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Assessment of floristic diversity in Pooh valley of cold deserts of District Kinnaur, Himachal Pradesh

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ABSTRACT : Assessment of floristic diversity provide basis for devising suitable strategies for conservation of the plant resources. Accordingly, a study was conducted to understand the floristic diversity along an altitudinal gradient with elevations varying from 2700m to 4200m above msl in Pooh area falling in cold desert area of Pooh sub division of district Kinnaur, Himachal Pradesh during 2007. The total number of plant species in this valley was 192 belonging to 55 families and 136 genera. The dominant families were Asteraceae, Rosaceae, Lamiaceae and Polygonaceae. The number of tree species at 2700-3200m and 3200-3700m was 13 and 5 with dominance of *Salix alba* and *Juniperus polycarpos* respectively. The number of shrub species was 22, 15 and 11 in the elevation of 2700-3200m, 3200-3700m and 3700-4200m respectively. *Rosa webbiana* was dominant shrub at 2700-3200m and 3200-3700m where as *Juniperus indica* was dominant at 3700-4200m elevation. The number of herb species was 83, 77 and 72 with the dominance of *Artemisia scoparia*, *Origanum vulgare* and *Bergenia stracheyi* respectively. The distribution pattern of most of the plant species was contiguous in all the altitudes. Index of diversity for herb species was 3.89, 3.86 and 3.81 for 2700-3200m, 3200-3700m and 3700-4200m elevation ranges respectively. The Index of similarity for shrub and herb species between different altitudes was low indicates remarkable degree of dissimilarity in plant species between different altitudes. Out of 62 medicinal plant species as recorded from the area, 10 species fall in the category of threatened plants. The better conservation of natural resources can be well achieved through promotion of community based conservation stressing *in-situ* conservation through the establishment of nature reserves and *ex-situ* conservation through tissue culture, developing cultivation technologies and nurseries of medicinal plants and conducting regular trainings on the procedure of medicinal plants collection, processing amongst the end users/ the local people, traders and real stake holders.

INTRODUCTION

Himalayas are one of the largest and youngest mountain chains in the world and cover roughly 10% of India total land surface. Variations in terms of its size, climate and altitudinal ranges have created environments those are unique and characteristic to this region only. The diverse climate and the varied environmental conditions prevailing in Himalayas support diverse habitat and ecosystems with equally diverse life forms. The Himalayan region is blessed with a wide variety of natural resources including medicinal plants. It provides an important habitat to the flora and fauna including 9,000 species of angiosperms and hence, is considered as the hot spot of biodiversity. There are about 3,470 species considered exclusively endemic to the Himalayas. The cold deserts in India occur in Ladakh region of Jammu & Kashmir, Spiti valley of Lahaul and Spiti district and Pooh sub division of Kinnaur district of Himachal Pradesh. The total area under cold deserts in Himachal Pradesh is about 11,000 sq.km., out of which 3,400 sq.km. area is in Kinnaur district. Human pressure on natural ecosystems is intensifying, some being incompatible with survival of certain species of plants.

In cold desert areas, continuous removal of plant species for various uses and overgrazing by migratory livestock have resulted in desertification and loss of biodiversity. If these naturally occurring plant resources are not timely conserved then they may soon become extinct. In cold desert this genetic erosion coupled with soil erosion may retard prospects of future economic development and welfare of the people. The assessment of plant wealth in this harsh cold arid belt may provide a key for its conservation. Keeping these aspects in view, a study was undertaken to know the plant diversity in Pooh valley of cold desert in Kinnaur district of Himachal Pradesh.

MATERIALS AND METHODS

The present study was conducted in Pooh valley of cold desert area of Pooh sub division of district Kinnaur, Himachal Pradesh during, 2008 at an elevation of 2700-4200m. The study site was situated 31° 45′ 37.6″ to 31° 46′ 53.4″ N latitude and 78° 34′ 54.9″ to 78° 36′ 57.1″ E longitudes. The whole area of the valley was divided into four altitudes *i.e.*, 2700-3200m, 3200-3700m and 3700-4200m for conducting the phyto-sociological study. Quadrats of size 10 × 10m, 3 × 3m amd 1 × 1m laid out randomly for enumerating trees, shrubs and herbs + regeneration respectively. The seedlings were considered as herb while saplings as shrubs. The vegetation data was analysed for density, frequency and abundance

according to formulas given by Curtis and McIntosh (1950). The relative values of density, frequency and dominance were summed to get Importance Value Index (IVI) of individual species. The abundance to frequency ratio (A/F) of different species was determined for eliciting the distribution pattern. This ratio indicates regular (<0.025), random (0.025 to 0.050) and contiguous (>0.050) distribution (Curtis and Cottam, 1956). The plant species diversity was calculated by using Shanon-Wiener diversity Index (H) (Shannon-Wiener, 1963).

$$H = -\sum_{i=1}^{S}(Ni/N)\ln(Ni/N)$$

Concentration of dominance (C) was measured by Simpson's Index (Simpson, 1949).

$$C = \sum_{i=1}^{S}(Ni/N)^2$$

Where Ni = importance value of species i and N = total importance value of all the species in both the indices.

Index of similarity and dissimilarity between different altitudes were calculated by using following formula (Misra, 1989).

Index of similarity, $S = 2C/A + B$

Where A = number of species in community A, B = number of species in community B, C = number of species common to both communities.

Index of dissimilarity = 1 - S

Richness Index was estimated as per Margalef (1958) *i.e.* $R = S - 1/\ln N$

Evenness Index was calculated as per Hill (1973) *i.e.*

$$E = H/\ln S$$

Where S = total number of species, N = total number of individuals of all the species, H = Index of diversity.

RESULTS AND DISCUSSION

In this valley, total number of plant species was 192 belonging to 55 families and 136 genera. The dominant families were Asteraceae, Rosaceae, Lamiaceae and Polygonaceae. At elevation 2700-3200 m, total number of trees species was 13 (Table-1). *Salix alba* was dominant species having maximum density. This was followed by *Populus ciliata, Robinia pseudoacacia* and *Populus alba* in term of density. The frequency was maximum for *Populus ciliata* followed by *Salix alba*, *Robinia pseudoacacia and Populus alba*. For a particular species higher frequency indicated its more frequent distribution at a particular site. *Salix alba* recorded highest value in term of IVI (61.83) followed by *Populus ciliata* (57.87), *Populus alba (*33.36) and *Robinia Pseudoacacia* (30.35). The ratio of abundance to frequency (A/F) indicates that the distribution pattern of all the species except *Populus alba, P.nigra, P.ciliata, Robinia pseudoacacia* and *Salix alba* was contiguous. The contiguous distribution is the commonest pattern in nature, random distribution is found in very uniform environment. The general preponderance of contiguous distribution in vegetation has been reported by several worker (Kershaw, 1973; Singh & Yadava, 1974; Kunhikannan *et al.,* 1998).

Among the 22 species of shrubs including sapling (Table-2), *Rosa webbiana*, was the dominant species followed by *Sorbaria tomentosa* in term of density and frequency at elevation of 2700-3200m. In term of abundance, *Colutea napalensis* observed maximum value followed by *Lonicera orientalis* and *Sorbaria tomentosa*. *Rosa webbiana* recorded the highest value of IVI (45.91) followed by *Sorbaria tomentosa* (34.23) and *Salix denticulata* (28.05). The distribution pattern of all the species was contiguous.

In case of herb including regeneration, total number of species was 83 at elevation of 2700-3200m (Table-3). *Artemisia scoparia* was dominant herb having maximum density followed by *Malva rotundifolia, Origanum vulgare* and *Erigeron alpinus*. The value of abundance was maximum for *Origanum vulgare* followed by *Artemisia vestita* and *Artemisia scoparia*. *Artemisia scoparia* recorded highest value of IVI (26.08), followed by *Malva rotundifolia* (22.68), *Origanum vulgare* (20.65) and *Verbascum thapsus* (16.94). The ratio of abundance to frequency indicates that the distribution pattern for all the species except *Artemisia brevifolia* and *Verbascum thapsus* was contiguous.

At 3200-3700m elevation number of tree species was 5 (Table-4). *Juniperus polycarpos* was dominant tree species followed by *Salix alba* and *Populus ciliata* in term of density, frequency and abundance. The value IVI was highest for *Juniperus polycarpos* followed by *Salix alba, Populus ciliata* and *Populus alba*. The distribution pattern of all the species except *Juniperus polycarpos* and *Populus alba* was contiguous.

Among 15 species of shrub including sapling (Table-5), *Rosa webbiana* was the dominant species in term of density and frequency. The value of abundance was maximum for *Juniperus indica* followed by *Ribes alpestre, Juniperus communis* and *Sorbaria tomentosa*. In term of IVI, Rosa webbiana was dominant species followed by *Juniperus polycarpos*, *Juniperus communis* and *Cotoneaster microphyllus*. The ratio of abundance and frequency showed that distribution pattern of all the species was contiguous.

In case of herbs including regeneration, total number of species was 77 at 3200-3700m elevation (Table-6). *Artemisia brevifolia* was dominant herb having maximum density fallowed by *Origanum vulgare*, *Thymus linearis* and *Nepeta linearis*. In term of abundance, *Hyssopus officinalis* noted maximum value fallowed by *Sibbaldia parviflora*, *Artemisia brevifolia* and *Artemisia vestita*. *Origanum vulgare* recorded highest value of IVI (31.26) followed by *Artemisia brevifolia* (27.90), *Rheum webbianum* (13.56) and *Thymus linearis* (13.09). The distribution patterns of all the species except *Rheum webbianum, Stellaria media* and *Verbascum thapsus* was contiguous.

At elevation 3700-4200m, total number of shrubs species was 11(Table-7). *Juniperus indica* was dominant species having maximum density, frequency and abundance. This was followed by *Cotoneaster microphyllus*, *Rosa webbiana* and *Abelia triflora* in term of density. *Juniperus indica* recorded highest value of IVI (82.36) followed by *Cotoneaster microphyllus* (37.58), *Juniperus polycarpos* (36.61) and *Juniperus communis* (33.41). The distribution pattern of all the species was contiguous.

In case of herbs including regeneration, total number of species was 72 with the dominance of *Stellaria media* in term of density and frequency (Table-8). This was followed by *Thymus linearis, Arenaria festucoides* and *Galium asperuloides* in term of density. The value of abundance was maximum for *Bergenia stracheyi* followed by *Arenaria festucoides*, *Thymus linearis* and *Polygonum polystachya*. *Bergenia stracheyi* recorded highest value of IVI (31.80) followed by *Stellaria media* (19.21), *Rheum webbianum* (16.61) and *Thymus linearis* (14.43). The distribution pattern of all the species except *Verbascum thapsus* was contiguous.

The value of concentration of dominance (C), index of diversity (H), richness index (R) and evenness index (E) for trees, shrubs and herbs at different altitudes was given in Table-9. The higher the value of concentration of dominance, the greater is the homogenous nature of the community and vice- versa. The diversity indices and richness index was more in lower elevation indicating higher diversity of the species. The evenness index was comparatively more in lower altitudinal ranges than higher altitudinal ranges indicating that species are evenly distributed in lower elevations.

Index of similarity for shrubs between 2700-3200m and 3200-3700m, between 2700-3200m and 3700-4200m and between 3200-3700m and 3700-4200m was 0.43, 0.30 and 0.69 respectively whereas, index of dissimilarity for the same was 0.57, 0.70 and 0.31 respectively. This indicating less similarity of species between these elevations. Index of similarity for herb species between different altitudes was low as given in Table-10. This indicating more dissimilarity of species between different altitudes.

PLANTS OF MEDICINAL VALUE

The important plants of medicinal value found in the Pooh valley of cold desert area in Kinnaur district were compiled following Chopra *et al* (1956), Kirtikar and Basu (1987) and Kala (2002). These include, *Anaphalis triplinervis, Arnebia euchroma, Artemisia brevifolia, Artemisia gmelinii, Astragalus rizanthus, Bergenia stracheyi, Bistorta affinis, Cannabis sativa, Capparis spinosa,*

Table 1 : Distribution of tree species in Pooh area of Kinnaur district at 2700-3200m elevation.

S. No.	Species	Density (ha^{-1})	Frequency (%)	Abundance	A/F	IVI
1	*Alnus nitida* (Spach) Endl.	35.00	25.00	1.40	0.06	17.99
2	*Cedrus deodara* (Roxb. ex D. Don) G. Don	30.00	10.00	3.00	0.30	15.06
3	*Fraxinus xanthoxyloides* Wall ex G. Don DC	15.00	15.00	1.00	0.07	7.50
4	*Hippophae rhamnoides* Linn.	15.00	15.00	1.00	0.07	8.22
5	*Juglans regia* Linn.	20.00	10.00	2.00	0.20	9.55
6	*Juniperus polycarpos* C. Koch	60.00	30.00	2.00	0.07	25.18
7	*Pinus gerardiana* Wall ex Lamb	10.00	5.00	2.00	0.40	4.20
8	*Populus alba* Linn.	65.00	40.00	1.63	0.04	33.36
9	*Populus nigra* Linn.	40.00	30.00	1.33	0.04	17.96
10	*Populus ciliata* Wall. ex Royle	140.00	75.00	1.87	0.02	57.87
11	*Prunus armeniaca* Linn.	20.00	20.00	1.00	0.05	10.96
12	*Robinia pseudoacacia* Linn.	80.00	50.00	1.60	0.03	30.35
13	*Salix alba* Linn.	155.00	65.00	2.38	0.04	61.83

Table 2 : Distribution of shrub species in Pooh area of district Kinnaur at 2700-3200m elevation.

S. No.	Species	Density (ha^{-1})	Frequency (%)	Abundance	A/F	IVI
1	*Abelia triflora* R. Br. ex Wall.	3611.11	37.50	8.67	0.23	22.77
2	*Capparis spinosa* Linn.	416.67	22.50	1.67	0.07	6.28
3	*Caragana brevispina* Royle	555.56	10.00	5.00	0.50	4.48
4	*Clematis grata* Wall.	250.00	7.50	3.00	0.40	2.46
5	*Colutea nepalensis* Shap ex Ali	2361.11	20.00	10.63	0.53	13.66
6	*Cotoneaster bacillaris* Wall ex Lindl.	2305.56	30.00	6.92	0.23	19.40
7	*Fraxinus xanthoxyloides* * Wall ex G. Don DC.	777.78	22.50	3.11	0.14	18.13
8	*Hippophae rhamnoides* Linn	527.78	12.50	3.80	0.30	10.74

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S. No.	Species	Density (ha^{-1})	Frequency (%)	Abundance	A/F	IVI
9	*Juniperus polycarpos* * C. Koch	555.56	20.00	2.50	0.13	10.99
10	*Lespedeza gerardiana* Grah. ex Max.	500.00	7.50	6.00	0.80	3.30
11	*Lonicera asperifolia* (Decne) Hook. f. & Thoms	583.33	10.00	5.25	0.53	10.25
12	*Lonicera hypoleuca* Decne	666.67	10.00	6.00	0.60	4.62
13	*Lonicera myrtillus* Hook. f. & Thoms.	527.78	12.50	3.80	0.30	4.65
14	*Lonicera orientalis* Lamk.	3500.00	32.50	9.69	0.30	23.40
15	*Lonicera quinquelocularis* Hardw.	722.22	7.50	8.67	1.16	4.22
16	*Pinus gerardiana** Wall ex Lamb.	500.00	17.50	2.57	0.15	14.32
17	*Rhamnus virgatus* Roxb.	583.33	12.50	4.20	0.34	5.75
18	*Ribes orientale* Desf.	972.22	12.50	7.00	0.56	6.32
19	*Rosa webbiana* Wall ex Royle	7833.33	77.50	9.10	0.12	45.91
20	*Salix denticulata* Anderson	1472.22	20.00	6.63	0.33	28.05
21	*Sorbaria tomentosa* (Lindl.) Rehder	4250.00	40.00	9.56	0.24	34.23
22	*Spiraea canescens* D. Don.	500.00	17.50	2.57	0.15	6.06

*Sapling

Table 3 : Distribution of herb species in Pooh area of district Kinnaur at 2700-3200m elevation.

S. No.	Species	Density (ha^{-1})	Frequency (%)	Abundance	A/F	IVI
1	*Aconogonum tortuosum* D. Don Hara	0.15	5.00	3.00	0.60	0.70
2	*Amaranthus caudatus* Linn.	0.07	3.33	2.00	0.60	0.76
3	*Arabidopsis thaliana* (L.) Heynth	0.22	6.67	3.25	0.49	0.89
4	*Arenaria festucoides* Benth.	0.50	6.67	7.50	1.13	1.29
5	*Arenaria griffithii* Boiss.	0.47	11.67	4.00	0.34	1.59
6	*Artemisia brevifolia* Linn.	1.08	76.67	1.41	0.02	8.98
7	*Artemisia gmelinii* Weber ex Steckm.	0.67	16.67	4.00	0.24	2.65
8	*Artemisia scoparia* Waldst & Kit.	8.12	70.00	11.60	0.17	26.08
9	*Artemisia vestita* Wall ex DC.	1.27	10.00	12.67	1.27	5.12
10	*Astragalus rhizanthus* Royle ex Benth.	0.20	5.00	4.00	0.80	1.24
11	*Cannabis sativa* Linn. Hemp.	0.58	11.67	5.00	0.43	6.68
12	*Capparis spinosa* Linn.	0.15	5.00	3.00	0.60	1.07
13	*Chenopodium album* Linn.	1.77	33.33	5.30	0.16	9.90
14	*Chenopodium ambrosisoides* Linn.	0.13	10.00	1.33	0.13	1.05
15	*Chenopodium foliolosum* (Moench) Asch.	0.17	16.67	1.00	0.06	1.70
16	*Chrysanthemum pyrethroides* Karelin & Kir (B. Fedtsch)	0.12	11.67	1.00	0.09	1.13
17	*Cicer microphyllum* Benth.	0.03	3.33	1.00	0.30	0.36
18	*Cirsium wallichii* DC.	0.20	16.67	1.20	0.07	2.25
19	*Clematis orientalis* Linn.	0.13	6.67	2.00	0.30	0.79
20	*Convolvulus arvensis* Linn.	0.13	10.00	1.33	0.13	0.99
21	*Conyza japonica* (Thumb.) Less ex DC.	0.65	25.00	2.60	0.10	3.79
22	*Conyza stricta* Willd.	0.83	30.00	2.78	0.09	3.71
23	*Corydalis govaniana* Wall.	0.17	8.33	2.00	0.24	0.90
24	*Cousinia thomsonii* C.B. Clarke	0.15	13.33	1.13	0.08	1.88
25	*Cuscuta reflexa* Roxb.	0.08	8.33	1.00	0.12	0.72
26	*Cynoglossum micranthum* Desf.	0.30	15.00	2.00	0.13	1.86
27	*Datisca cannabina* Linn.	1.53	13.33	11.50	0.86	10.95
28	*Datura stramonium* Linn.	0.10	10.00	1.00	0.10	1.33
29	*Dracocephalum heterophyllum* Benth.	0.27	10.00	2.67	0.27	1.29
30	*Echinops cornigerus* DC.	0.33	13.33	2.50	0.19	3.27
31	*Ephedra gerardiana* Wall. ex Stapf.	1.03	41.67	2.48	0.06	13.63

(Cont...)

S. No.	Species	Density (ha^{-1})	Frequency (%)	Abundance	A/F	IVI
32	*Epilobium laxum* Royle	0.38	11.67	3.29	0.28	1.53
33	*Epilobium royleanum* Hausskn.	0.69	20.00	7.13	0.83	2.92
34	*Erigeron alpinus* Linn.	2.28	48.33	4.72	0.10	7.74
35	*Galium aparine* Linn.	0.72	8.33	8.60	1.03	1.78
36	*Galinsoga parviflora* Cav.	0.25	10.00	2.50	0.25	1.18
37	*Galium asperuloides* Edgew	0.63	15.00	4.22	0.28	2.13
38	*Geranium pratense* Linn.	0.47	11.67	4.00	0.34	1.73
39	*Heracleum candicans* Wall ex DC.	0.57	23.33	2.43	0.10	8.24
40	*Hippophae rhamnoides* ** Linn.	0.17	8.33	2.00	0.24	1.01
41	*Jasminum humile* Linn.	0.33	6.67	5.00	0.75	1.21
42	*Juniperus polycarpos* ** C. Koch	0.23	20.00	1.17	0.06	1.97
43	*Lactuca dissecta* D.Don.	0.47	16.67	2.80	0.17	1.98
44	*Lotus corniculatus* Linn.	1.08	21.67	5.00	0.23	3.55
45	*Lathyrus emodi* (Fritsch)Ali	0.10	10.00	1.00	0.10	0.87
46	*Malva rotundifolia* Linn.	6.33	133.33	4.75	0.04	22.68
47	*Medicago falcata* Linn.	1.83	30.00	6.11	0.20	5.65
48	*Melilotus alba* Medik ex Desr.	0.53	10.00	5.33	0.53	1.73
49	*Mentha longifolia* (L.) Hunds.	3.07	30.00	10.22	0.34	9.20
50	*Nepeta erecta* Royle ex Benth.	0.18	13.33	1.38	0.10	1.29
51	*Oplismenus compositus* L.Beauv	0.80	10.00	8.00	0.80	2.07
52	*Origanum vulgare* Linn.	6.30	40.00	15.75	0.39	20.65
53	*Orobranche alba* Stephen ex Willd.	0.17	6.67	2.50	0.38	1.15
54	*Oxalis corniculata* Linn.	0.38	11.67	3.29	0.28	1.47
55	*Oxytropis lapponica* (Wahl.) Gay.	0.47	15.00	3.11	0.21	2.22
56	*Plantago lanceolata* Linn.	0.45	10.00	4.50	0.45	1.62
57	*Polygonum nepalensis* Meissn.	0.53	15.00	3.56	0.24	2.38
58	*Polygonum paronychioides* C.Meyer ex Hohen.	2.07	25.00	8.27	0.33	5.38
59	*Polygonum polystachya* Wall ex Meissn.	0.57	15.00	3.78	0.25	5.45
60	*Populu Populus ciliata* ** Wall ex Royle	0.10	5.00	2.00	0.40	0.93
61	*Potentilla argyrophylla* Wall ex Lehm.	0.53	6.67	8.00	1.20	2.07
62	*Prangos pabularia* Lindley.	0.17	8.33	2.00	0.24	1.07
63	*Rheum webbianum* Royle	0.20	5.00	4.00	0.80	2.68
64	*Rumex hastatus* D. Don	0.63	16.67	3.80	0.23	2.32
65	*Rumex nepalensis* Sprengel	0.20	6.67	3.00	0.45	2.18
66	*Salsola callina* Pall-Slender Russian Twistle	0.13	10.00	1.33	0.13	1.08
67	*Scorzonera virgata* DC.	0.62	15.00	4.11	0.27	2.45
68	*Scrophularia calycina* Benth	0.50	10.00	5.00	0.50	2.21
69	*Scutellaria prostrate* Jacq. ex Benth.	0.13	10.00	1.33	0.13	1.01
70	*Senecio chrysanthemoides* DC.	0.20	18.33	1.09	0.06	1.68
71	*Sisymbrium brassiciforme* Linn.	0.05	5.00	1.00	0.20	0.43
72	*Solanum nigrum* Linn.	0.05	5.00	1.00	0.20	0.45
73	*Sorbaria tomentosa* ** Lindl.	0.47	11.67	4.00	0.34	3.16
74	*Stellaria crespeta* Wall	0.32	11.67	2.71	0.23	1.39
75	*Stellaria media* Linn.	0.25	5.00	5.00	1.00	0.81
76	*Swertia cordifolia* (G.Don.) Wall	0.30	13.33	2.25	0.17	1.54
77	*Taraxacum officinale* Wigg.	0.30	16.67	1.80	0.11	2.21
78	*Thalictrum cultratum* Wall.	0.33	18.33	1.82	0.10	3.20
79	*Thalictrum minus* Linn	0.22	10.00	2.17	0.22	1.17
80	*Tricholepis elongata* DC.	0.13	8.33	1.60	0.19	0.96
81	*Trifolium repens* Linn.	0.83	8.33	10.00	1.20	2.01
82	*Urtica dioica* Linn.	1.03	13.33	7.75	0.58	6.65
83	*Verbascum thapsus* Linn.	1.10	71.67	1.53	0.02	16.94

**Regeneration

Table 4 : Distribution of tree species in Pooh area of district Kinnaur at 3200-3700m elevation.

S. No.	Name of the Species	Density (ha^{-1})	Frequency (%)	Abundance	A/F	IVI
1	*Juniperus polycarpos* C. Koch	255.00	90.00	2.83	0.03	142.22
2	*Populus alba* Linn	30.00	30.00	1.00	0.03	23.86
3	*Populus ciliata* Wall ex Royle	60.00	30.00	2.00	0.07	33.09
4	*Prunus armeniaca* Linn.	20.00	20.00	1.00	0.05	15.25
5	*Salix alba* Linn.	165.00	60.00	2.75	0.05	85.58

Table 5 : Distribution of shrub species in Pooh area of district Kinnaur at 3200-3700m elevation.

S. No.	Species	Density (ha^{-1})	Frequency (%)	Abundance	A/F	IVI
1	*Berberis jaeschkeana* C.K. Schneider	1444.44	20.00	6.50	0.33	10.10
2	*Caragana brevispina* Royle	1972.22	20.00	8.88	0.44	12.85
3	*Cotoneaster microphyllus* Wall ex Lindl.	3861.11	40.00	8.69	0.22	34.34
4	*Juniperus communis* Linn.	2527.78	22.50	10.11	0.45	35.52
5	*Juniperus indica* Bertol	1694.44	12.50	12.20	0.98	18.47
6	*Juniperus polycarpos** C. Koch	2222.22	50.00	4.00	0.08	38.79
7	*Lonicera alpigena* Linn.	944.44	12.50	6.80	0.54	6.78
8	*Lonicera orientalis* Lamk.	3500.00	32.50	9.69	0.30	23.75
9	*Lonicera parviflora* Edgew.	1555.56	20.00	7.00	0.35	10.30
10	*Lonicera quinquelocularis* Hardw.	1666.67	20.00	7.50	0.38	10.68
11	*Ribes alpestre* Wall ex Decne	1138.89	10.00	10.25	1.03	6.38
12	*Ribes orientale* Desf.	2777.78	27.50	9.09	0.33	16.69
13	*Rosa webbiana* Wall ex Royle	8166.67	82.50	8.91	0.11	49.47
14	*Salix denticulata* Anderson	250.00	7.50	3.00	0.40	5.65
15	*Sorbaria tomentosa* Lindl.Rehder	2500.00	22.50	10.00	0.44	20.24

*Sapling

Table 6 : Distribution of herb species in Pooh area of district Kinnaur at 3200-3700m elevation.

S. No.	Species	Density (ha^{-1})	Frequency (%)	Abundance	A/F	IVI
1	*Anaphalis triplinervis* (Sims) C.B. Clarke	0.20	6.67	3.00	0.45	0.72
2	*Arabidopsis thaliana* (L.) Heynth.	0.30	16.67	1.80	0.11	1.56
3	*Arenaria festucoides* Benth.	1.77	13.33	13.25	0.99	3.03
4	*Artemisia brevifolia* Wall.	12.15	71.67	16.95	0.24	27.90
5	*Artemisia dracunculus* Tarragon.	0.60	6.67	9.00	1.35	2.45
6	*Artemisia scoparia* Waldst & Kit.	3.23	23.33	13.86	0.59	11.42
7	*Artemisia tournefortiana* Reicheb	0.67	6.67	10.00	1.50	10.22
8	*Artemisia vestita* Wall ex DC.	2.25	15.00	15.00	1.00	7.28
9	*Astragalus rhizanthus* Royle ex Benth.	1.55	41.67	3.72	0.09	5.02
10	*Bistorta affinis* (D.Don) Greene	0.60	21.67	2.77	0.13	2.52
11	*Bupleureum tenue* Buch-Ham ex D.Don.	0.38	23.33	1.64	0.07	2.14
12	*Campanula colorata* Wall.	0.28	18.33	1.55	0.08	1.63
13	*Chenopodium botrys* Linn.	0.05	5.00	1.00	0.20	0.42
14	*Cirsium wallichii* DC.	0.77	28.33	2.71	0.10	5.37
15	*Conyza japonica* (Thunb) Less ex DC	1.57	40.00	3.92	0.10	5.67
16	*Corydalis govaniana* Wall.	0.63	16.67	3.80	0.23	4.32
17	*Crepis flexuosa* DC.Benth	0.20	11.67	1.71	0.15	1.14
18	*Cuscuta reflexa* Roxb.	0.15	5.00	3.00	0.60	0.53
19	*Cynoglossum furcatum* Wall.ex Roxb.	0.12	11.67	1.00	0.09	0.97
20	*Echinops cornigerus* DC.	0.57	20.00	2.83	0.14	4.67
21	*Epilobium brevifolium* Linn.	0.63	16.67	3.80	0.23	2.28
22	*Epilobium chitralensis* Bang Hass	0.65	5.00	13.00	2.60	1.25

(Cont...)

S. No.	Species	Density (ha^{-1})	Frequency (%)	Abundance	A/F	IVI
23	*Epilobium cylindricum* D. Don.	0.63	20.00	3.17	0.16	2.34
24	*Epipactus gigantea* Dougl ex Hook.	0.13	10.00	1.33	0.13	0.93
25	*Eremurus himalaicus* Baker	0.57	21.67	2.62	0.12	3.59
26	*Erigeron alpinus* Linn.	1.35	31.67	4.26	0.13	3.99
27	*Euphrobia helioscopia* Linn.	0.13	3.33	4.00	1.20	0.47
28	*Fragaria indica* Andrew.	1.08	20.00	5.42	0.27	2.98
29	*Fragaria vesca* Linn.	0.17	3.33	5.00	1.50	0.44
30	*Galium acutum* Edgew.	0.20	5.00	4.00	0.80	0.59
31	*Galium asperuloides* Edgew.	0.20	5.00	4.00	0.80	0.59
32	*Gentiana carinata* Griseb.	1.72	23.33	7.36	0.32	4.01
33	*Geranium wallichianum* D. Don ex Sweet	0.25	8.33	3.00	0.36	0.91
34	*Geranium pratense* Linn.	0.78	23.33	3.36	0.14	2.68
35	*Heracleum candicans* Wall ex DC.	0.47	23.33	2.00	0.09	6.19
36	*Hyssopus officinalis* Linn.	2.80	13.33	21.00	1.58	4.70
37	*Inula grandiflora* Willd.	0.13	6.67	2.00	0.30	0.92
38	*Juniperus polycarpos* ** C. Koch	0.13	8.33	1.60	0.19	1.24
39	*Lactuca longifolia* DC.	0.40	6.67	6.00	0.90	1.17
40	*Leontopodium himalayanum* DC	0.58	16.67	3.50	0.21	1.96
41	*Leptorhabdos parviflora* (Benth.)Benth	0.53	6.67	8.00	1.20	1.25
42	*Lomantogonium carinthiacum* (Wulfen)Reichb	0.58	25.00	2.33	0.09	2.63
43	*Malva rotundifolia* Linn.	0.25	8.33	3.00	0.36	1.41
44	*Medicago falcata* Linn.	0.10	5.00	2.00	0.40	0.55
45	*Mentha longifolia* (L.) Hudson.	2.83	25.00	11.33	0.45	6.33
46	*Nasturtium officinale* W.T.Ait	0.30	10.00	3.00	0.30	1.18
47	*Nepeta linearis* Royle ex Benth.	5.10	56.67	9.00	0.16	10.50
48	*Origanum vulgare* Linn.	11.63	80.00	14.54	0.18	31.26
49	*Oxyria digyna* (L.) Hill	0.35	11.67	3.00	0.26	1.30
50	*Plantago tibetica* Hook. f.&Thoms	0.43	11.67	3.71	0.32	1.47
51	*Poa annua* Linn.	1.22	28.33	4.29	0.15	3.56
52	*Polygonum paronychioides* C. Meyer ex Hohen	0.78	11.67	6.71	0.58	1.82
53	*Polygonum polystachya* Wall.ex Meissn	0.27	11.67	2.29	0.20	2.56
54	*Potentilla parviflora* Willd.	0.22	8.33	2.60	0.31	1.13
55	*Ranunculus hirtellus* Royle ex D.Don.	0.27	11.67	2.29	0.20	1.18
56	*Rheum webbianum* Royle	0.98	56.67	1.74	0.03	13.56
57	*Rhodiola heterodonta* (Hook.f. & Thoms.) Boriss.	0.83	18.33	4.55	0.25	2.48
58	*Rumex nepalensis* Sprenel	0.68	20.00	3.42	0.17	6.27
59	*Salvia moorcroftiana* Wall. ex Benth.	0.50	5.00	10.00	2.00	2.19
60	*Salvia nubicola* Wall ex Sweet	0.07	3.33	2.00	0.60	0.36
61	*Scrophularia calycina* Benth	0.67	13.33	5.00	0.38	2.50
62	*Sedum ewersii* Ledeb.	0.30	15.00	2.00	0.13	1.46
63	*Selinum tenuifolium* Wall ex C.B. Clarke	0.75	8.33	9.00	1.08	4.04
64	*Senecio chrysanthemoides* DC.	0.25	16.67	1.50	0.09	1.53
65	*Sibbaldia cuneata* Hornem ex Kuntze	0.32	11.67	2.71	0.23	1.26
66	*Sibbaldia parviflora* Edgew.	1.20	6.67	18.00	2.70	2.13
67	*Silene conoidea* Linn.	0.10	5.00	2.00	0.40	0.47
68	*Silene gonosperma* (Rupr.) Bocquet	0.48	20.00	2.42	0.12	2.00
69	*Smilacina purpurea* Wall.	0.30	16.67	1.80	0.11	1.87
70	*Sorbaria tomentosa* ** (Lindl.)Rehder	0.30	8.33	3.60	0.43	1.81
71	*Stellaria media* Linn.	0.72	48.33	1.48	0.03	4.33
72	*Tanacetum tibeticum* Hook. f. & Thoms ex C.B. Clarke	0.58	8.33	7.00	0.84	1.51
73	*Taraxacum officinale* Wigg.	0.58	11.67	5.00	0.43	2.04
74	*Thymus linearis* Benth ex Benth.	7.68	56.67	13.56	0.24	13.09
75	*Tragopogon gracilis* D. Don.	1.25	13.33	9.38	0.70	5.83
76	*Urtica dioica* Linn.	0.83	16.67	5.00	0.30	5.16
77	*Verbascum thapsus* Linn.	1.17	58.33	2.00	0.03	12.39

**Regeneration

Table 7 : Distribution of shrub species in Pooh area of district Kinnaur at 3700-4200m elevation

S. No.	Species	Density (ha^{-1})	Frequency (%)	Abundance	A/F	IVI
1	*Abelia triflora* R. Br. ex Wall.	3750.00	32.50	10.38	0.32	22.27
2	*Berberis jaeschkeana* C.K.Schneider	1750.00	12.50	12.60	1.01	9.20
3	*Caragana brevispina* Royle	2833.33	22.50	11.33	0.50	16.42
4	*Cotoneaster microphyllus* Wall ex Lindley	4861.11	45.00	9.72	0.22	37.58
5	*Juniperus communis* Linn	2916.67	27.50	9.55	0.35	33.41
6	*Juniperus indica* Bertol	9916.67	50.00	17.85	0.36	82.36
7	*Juniperus polycarpos* * C. Koch	3027.78	35.00	7.79	0.22	36.61
8	*Lonicera alpigena* Linn.	2333.33	35.00	6.00	0.17	18.27
9	*Lonicera ovabata* Royle ex.Hook.f.&Thoms	1250.00	15.00	7.50	0.50	8.35
10	*Ribes orientale* Desf.	888.89	10.00	8.00	0.80	5.76
11	*Rosa webbiana* Wall.ex. Royle	4750.00	50.00	8.55	0.17	29.77

Table 8 : Distribution of herb species in Pooh area of district Kinnaur at 3700-4200m elevation

S. No.	Species	Density (ha^{-1})	Frequency (%)	Abundance	A/F	IVI
1	*Allium stracheyi* Linn.	0.25	5.00	5.00	1.00	0.74
2	*Anaphalis contorta* (D.Don.) Hook. f.	2.00	13.33	15.00	1.13	2.87
3	*Anaphalis triplinervis* (Sims) C.B.Clarke	2.83	28.33	10.00	0.35	4.67
4	*Androsace sarmentosa* Wall.	4.45	33.33	13.35	0.40	6.63
5	*Arenaria festucoides* Benth.	8.95	45.00	19.89	0.44	11.30
6	*Arnebia euchroma* (Royle ex Benth)I.M.Johnston	0.42	13.33	3.13	0.23	1.75
7	*Artemisia brevifolia* Wall	1.83	20.00	9.17	0.46	4.15
8	*Artemisia dracunculus* L.Tarragon	1.80	20.00	9.00	0.45	6.46
9	*Artemisia scoparia* Waldst & Kit.	1.47	11.67	12.57	1.08	4.59
10	*Artemisia vestita* Wall ex DC.	1.17	11.67	10.00	0.86	3.53
11	*Astragalus chlorostachys* Lindl.	0.30	5.00	6.00	1.20	1.05
12	*Astragalus rhizanthus* Royle ex Benth	1.65	30.00	5.50	0.18	3.75
13	*Bergenia stracheyi* (Hook.f. Thoms.) Engl.	4.20	15.00	28.00	1.87	31.80
14	*Bistorta affinis* (D.Don) Greene	0.70	25.00	2.80	0.11	2.57
15	*Pedicularis hoffmeisteri* Klotz.	0.33	6.67	5.00	0.75	0.84
16	*Cirsium wallichii* DC.	2.15	65.00	3.31	0.05	12.58
17	*Clintonia udensis*Trautv. & Meyer	0.40	16.67	2.40	0.14	1.56
18	*Conyza japonica* (Thumb.) Less ex DC.	1.43	31.67	4.53	0.14	4.21
19	*Dianthus angulatus* Royle	0.40	5.00	8.00	1.60	0.75
20	*Echinops cornigerus* DC.	0.45	25.00	1.80	0.07	3.93
21	*Ephedra gerardiana* Wall ex Stapf.	0.33	11.67	2.86	0.24	3.36
22	*Eremurus himalaicus* Baker	0.75	20.00	3.75	0.19	3.70
23	*Fragaria indica* Andrews.	0.80	8.33	9.60	1.15	1.32
24	*Fragaria vesca* Linn.	0.40	10.00	4.00	0.40	1.04
25	*Fritillaria oxypetalum* D.Don.	0.80	23.33	3.43	0.15	2.48
26	*Galium asperuloides* Edgew	4.60	40.00	11.50	0.29	6.89
27	*Geranium pratense* Linn.	1.05	31.67	3.32	0.10	3.01
28	*Geranium wallichianum* D. Don. ex Sweet	2.20	41.67	5.28	0.13	5.10
29	*Geum elatum* Wallich	0.50	5.00	10.00	2.00	1.76
30	*Heracleum candicans* Wall ex DC.	0.28	16.67	1.70	0.10	3.58
31	*Hyssopus officinalis* Linn.	2.83	26.67	10.63	0.40	4.72
32	*Juniperus indica* ** Bertol	0.10	5.00	2.00	0.40	0.49
33	*Juniperus polycarpos* ** C. Koch	0.15	10.00	1.50	0.15	0.98
34	*Lactuca macrorhiza* (Royle) Beauv	0.93	21.67	4.31	0.20	2.46
35	*Mentha longifolia* (L.) Hudson	1.23	11.67	10.57	0.91	2.45
36	*Micromeria biflora* (Buch-Ham ex D.Don) Benth.	0.60	15.00	4.00	0.27	1.52
37	*Morina coulteriana* Linn.	0.85	10.00	8.50	0.85	3.03
38	*Nepeta glutinosa* Benth.	4.97	61.67	17.82	1.64	10.48
39	*Origanum vulgare* Linn.	2.67	21.67	12.31	0.57	4.90

(Cont...)

S. No.	Species	Density (ha^{-1})	Frequency (%)	Abundance	A/F	IVI
40	*Orobanche alba* Stephen ex Willd.	0.20	15.00	1.33	0.09	1.85
41	*Parnessia nubicola* Wall ex Royle	0.80	15.00	5.33	0.36	1.83
42	*Plantago tibetica* Hook. f. & Thoms.	0.90	10.00	9.00	0.90	1.75
43	*Pleurospermum candollei* (DC.) C. B. Clarke	0.07	6.67	1.00	0.15	0.58
44	*Poa annua* Linn.	1.50	30.00	5.00	0.17	3.46
45	*Polygonum paronychioides* C.Meyer ex Hohen.	2.00	30.00	6.67	0.22	3.94
46	*Polygonum polystachya* Wall.ex.Meissn	1.18	6.67	17.75	2.66	7.39
47	*Potentilla atrosanguinea* Lodd.	0.60	15.00	4.00	0.27	3.21
48	*Potentilla parviflora* Willd.	1.75	25.00	7.00	0.28	3.37
49	*Primula denticulata* Smith.	0.63	11.67	5.43	0.47	1.58
50	*Ranunculus hirtellus* Royle ex D.Don.	0.42	18.33	2.27	0.12	1.63
51	*Rheum webbianum* Royle	1.60	70.00	2.29	0.03	16.61
52	*Rhodiola hetrodonta* (Hook.f. & Thoms.) Boriss.	1.23	36.67	6.50	0.35	4.84
53	*Rhodiola himalensis* (D.Don) S.H. Fu	0.80	26.67	3.00	0.11	2.65
54	*Rorippa nasturtium aquaticum (*Linn.) Hayek.	0.33	6.67	5.00	0.75	0.80
55	*Rosularia adenotricha* Wall.ex.Edgew	0.35	20.00	1.75	0.09	1.69
56	*Sedum ewersii* Ledeb.	0.55	21.67	2.54	0.12	2.08
57	*Selinum tenuifolium* Wall. ex C.B. Clarke	0.70	10.00	7.00	0.70	3.44
58	*Senecio laetus* Edgew.	0.43	26.67	1.63	0.06	2.22
59	*Sibbaldia parviflora* Edgew	1.55	15.00	10.33	0.69	2.68
60	*Silene gonosperma* (Rupr.) Bocquet.	1.00	25.00	4.00	0.16	2.58
61	*Silene viscosa* (L.) Pers.	0.90	25.00	3.60	0.14	2.58
62	*Smilacina purpurea* Wall.	0.35	20.00	1.75	0.09	1.98
63	*Stellaria media* Linn.	13.23	80.00	16.54	0.21	19.21
64	*Tanacetum longifolium* Wall.ex.DC.	0.40	10.00	4.00	0.40	1.30
65	*Thalictrum cultratum* Wall	0.30	11.67	2.57	0.22	1.08
66	*Thymus linearis* Benth. ex Benth.	11.50	60.00	19.17	0.32	14.43
67	*Tragopogon gracilis* D. Don.	1.23	26.67	8.80	0.67	5.96
68	*Urtica dioica* Linn.	0.58	8.33	7.00	0.84	2.72
69	*Verbascum thapsus* Linn.	0.37	31.67	1.16	0.04	4.38
70	*Veronica lanosa* Royle ex. Benth	0.30	8.33	3.60	0.43	0.84
71	*Viola biflora* Linn.	1.47	11.67	12.57	1.08	2.16
72	*Waldheimia glabra* (Decne.) Regel.	0.45	10.00	4.50	0.45	1.33

Table 9 : Concentration of dominance (C), diversity index (H), richness index (R) and evenness index (E) for trees, shrubs and herbs at different elevations in Pooh area of district Kinnaur

Altitude	Plant Category	Concentration of Dominance (C)	Diversity Index (H)	Richness Index (R)	Evenness Index (E)
2700-3200m	Tree	0.12	2.30	2.44	0.89
	Shrub	0.08	2.80	2.95	0.91
	Herb	0.03	3.89	10.08	0.87
3200-3700m	Tree	0.33	1.31	0.85	0.82
	Shrub	0.10	2.50	1.95	0.92
	Herb	0.03	3.86	8.89	0.88
3700-4200m	Shrub	0.14	2.15	1.38	0.89
	Herb	0.04	3.81	8.04	0.91

Table 10 : Index of similarity and dissimilarity for herb species at different altitudes in Pooh area of district Kinnaur

Altitudes	3200-3700m	3700-4200m
2700-3200m	0.37 (0.63)	0.30(0.70)
3200-3700m	-	0.51(0.49)

Note : Values in parenthesis are index of dissimilarity.

Chenopodium album, Chenopodium foliosum, Clematis orientalis, Colutea nepalensis Corydalis govaniana, Cousinia thomsonii, Cynoglossum micranthum,Datisca cannabina, Datura stramonium, Dracocephalum heterophyllum, Echinops cornigerus, Ephedra geradiana, Erigeron alpinus, Fragaria vesca, Fraxinus xanthoxyloides, Galium aparine, Geranium wallichianum ,Geum elatum, Heracleum candicans, Hippophae rhamnoides, Hyssopus officinalis, Inula grandiflora, Jasminum humile, Juglans regia, Juniperus communis, Juniperus polycarpos, Lactuca macrorhiza, Mentha longifolia, Micromeria biflora, Nepeta erecta, Origanum vulgare, Oxyria digyna, Oxytropis laponica, Plantago lanceolata, Plantago tibetica, Pleurospermum candollei, Polygonum polystachya, Potentilla argyrophylla, Primula denticulate, Rheum webbianum, Rhodiola heterodonta, Rosa webbiana, Rumex nepalensis Scorzonera virgata, Sedum ewersii, Selinum tenuifolium ,Senecio chrysanthemoides, Tanacetum longifolium, Taraxacum officinale, Thalictrum minus, Thymus linearis, Trifolium repens, Urtica dioica, Verbascum thapsus, Viola biflora and *Waldheimia glabra.*

THREATENED PLANTS

Out of 62 medicinal plant species recorded from the area, 10 species *i.e.*, *Arnebia evchroma, Bergenia stracheyi, Datisca cannabina, Ephedra gerardiana, Hippophae rhamnoides, Hyssopus officinalis, Hyoscyamus niger, Juniperus polycarpos, Rheum webbianum* and *Rhodiola heterodonta* fall in the category of threatened plants.

The habitat of most of the plant species have shrunk due to expansion of human population and environmental degradation primarily due to heavy live stock grazing, uncontrolled and unscientific harvest of species, unregulated tourism and construction of roads etc. The better conservation of natural resources can be done by inclusion of a section on the plant conservation especially of rare and endangered medicinal plants in the wild life protection act, promotion of community based conservation, *in-situ* conservation through the establishment of nature reserves, *ex-situ* conservation through tissue culture, developing cultivation technologies and nurseries of medicinal plants and conducting of regular training on the procedure of medicinal plants collection, processing among the local people, traders and real stake holders.

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