.7	0.20	20.08	47	1.78	0.08	9.78	22.5	0.83	0.16	16.23
Persicaria alpina	6	0.23	0.63	3.27	4	0.28	1.75	1.17	-	-	-	-
Taraxacum officinale	-	-	-	-	6.5	0.19	0.46	1.21	-	-	-	-
Thymus linearis	9.5	0.33	0.36	4.92	12	0.21	0.14	1.86	17.5	0.46	0.15	10.7
Trifolium pratense	7.5	0.27	0.48	3.99	15.5	0.62	0.26	3.32	-	-	-	-
Trigonella emodi	12	0.44	0.30	6.43	13.5	0.47	0.26	2.71	-	-	-	-
Tussilago farfara	5.5	0.22	0.74	3.10	12.5	0.29	0.18	2.12	4.5	0.24	1.18	3.96
Verbascum Thapsus	22.5	0.75	0.14	11.44	9.5	0.55	0.61	2.49	-	-	-	-
Viola canescens	3	0.1	1.11	1.52	7.5	0.41	0.72	1.89	-	-	-	-

F=Frequency (%); D=Density/m^2; A/F= Abundance to Frequency Ratio, IVI =Important Value Index

The highest density of *Poa annua* was also recorded in Sangla valley in Himachal Pradesh [18]. Highest value for density (1.7 plants/m^2) was observed for *Stipa sibirica* followed by *Poa annua* (0.9 plants/m^2). The lowest value of density (0.07 plants/m^2) was recorded for *Dioscorea deltoidea* and *Mentha longifolia* with (0.1 plants/m^2). The overall herb density was (14 plants/m^2). The highest value of frequency was recorded for *Stipa sibirica* (29%) followed by *Poa annua* (25%). The lowest value of frequency (2%) was recorded for *Dioscorea deltoidea*, (3%) each for *Sisymbrium officinale, Viola canescens* and *Mentha longifolia*. The different diversity indices recorded for the tree layer were Shannon diversity as 1.1 and Simpson index as 0.4 (Table 4). The different diversity indices recorded for herbaceous layer were Shannon diversity as 3.5, and Simpson index as 0.3. (Table 4), (Figure 3).

Table 4. Different ecological and diversity parameters across the studied *Juniperus macropoda* dominant tree stands at Gurez Forest Range.

Parameters	Kanzalwan	Dawar	Burnai
Tree density (m^{2}ha^{-1})	222	384	114
Shrub density 25m^2)	-	13.5	-
Herb density (m^2)	13.75	38.0	10.1
TBC (m^2/ha)	18.34	51.72	2.61
Diversity Index (Trees)			
Shannon	1.1	0.2	0.4
Simpson	0.4	0.8	0.6
Diversity Index (Shrubs)			
Shannon	-	1.1	-
Simpson	-	0.9	-
Diversity Index (Herbs)			
Shannon	3.5	3.99	3.5
Simpson	0.3	0.02	0.3

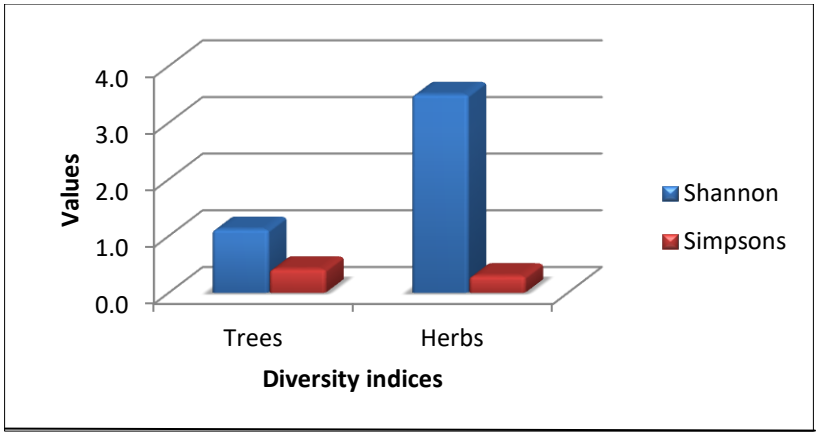

Figure 3. Diversity indices for trees and herbs at Kanzalwan forest stand

Dawar Forest stand/Site

A total of 74 plant species representing 73 genera belonging to 38 families were recorded from Dawar site. Out of these 2 species were trees, representing 2 genera under 2 families. Four species were shrubs belonging to 4 genera from 4 families. The number of herbaceous species was 68 representing 67 genera under 32 families (Figure 4). Among tree species *Juniperus macropoda* was dominant with IVI (279.62) followed by *Juglans regia* with IVI (20.37). The maximum value for

frequency (80%), density (3.6 trees/100m^2) and abundance (4.5) were also recorded for *Juniperus macropoda* followed by *Juglans regia* with frequency (12%), density (0.24 trees/100m^2) and abundance (2). The highest value for the basal area (51.16m^2/ha) was again observed for *Juniperus macropoda* followed by *Juglans regia* (0.56m^2/ha).

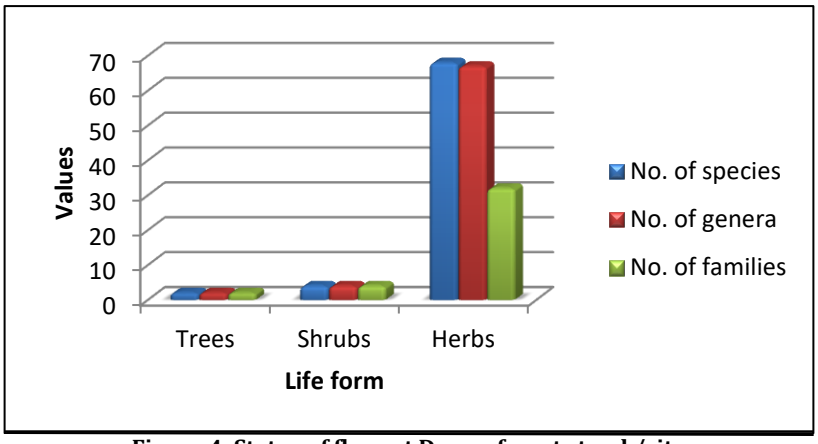

Figure 4. Status of flora at Dawar forest stand /site

The overall density and TBC were recorded as 3.84 tree/100m^2 and 51.72m^2/100m^2 respectively (Table 1). The difference in the distribution and diversity of flora in these forest divisions is mainly due to the topographic variations and slope. This is consistent with studies conducted on the mountain vegetation in other regions, wherein authors have also found slope to be an important factor in affecting the species distribution [19].

Among shrubs *Rosa webbiana* with IVI value of (114.5) was the dominant species followed by *Hippophae rhamnoides* (34.6) and *Lonicera quinquelocularis* (33.8). *Viburnum grandiflorum* with IVI value of (16.9) was found least dominant. Highest density (0.31 plants/25m^2) was observed again for *Rosa webbiana* followed by *Hippophae rhamnoides* (0.11 plants/25m^2) and *Lonicera aquinquelocularis* (0.08 plants/25m^2). The overall density of shrubs was 0.54 plants/ 25m^2. The lowest value of density was observed for *Viburnum grandiflorum* (0.04plants/25m^2). The highest value for frequency was observed for *Rosa webbiana* (12%), followed by *Lonicera aquinquelocularis* and *Hippophaer hamnoides* with frequency value of (4%) and (3%) respectively. The lowest value of frequency was observed for *Viburnum grandiflorum* (2%) (Table 2). Out of sixty-seven herbaceous species, *Stipa sibirica* with IVI value of (9.78) was dominant species followed by *Artemisia maritime* (9.76), *Chenopodium album* (8.72). *Podophyllum hexandrum* with IVI value of (0.52) was found least dominant followed by *Sambucus wightiana* and *Persicaria alpine* with IVI values of (0.80) and (0.89) respectively. IVI value of any species indicates the dominance of species in a mixed population and it gives a total picture of the social structure of species in a community and can be used to form an association of dominant species [20]. The highest value for density (1.79 plants/m^2) was observed for *Artemisia maritime* followed by, *Stipa sibirica* (1.78 plants/m^2), *Poa annua* (1.37 plants/m^2). The lowest value of density (0.09plants/m^2) was recorded for *Podophyllum hexandrum* and *Dracocephalum heterophyllum* with (0.12 plants/m^2). The overall herb density was (38plants/m^2). The highest value of frequency was recorded for *Stipa sibirica* (47%) followed by *Artemisia maritime* (46%) and *Fragaria nubicola* (33%). The lowest value of frequency (4%) each was recorded for *Persicaria alpine* and *Sambucus wightiana* (Table 3). The different diversity indices recorded for tree layer were Shannon diversity as 0.8 and Simpson index as 0.2. The different diversity indices recorded for shrub layer were Shannon diversity as 1.1, Simpson index as 0.9. The different diversity indices recorded for herbaceous layer were Shannon diversity as 3.99, Simpson index as 0.03 (Table 4). (Figure 5). The highest herb and shrub density in Dawar is mainly due to presence of maximum pasture lands in this site. The pasture lands tend to increase the soil acidity and organic matter

content which is considered a good indicator of nutritional standing of the soils. The possible explanation for the greater effect of the soil acidity on herb distribution could be the higher urine and dung depositions of grazers in those areas. This may be primarily because of the combined effect of dung and urine depositions with cattle grazing [21-22].

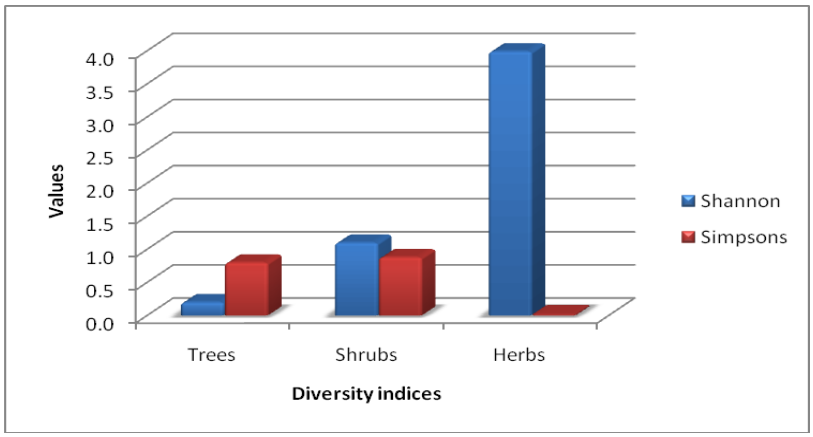

Figure 5. Showing different diversity indices for trees shrubs and herbs in the study area

Burnai Forest stand/site

A total of 43 plant species representing 39 genera belonging to 24 families were recorded from Burnai site. Out of these, 2 species were trees, representing 2 genera under 2 families. The number of herbaceous species was 41 representing 37 genera under 22 families (Figure 6). Among tree species, *Juniperus macropoda* was dominant with IVI (239) followed by *Salix alba* with IVI (60.99). The maximum value for frequency (36%), density (0.92 trees/100m^2), and abundance (2.55) were also recorded for *Juniperus macropoda* followed by *Salix alba* with frequency (10%), density (0.22 trees/100m^2) and abundance (2.2). The highest value for the basal area (2.368/ha) was again observed for *Juniperus macropoda* followed by *Salix alba* (0.56m^2/ha).

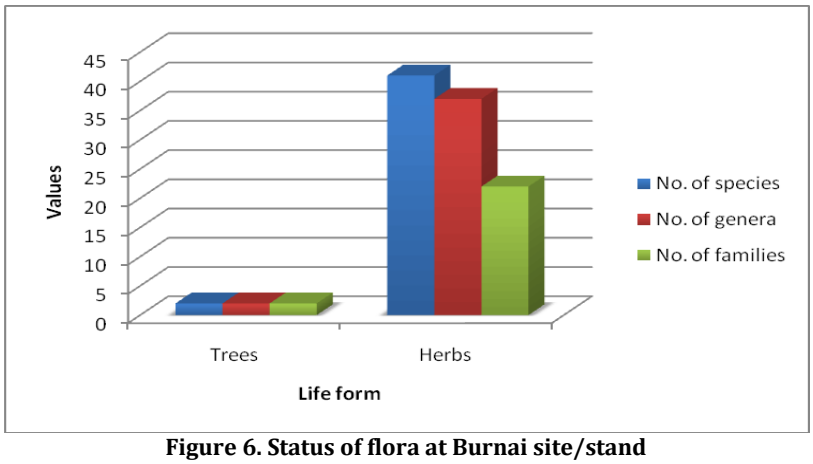

Figure 6. Status of flora at Burnai site/stand

The overall density and TBC were recorded as 1.9 tree/100m^2 and 2.93m^2/100m^2 respectively (Table 1). The different diversity indices recorded for the tree layer were Shannon diversity of 0.4, Simpson index as 0.6 (Table 4). The less tree diversity in these regions is mainly due to anthropogenic disturbances and soil nutrient profiles. Anthropogenic disturbance has been reported to be an important factor in determining the vegetation pattern across different ecosystems

[23] and often more dominating as compared to other climatic effects [24]. The human induced changes have also been reported as the major reason for changes in vegetation composition of alpine region of Garhwal Himalaya [25].

Out of forty herbaceous species, *Stipa sibirica* with IVI value of (16.23) was the dominant species followed by *Aster flaccidus* (8.43), and *Poa annua* with IVI value of (8.43). *Aconogo nonmolle* with IVI value of (1.02) was found least dominant followed by *Chenopodium botrys* and *Sisymbrium officinale* with IVI values of (1.07) and (1.12) respectively. Highest value for density (0.83plants/m^2) was observed for *Stipa sibirica* followed by *Thymus linearis* (0.46 plants/m^2) and *Poa annua* with (0.42 plants/m^2). The lowest value of density (0.05plants/m^2) each was recorded for *Aconogo nonmolle* and *Chenopodium botrys* followed by *Sisymbrium officinale* with (0.06 plants/m^2). The overall herb density was (10.11 plants/m^2). The highest value of frequency was recorded for *Stipa sibirica* (22.5%) followed by *Thymus linearis* (17.5%). The lowest value of frequency (1.5%) each was recorded for *Chenopodium botrys, Aconogo nonmolle* and *Sisymbrium officinale* followed by *Dioscorea deltoidea* (2.5) (Table 3).The different diversity indices recorded for the herbaceous layer were Shannon diversity at 3.5, Simpson index as 0.3 (Table 4). The highest herbaceous diversity may be due to the presence of soil nutrients in the soils of these forests. Vital to the plant growth and vegetation development and spatial distribution of plant resources, the importance of soil nutrients in a region depends on their amount and distribution [26].

Diversity indices

In the present study, Shannon diversity index (H') for tree species was recorded as highest in Kanzalwan (1.1) whereas lowest value (0.2) was recorded in Dawar. For shrubs, Shannon diversity index (H') was found (1.1) for Dawar only. For the herb layer highest value of the Shannon diversity Index was observed for Dawar (3.99) whereas the lowest was observed for both Kanzalwan and Burnai (3.5) each. The diversity index (H') for different forests has been reported to be between 0.83 to 4.1 [27,28] and supports the present study. Variation in density and basal area of different forest stands may be attributed to altitudinal variation, species composition, age structure, successional stage of the forest, and degree of disturbance [29]. The highest value of Simpson's index 0.8 was recorded for Dawar, whereas the lowest 0.4 was observed for Kanzalwan. Simpson's value for shrubs was found (0.9) for Dawar only. Simpson's index observed for the herb layer was within the range of 0.2 to 0.3. Simpson's index values by various authors have been reported in the range from 0.03 to 0.92 [30,31] and the average value is 0.06 as reported by Knight [32].

Conclusion

The results of the present study report 80 floral species from the study area and showed good variation across three sites mostly in herbaceous species. All the three sites studied in the present study showed the dominance of Juniperus and which can be planted with other important tree species of economic and ecological significance for sustainable development of this fragile ecosystem. The Shannon diversity index (H') for tree species ranged from1.1 to 0.2 which is a cause of concern. The species having low-density values reported in the present study must be taken as a serious concern for conservation programs. The results of the present study in terms of density and IVI has of various species are baseline data and can be useful for future management practices. The existing ecosystem of this species has the potential to safeguard the rest of the species for future conservation and management.

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