CONSERVATION PRIORITIZATION OF HABITATS AND FOREST COMMUNITIES IN THE LAHAUL VALLEY OF PROPOSED COLD DESERT BIOSPHERE RESERVE, NORTH WESTERN HIMALAYA, INDIA

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Abstract. The rapid loss of biodiversity due to habitat degradation and over exploitation has necessitated the conservation prioritization of habitats, species and communities for conservation. The prioritization of habitats and communities through qualitative and quantitative assessment of vegetation is prerequisite for initiating any conservation and management programme. Therefore, an attempt has been made to; (i) identify the habitats and communities; (ii) evaluate habitats and communities for species richness, native, endemic, economically important and threatened species; (iii) prioritize habitats and communities for conservation. Fifteen (15) habitats and fourteen forest (14) communities distributed between 2490-4000m were recorded. Overall, 35.71% communities were broad-leaved, 57.14% coniferous and 7.14% mixed. The habitats and communities have been evaluated for the species richness, native, endemic, economically important and threatened species. Based on these attributes habitats and communities have been prioritized. Among communities *Abies pindrow - Pinus wallichiana* mixed, *Fraxinus xanthoxyloides*, *Picea smithiana - Pinus wallichiana* mixed and *Cedrus deodara -Acer cappadocicum* mixed showed highest CPI and habitats forest, shady moist showed highest CPI value. Regular monitoring of the prioritized habitats and communities has been suggested. Also, mass scale propagation of native, endemic, economically important and threatened species and their plantation in the Lahaul valley have been suggested.
Key words: s*tructure, composition, habitat, community, conservation, prioritization*

Introduction

The Indian Himalayan Region (IHR) is very well known for its representative, natural, unique and socio-economically important plant diversity (Samant et al., 1998a). It is designated as one of the Biodiversity Hot Spots (Anonymous, 2007). It supports 18 440 species of plants with 25-30% of endemics (Samant et al., 1998a; Singh and Hajra, 1996). The inhabitants use this rich diversity for their sustenance. The increase in human population has increased the demand of economically important biodiversity elements. This has caused the over exploitation and habitat degradation of many economically important biodiversity elements and led the rapid loss of these elements. In view of the rapid loss of biodiversity elements, ecological and economical evaluation of the habitats and

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communities are essentially required. The review of literature indicates that in general, a large number of studies have been carried out on the flora, ecology, ethnobotany and rare endangered plants separately in the IHR (Aswal and Mehrotra, 1994; Chowdhery and Wadhwa, 1984; Dhaliwal and Sharma, 1999; Dhar et al., 1997; Kalakoti et al., 1986; Maity and Chauhan, 2002; Nautiyal et al., 1997; Rawal et al., 1994; Rawal and Pangtey, 1994; Rawat et al., 2001; Rawat et al., 1989; Rikhari et al., 1989; Samant and Joshi, 2004; Samant et al., 2002; Saxena and Singh, 1982; Singh and Singh, 1992; Singh and Rawat, 1999; Singh et al., 1996). In the IHR, a very few studies have been carried out to prioritize potential species and altitudinal zones (Dhar et al., 2000; Dhar and Samant, 1993; Pandey, 2006; Samant et al., 2007a; Samant and Pal, 2003; Samant et al., 2007b; Samant et al., 2007c), and habitats and communities (Arya, 2002; Joshi, 2002; Joshi and Samant, 2004; Pant and Samant, 2007; Samant et al., 2002). However, prioritization of habitats and communities based on species richness, native, endemic, economically important and threatened plants have been carried out by a few workers (Joshi and Samant, 2004; Pant and Samant, 2007). In Himachal Pradesh such integrated studies are not available. Therefore, present attempt has been made to; (i) assess the forest vegetation for community identification; (ii) evaluate the habitats and communities for species richness, native, endemic, economically important and threatened plants; (iii) prioritize habitats and communities for conservation; and (iv) suggest conservation measures.

Materials and methods

Study area

The study has been carried out during 2004-2007 in Lahaul Valley (32°22.517'N – 32° 48.564'N Latitudes and 76°25.017'E – 77°16.636'E Longitudes) of a proposed Cold Desert Biosphere Reserve (CDBR) (*Fig. 1*).

The climate varies from dry temperate to alpine types. The area remains snow covered almost for six months and receives average snowfall 120-400 cm year^{-1}, and average rainfall 10-300 mm year^{-1}. The temperature ranges between -19°-32° C (Sinha and Samant, 2006). The highest mountain peak is Mulkila (6,517 m) and lowest point at Karunallah, (2 400 m) the entrance of Chenab into Pangi valley. The whole area of Lahaul is divided into three valleys namely, Chandra, Bhaga and Chandra-Bhaga. The rock system is very fragile and liable to erosion which is often accentuated by the rigorous of severe winters, avalanches and the strong winds that accompany them. The valley is inhabited by a large number of villages and the inhabitants are largely dependent on biodiversity elements for their sustenance.

Survey, sampling, identification and data analysis

Surveys were conducted to select sites and habitats along the Lahaul valley in forest zone between 2490-4000m amsl. The habitats were identified on the basis of physical characters and dominance of vegetation. Attempts have been made to select sites and habitats on each and every accessible aspects. In each site, a plot of 50 × 50 m was laid.

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Trees, saplings and seedlings were sampled by randomly placed 10, 10x10 m quadrats; shrubs by 20, 5 × 5 m quadrats; and herbs by 20, 1 × 1 m quadrats in each plot. For the collection of data from these quadrats standard ecological methods were followed (Curtis and Mc Intosh, 1950; Dhar et al., 1997; Greig-Smith, 1957; Misra, 1968; Mueller-Dombois and Ellenberge, 1974; Samant et al., 2002; Joshi and Samant, 2004). From each site, samples of each species were collected and identified with the help of floras (Aswal and Mehrotra, 1994; Chowdhery and Wadhwa, 1984; Dhaliwal and Sharma, 1999; Polunin and Stainton, 1984; Murti, 2001).

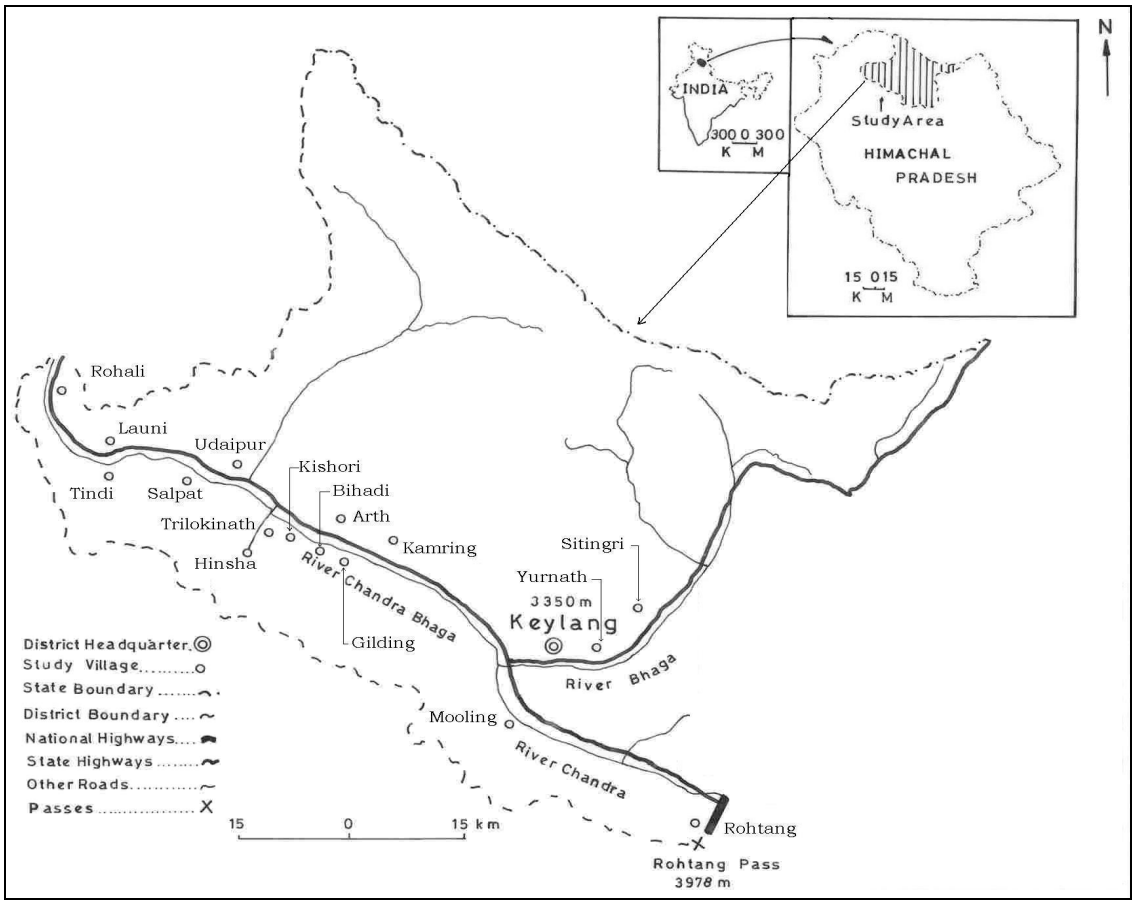

Figure 1. *Study area*

The forest communities were identified on the basis of IVI values of trees. The single tree species representing > 50% of the total IVI was designated as a single species dominated community, whereas two or more species contributing 50 or > 50% of the total IVI were named as a mixed community. Species richness was determined as the number of species.

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Identification of native, endemic, economically important and threatened plants

The species with its origin or first record from the Himalayan Region were considered as natives (Samant et al., 1998a; 2002). In case of Pteridophytes the endemic and near-endemic species have been considered as natives to the Himalayan region. The species restricted to IHR have been considered as endemic, whereas those extending their distribution to neighbouring Countries/States were considered as near-endemic (Dhar and Samant, 1993; Samant and Dhar, 1997; Samant et al., 1996a; 1998a).

The information on economically important species was generated through Participatory Rural Appraisal (PRA) (Samant et al., 2002; 2003) and the interviews of the knowledgeable persons including Amchies (local herbal doctors). Among the village experts, one person was hired to survey and collect the economically important species from wild habitats. Fresh samples of the useful species were collected and identified with the help of florulas (Aswal and Mehrotra, 1994; Chowdhery and Wadhwa, 1984; Polunin and Stainton, 1984).

The threatened species were identified based on habitat preference, distribution range, population size, use pattern, extraction trend, nativity and endemism of the species (Samant et al., 1996b; 1998b; 2002).

Prioritization of habitats and communities

The prioritization of habitats and communities has been done using eight parameters like species richness, economically important, native, endemic, threatened plants, altitude, site representation and habitats number following Joshi and Samant (2004); Pant and Samant (2007); Samant et al. (2002) (*Table 1*).

Table 1. *Criteria's used for the prioritization of habitats and communities*

Marks	Richness (%)	EIP (%)	Native (%)	Endemic (%)	Threatened (%)	SR	Altitude (m)	Habitats *
10	>50	>45	>45	>40	>40	1	<200	1
8	46-50	41-45	41-45	36-40	36-40	2	200-400	2
6	41-45	36-40	36-40	31-35	31-35	3	400-600	3
4	36-40	31-35	31-35	26-30	26-30	4	600-800	4
2	<36	<31	<31	<26	<26	>4	>800	>4

Abbreviations: EIP = Economically Important Plants; SR = Site representation; and * = Criteria only applied for the communities

Results

Habitat diversity

Fifteen habitats (15) Rocky, Bouldary, Shady moist, Forest, Parasite, Degraded, Dry, Riverine, Water courses, Grassland, Marshy, Shrubberies, Near-settlements, Camping sites, and Road sides were identified (*Table 2*). The bouldary, dry, rocky, shady moist and grassland habitats showed wide range of distribution. The site representation varied from 3-16, Species richness ranged from 5-259, natives 3-104, endemics 0-87, economical important species 3-202, and threatened species 3-98. Amongst the habitats, maximum

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species richness (259), native (104), endemic (87), economically important (202), threatened (98) species were recorded in the forest habitat, followed by shady moist, species richness (235), native (94), endemic (84), economically important (191), threatened (93); dry habitat, species richness (170), native (69), endemic (42), economical important (134), threatened (45); grasslands, species richness (146), native (47), endemic (28), economical important (143), and threatened (29) species were recorded. The remaining habitats showed relatively less number of species (*Table 2*). The notable native, endemic, economically important and threatened species of the prioritized habitats have been presented in *Table 3*.

Table 2. *Prioritization of habitats for conservation in Lahaul valley of the proposed CDBR*

Habitat Type	SR	AD (m)	SPR	N	En	EIP	TS	CPI
Rocky	15	2500-4000	106	40	30	77	35	14
Bouldary	16	2490-4000	88	24	18	62	28	14
Shady Moist	15	2400-4000	235	94	84	191	93	38
Forest	14	2500-4000	259	104	87	202	98	44
Parasitic	3	2500-3690	5	3	3	3	4	14
Degraded	12	2500-4000	56	12	11	44	10	14
Dry	15	2490-4000	170	69	42	134	45	14
Riverine	14	2500-4000	71	23	19	60	17	14
Water Courses	11	2490-4000	21	9	5	14	6	14
Grassland	15	2400-4000	146	47	28	143	29	14
Marshy	11	2500-3855	17	4	-	11	3	14
Shrubberries	14	2500-4000	45	15	11	38	14	14
Near Settlements	13	2490-4000	52	12	10	50	11	14
Camping Sites	14	2500-4000	51	13	8	49	3	14
Road Sides	12	2500-3900	60	14	11	58	13	14

Abbreviations: SR = Site representation; AD = Altitudinal Distribution; EIP = Economically Important Plants; CPI = Conservation Priority Index; SPR = Species Richness; N = Native; En = Endemic; and TS = Threatened Species

Community diversity, species composition and structural pattern

Overall 96 sites representing 8 aspects and 15 habitats were sampled and 14 tree communities from forests zone were identified (*Table 4*). The identified communities were broad leaved deciduous (i.e., Betula utilis, Hippophae salicifolia, Juglans regia - Ulmus wallichian - Acer acuminatum mixed, Salix daphnoides and Fraxinus xanthoxyloides); evergreen coniferous and deciduous broad leaved mixed (i.e., Cedrus deodara - Acer cappadocicum mixed), and coniferous evergreen (i.e., Abies pindrow, Abies pindrow - Pinus wallichiana mixed, Cedrus deodara, Juniperus polycarpos, Juniperus polycarpos - Cedrus deodara mixed, Picea smithiana, Picea smithiana - Pinus wallichiana mixed and Pinus wallichiana) communities. The communities having relatively wide altitudinal range of distribution were Juniperus polycarpos, Pinus wallichiana, Cedrus deodara and Picea smithiana (*Table 4*).

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Table 3. *Some important native, endemic, near-endemic, economically important and threatened species of the main prioritized habitat*

Prioritized habitats	Native	Endemic/Near-Endemic	Economically important	Threatened
Forests	Selinum coniifolium, Campanula aristata, Cyananthus lobatus, Rhododendron campanulatum, Picrorhiza kurrooa	Allium stracheyi, Berberis pseudumbellata, Campanula cashmeriana, Dactylorhiza hatagirea	Carum carvi, Heracleum candicans, Hippophae rhamnoides, Corydalis govaniana, Gentiana coronata, Juglans regia, Rheum webbianum, Abies pindrow	Allium stracheyi, Heracleum thomsonii, Selinum coniifolium, Lonicera spinosa, Dioscorea deltoidea, Gentianella moorcroftiana, Swertia alternifolia, Polygonatum cirrhifolium, Aconitum heterophyllum, Juniperus indica
Shady Moist	Acer acuminatum, Angelica glauca, Bupleurum candollii, Chaerophyllum villosum, Indigofera heterantha	Acer acuminatum, Chaerophyllum villosum, Erigeron bellidioides, Codonopsis clematidea	Allium carolinianum, Angelica glauca, Chaerophyllum reflexum, Corylus jacquemontii, Cedrus deodara, Taxus baccata subsp. wallichiana	Acer acuminatum, Allium victorialis, Bunium persicum, Inula grandiflora, Saussurea glanduligera, Onosma hispida, Lilium polyphyllum
Dry	Bupleurum lanceolatum, Cortia depressa, Ligusticum elatum, Anaphalis busua, Eremurus himalaicus	Bupleurum lanceolatum, Heracleum thomsonii, Berberis jaeschkeana, Cortia depressa, Aster indamellus, Echinops cornigerus	Bunium persicum, Bupleurum falcatum, Ferula jaeschkeana, Caragana versicolor, Ribes alpestre, Ajuga bracteosa	Saussurea deltoidea, Vincetoxicum hirundinaria, Lonicera hypoleuca, Datisca cannabina, Syringa emodi, Hyoscyamus niger, Juniperus polycarpos
Bouldary	Cirsium verutum, Gnaphalium thomsonii, Hackelia uncinata, Rhodiola tibetica, Hedysarum astragaloides, Poa koelzii	Cirsium verutum, Silene moorcroftiana, Rhodiola heterodonta, Oryzopsis lateralis, Physochlaena praealta, Cystopteris montana	Cardamine impatiens, Nepeta eriostachya, Podophyllum hexandrum, Rheum australe, Bergenia stracheyi, Ephedra gerardiana, Adiantum capillus-veneris	Silene moorcroftiana, Hypericum perforatum, Meconopsis aculeata, Podophyllum hexandrum, Bergenia ligulata, Physochlaena praealta, Viola biflora, Athyrium davidii
Degraded	Cousinia thomsonii, Astragalus rhizanthus, Rubus cordifolius, Bupleurum lanceolatum, Ligusticum elatum, Senecio krascheninnikovii	Astragalus bicuspis, Agrostis pilosula, Bupleurum lanceolatum, Cirsium wallichii, Echinops cornigerus	Cousinia thomsonii, Medicago falcata, Melilotus officinalis, Thymus linearis, Plantago depressa, Prunus armeniaca, Verbascum thapsus, Pinus wallichiana	Hyssopus officinalis, Bupleurum lanceolatum, Arctium lappa, Artemisia maritima, Juniperus polycarpos, Solanum nigrum

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Amongst the communities, tree density was maximum for Hippophae salicifolia community (1850.00 Ind ha^{-1}), followed by Fraxinus xanthoxyloides (1000.00 Ind ha^{-1}), Juglans regia - Ulmus wallichiana - Acer acuminatum mixed (760.00 Ind ha^{-1}), Abies pindrow - Pinus wallichiana mixed (640.00 Ind ha^{-1}), Juniperus polycarpos - Cedrus deodara mixed (600.00 Ind ha^{-1}). Cedrus deodara - Acer cappadocicum mixed (170.54 m^2 ha^{-1}) community had lowest density. The total basal area (124.89 m^2 ha^{-1}) was maximum for Abies pindrow - Pinus wallichiana mixed community, followed by Juniperus polycarpos - Cedrus deodara mixed (110.64 m^2 ha^{-1}), Picea smithiana (92.26 m^2 ha^{-1}), and Juglans regia - Ulmus wallichiana - Acer acuminatum mixed (91.23 m^2 ha^{-1}). Juniperus polycarpos (13.65 m^2 ha^{-1}) community showed lowest total basal area. Total shrub density was highest in Cedrus deodara (2611.7 Ind ha^{-1}) community, followed by Hippophae salicifolia (2520.00 Ind ha^{-1}), Betula utilis (2230.00 Ind ha^{-1}) and Abies pindrow (1994.00 Ind ha^{-1}). Pinus wallichiana community showed the highest herb density (95.10 Ind m^{-2}), followed by Hippophae salicifolia (63.85 Ind m^{-2}), Juniperus polycarpos (32.77 Ind m^{-2}) and Picea smithiana (32.40 Ind m^{-2}) communities. Fraxinus xanthoxyloides community showed the maximum seedlings density (1300.00 Ind ha^{-1}), followed by Abies pindrow (557.18 Ind ha^{-1}) and Abies pindrow - Pinus wallichiana mixed (390.00 Ind ha^{-1}) communities. Highest saplings density was recorded for Cedrus deodara community (816.42 Ind ha^{-1}), followed by Hippophae salicifolia (790.00 Ind ha^{-1}), Juniperus polycarpos (750.58 Ind ha^{-1}), Juglans regia - Ulmus wallichiana-Acer acuminatum mixed (660.00 Ind ha^{-1}) communities (*Table 4*).

Table 4. *Community types, distribution pattern, structural pattern and major tree associates in Lahaul valley of the Proposed CDBR*

Community types	SR	Altitudinal range (m)	Habitat type (s)	Slope (°)
Juniperus polycarpos	43	2760-3782	A, B, C, D, E, F	35-60
Pinus wallichiana	13	2845-3518	B, C, D, E, F	35-50
Cedrus deodara	11	2550-2830	A, E, C, D, F	20-60
Abies pindrow	6	3220-3440	A, D, F	40-55
Picea smithiana	8	2742-3100	A, B, D, F	40-50
Betula utilis	*5*	*3440-3855*	*A, D, E, F*	*55-70*
Juniperus polycarpos - Cedrus deodara mixed	*2*	*2760-2780*	*A, B*	*35-50*
Hippophae salicifolia	1	3000	L	35
Abies pindrow -Pinus wallichiana mixed	1	3268	D	65
Juglans regia - Ulmus wallichiana - Acer acuminatum mixed	1	2490	D	25
Picea smithiana - Pinus wallichiana mixed	2	2510-2650	D	50-60
Salix daphnoides	1	2560	A	55
Cedrus deodara - Acer cappadocicum mixed	1	2560	A	60
Fraxinus xanthoxyloides	1	2580	A	65

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Table 4. cont.

Community types	Density (Ind ha^{-1})					TBA	Major Associate
	Trees	Seedlings	Saplings	Shrubs	Herbs	(m^{2}ha^{-1})	Species
Juniperus polycarpos	448.55	89.03	750.58	696.24	32.77	13.65	*Picea smithiana* & *Pinus wallichiana*
Pinus wallichiana	456.01	222.05	362.42	1178.97	95.10	32.46	*Juniperus polycarpos* & *Betula utilis*
Cedrus deodara	422.12	178.75	816.42	2611.70	28.24	65.14	*Juniperus polycarpos, Robinia pseudoacacia, Pinus wallichiana, Picea smithiana, Acer acuminat.* & *Celtis australis*
Abies pindrow	475.79	557.18	162.15	1994.00	22.03	61.43	*Pinus wallichiana* & *Betula utilis*
Picea smithiana	399.76	290.52	337.26	767.20	32.40	92.26	*Pinus wallichiana, Juniperus polycarpos, Taxus baccata* subsp. *wallichiana* & *Corylus jacquemontii*
Betula utilis	588.52	136.30	330.00	2230.00	30.48	55.15	*Pinus wallichiana* & *Abies pindrow*
Juniperus polycarpos - Cedrus deodara mixed	600.00	216.67	566.67	1290.00	26.65	110.64	*Pinus wallichiana, Juglans regia* & *Pyrus pashia*
Hippophae salicifolia	1850.00	-	790.00	2520.00	63.85	22.07	*Rosa webbiana*
Abies pindrow - Pinus wallichiana mixed	640.00	390.00	310.00	545.00	30.96	124.89	*Picea smithiana*
Juglans regia -Ulmus wallichiana - Acer acuminatum mixed	760.00	-	660.00	490.00	23.77	91.23	*Ulmus villosa, Prunus cornuta, Fraxinus micrantha, Acer cappadoc, Corylus jacquemontii* & *Pinus wallichiana*
Picea smithiana - Pinus wallichiana mixed	305.56	290.00	310.00	1900.00	20.11	69.18	*Abies pindrow, Picea smithiana, Pinus wallich. Acer acuminatum* & *Corylus jacquemontii*
Salix daphnoides	220.00	-	500.00	610.00	23.67	25.33	*Cedrus deodara*
Cedrus deodara - Acer cappadocicum mixed	170.00	-	-	690.00	17.18	36.23	*Celtis australis*
Fraxinus xanthoxyloid.	1000.00	1300.00	300.00	480.00	7.83	46.97	*Corylus jacquemontii*

Abbreviations: m = Meters; Ind = Individual; ha^{-1} = Per hectare; A = Bouldary; B = Degraded; C = Dry slopes; D = Shady moist slopes; E = Riverine; F = Rocky; L = Grassland and SR = Site representation

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Species richness

The species richness within the identified communities for trees ranged from 1-9, shrubs 3-23, herbs 9-213, seedlings 0-5, and saplings 0-4. The richness of trees was highest in Juglans regia - Ulmus wallichiana - Acer acuminatum mixed community (i.e., 9), followed by Picea smithiana - Pinus wallichiana mixed community (8). The richness of shrubs was highest in Juniperus polycarpos community (23), followed by Cedrus deodara (18) and Pinus wallichiana (15) communities, whereas richness of herbs was again highest in Juniperus polycarpos community (213), followed by Pinus wallichiana (153) and Cedrus deodara (92) communities (*Table 4*).

Native, endemic, economically important and threatened species

The native species ranged from 7-90, endemic species 6-63, economically important species 15-194 and threatened species 6-47 within the communities. Maximum species were recorded in Juniperus polycarpos community (native 90; endemic 63; economically important 194), followed by Pinus wallichiana (native 81; endemic 61; economically important 147), Cedrus deodara (native 52; endemic 30; economically important 101), Picea smithiana (native 40; endemic 16; economically important 69) and Betula utilis (native 30; endemic 26; economically important 52) communities. The remaining communities showed comparatively less native and endemic species (*Table 5*).

Table 5. *Prioritization of forest communities for conservation using different parameters in the Lahaul valley of Proposed CDBR*

Community Type	Habitat(s)	SR	AD (m)	SPR	N	En	EIP	TS
Juniperus polycarpos	6	43	2760-3700	242	90	63	194	47
Pinus wallichiana	5	13	2845-3500	173	81	61	147	46
Cedrus deodara	5	11	2550-2830	117	52	30	101	33
Abies pindrow	3	6	3220-3440	57	30	16	49	15
Picea smithiana	4	8	2742-3100	83	40	16	69	20
Betula utilis	4	5	3440-3855	59	30	26	52	17
Juniperus polycarpos-Cedrus deodara mixed	2	2	2760-2780	39	12	11	36	12
Hippophae salicifolia	1	1	3000-3100	30	13	9	24	7
Abies pindrow-Pinus wallichiana mixed	1	1	3260-3340	24	14	10	21	9
Picea smithiana-Pinus wallichiana mixed	1	2	2490-2600	46	16	18	44	22
Juglans regia-Ulmus wallichiana-Acer acuminatum mixed	1	1	2450-2550	50	15	13	42	23
Cedrus deodara-Acer cappadocicum mixed	1	1	2560-2630	26	9	8	23	13
Salix daphnoides	1	1	2560-2620	28	8	6	24	7
Fraxinus xanthoxyloides	1	1	2500-2650	15	7	6	15	6

Abbreviations: SR = Site Representation; AD = Altitudinal Distribution; EIP = Economically Important Plants; SPR = Species Richness; N = Natives; En = Endemics; and TS = Threatened species

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Amongst the communities, threatened species ranged from 6-47 (*Table 5*). It was highest in Juniperus polycarpos community (Endangered 1; Vulnerable 11; Near Threatened 35), followed by Pinus wallichiana (Critically Endangered 2; Endangered 5; Vulnerable 13; Near Threatened 26), Cedrus deodara (Critically Endangered 2; Endangered 2; Vulnerable 7; Near Threatened 22), Juglans regia-Ulmus wallichiana-Acer acuminatum mixed (Critically Endangered 1; Endangered 8; Vulnerable 6; Near Threatened 8), Picea smithiana-Pinus wallichiana mixed (Critically Endangered 1; Endangered 2; Vulnerable 7; Near Threatened 12) and Picea smithiana (Vulnerable 2; Near Threatened 18) communities. The remaining communities showed comparatively less number for threatened species. The notable native, endemic, economically important and threatened species of the prioritized communities have been presented in *Table 6.*

Prioritization of habitats and forest communities

Amongst habitats, the forest habitat showed highest (i.e., 44) Conservation Priority Index (CPI), followed by shady moist (CPI: 38) habitat. The remaining habitats showed CPI 14, each (*Table 2*).

Among the communities, Abies pindrow - Pinus wallichiana mixed community showed highest i.e., 70 Conservation Priority Index (CPI), followed by Fraxinus xanthoxyloides (68) and Picea smithiana - Pinus wallichiana mixed and Cedrus deodara - Acer cappadocicum mixed (62, each) communities. However, lowest CPI (38, each) was recorded for Juniperus polycarpos and Cedrus deodara communities (*Table 1; Figure 2*).

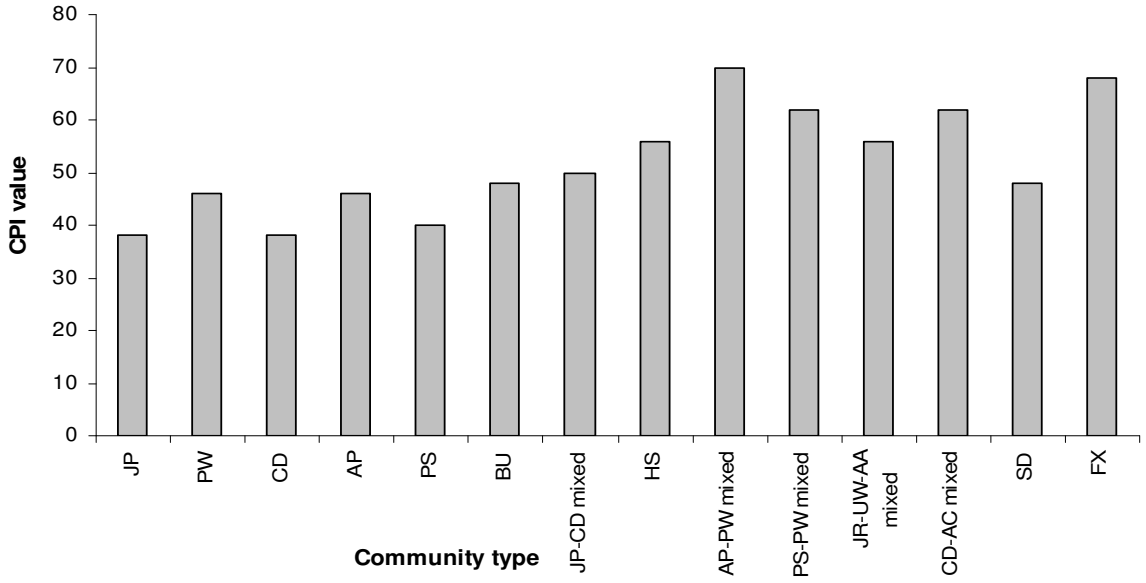

Figure 2. *Conservation Prioritization Index of forest communities in Lahaul valley of the Proposed CDBR*

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Table 6. *Some important native, endemic, near-endemic, economically important and threatened species of the prioritized communities*

Prioritized communities	Native	Endemic/near-endemic	Economically important	Threatened
Abies pindrow-Pinus wallichiana mixed	Cousinia thomsonii, Pedicularis porrecta, Plantago himalaica, Lonicera obovata, Rosa webbiana, Rubus foliolosus, Viburnum cotinifolium	Bergenia stracheyi, Galium asperuloides, Lonicera obovata, Pinus wallichiana, Abies pindrow	Viola biflora, Polygonatum multiflorum, Fragaria vesca var. nubicola, Eragrostis minor, Dactylis glomerata, Cousinia thomsonii	Polygonatum multiflorum, Plantago himalaica, Pedicularis porrecta, Bergenia stracheyi
Fraxinus xanthoxyloides	Cremanthodium arnicoides, Stachys melissaefolia, Indigofera hebepetala, Lonicera spinosa, Fraxinus xanthoxyloides	Stachys melissaefolia, Indigofera hebepetala, Lonicera spinosa, Fraxinus xanthoxyloides	Artemisia gmelinii, Carum carvi, Chenopodium hybridum, Galinsoga parviflora, Origanum vulgare, Verbascum thapsus, Sorbaria tomentosa, Rosa webbiana	Carum carvi, Indigofera hebepetala, Lonicera spinosa, Fraxinus micrantha
Picea smithiana-Pinus wallichiana mixed	Chaerophyllum reflexum, Cremanthodium arnicoides, Impatiens glandulifera, Cotoneaster obtusus, Lonicera hypoleuca, Salix denticulata	Bergenia stracheyi, Bilderdykia pterocarpa, Impatiens glandulifera, Rubia cordifolia, Indigofera hebepetala, Syringa emodi, Viburnum cotinifolium, Picea smithiana	Adiantum venustum, Artemisia dracunculus, Asparagus filicinus, Fragaria nubicola, Podophyllum hexandrum, Viola pilosa, Jasminum humile, Ribes alpestre, Corylus jacquemontii	Asparagus filicinus, Bilderdykia pterocarpa, Dioscorea deltoidea, Podophyllum hexandrum, Polygonatum multiflorum, Juniperus polycarpos, Taxus baccata subsp. wallichiana
Cedrus deodara-Acer cappadocicum mixed	Anaphalis busua, Thalictrum cultratum, Plectranthus rugosus, Rosa webbiana, Spiraea canescens	Stachys melissaefolia, Lonicera spinosa, Spiraea canescens, Cedrus deodara, Celtis australis	Artemisia maritima, Carum carvi , Dioscorea deltoidea, Elsholtzia ciliata, Geranium pratense , Sonchus oleraceus, Thymus linearis, Plectranthus rugosus, Sorbaria tomentosa	Viola sylvatica, Lonicera spinosa, Rubus ellipticus, Spiraea canescens, Acer cappadocicum, Celtis australis
Hippophae salicifolia	Aster molliusculus, Astragalus rhizanthus, Heracleum thomsonii, Impatiens tingens, Nepeta nervosa, Nepeta laevigata, Silene edgeworthii, Synotis kunthiana	Astragalus rhizanthus, Heracleum thomsonii, Phlomis bracteosa, Physochlaena praealta, Silene indica, Thalictrum minus, Hippophae salicifolia	Artemisia parviflora, Achillea millefolium, Carum carvi, Chaerophyllum reflexum, Equisetum arvens, Phlomis bracteosa, Rumex acetosa, Silene indica, Sonchus wightianus, Scorzonera virgata, Taraxacum officinale, Urtica dioica, Hippophae rhamnoides	Carum carvi, Heracleum thomsonii, Heracleum candicans, Nepeta nervosa, Physochlaena praealta, Thalictrum minus, Hippophae rhamnoides

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Discussion

Conservation prioritization of the habitats, species and communities is pre-requisite for the management planning of the biodiversity in protected and unprotected areas (Joshi and Samant, 2004). Therefore, present attempt has been made to prioritize the habitats and communities of the Lahaul valley in a proposed Cold Desert Biosphere Reserve. The habitat denotes the physical conditions that surround a species, or species population, or assemblage of species, or community (Clements and Shelford, 1939). Today, habitat destruction is a major factor in causing a species population to decrease, eventually leading to its being endangered, or even to its extinction. Due to sparse distribution of forest vegetation in Lahaul valley, the identified forest communities (14) were less than other Biosphere Reserves of the IHR (Samant et al., 2002). This may be due to the severe cold climatic conditions of the area. Mostly coniferous communities with wide range of distribution were recorded. Broad leaved communities were found in few patches and had narrow range of distribution. The loss of biodiversity is a growing concern throughout in the globe. The reasons are over exploitation and habitat destruction of the biodiversity elements. Therefore, protection of natural habitats is essential. Prioritization of habitats and communities supporting high species diversity and native, endemic, economically important and threatened species would help to some extent for the conservation of biodiversity.

Amongst the communities, Juniperus polycarpos, Pinus wallichiana, Cedrus deodara, Picea smithiana, Betula utilis and Abies pindrow showed high species richness, native, endemic, near-endemic, economically important and threatened species.

Significant positive correlations between species richness and native species ($r = 0.98$, $p < 0.01$, $n = 14$) (*Figure 3a*); species richness and endemic species ($r = 0.96$, $p < 0.01$, $n = 14$) (*Figure 3b*); and native and endemic species ($r = 0.97$, $p < 0.01$, $n = 14$) within the identified communities were found (*Figure 3c*). Like other parts of the IHR, in Lahaul valley, the percentage of native and endemic species increased with the altitude and species richness decreased. Regular monitoring of the habitats and populations of the native and endemic species facing high anthropogenic pressure is essentially required, so that adequate planning for their conservation management could be done intime.

In the IHR, most of the studies related to prioritization of species for conservation have been carried out using qualitative attributes/observations, only. Assessment of status of the species for prioritization using qualitative as well as quantitative attributes has been suggested by few workers (Joshi and Samant, 2004; Samant et al., 1996b; 1998a; 2001). Further, assessment status and values of the communities for conservation is urgently required (Joshi and Samant, 2004). In the present study, amongst habitats, forests (44), shady moist (38), respectively, and amongst communities, Abies pindrow - Pinus wallichiana mixed, Fraxinus xanthoxyloides, Picea smithiana - Pinus wallichiana mixed, Cedrus deodara - Acer cappadocicum mixed, Hippophae salicifolia, Juglans regia - Ulmus wallichiana - Acer acuminatum mixed, Juniperus polycarpos - Cedrus deodara mixed, Betula utilis and Salix daphnoides, respectively showed the high CPI, hence prioritized for conservation.

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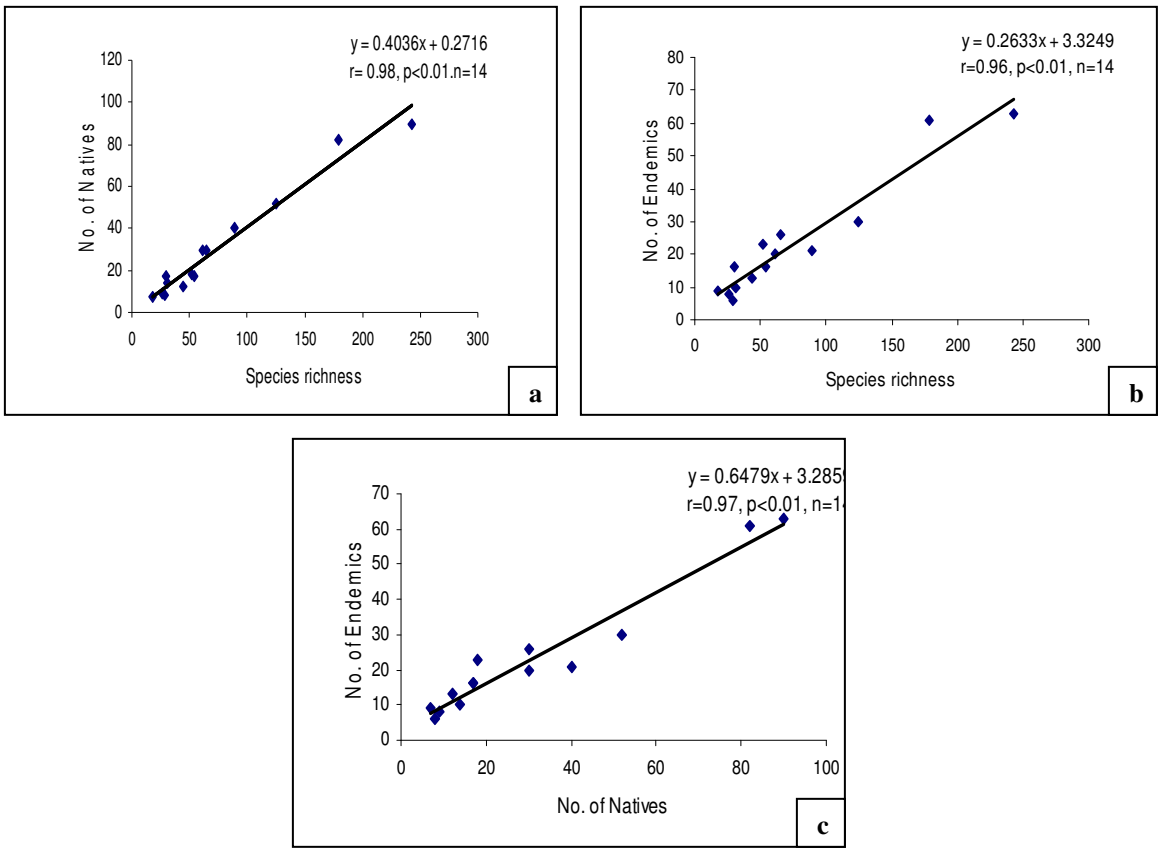

Figure 3. *Correlations between a) Species richness and Naives species; b) Species richness and Endemic species; and c) Native and Endemic species in Lahaul valley of the proposed CDBR*

These habitats and communities, requires regular monitoring, so that adequate management of these habitats and communities could be done intime. Some of the communities, such as Juniperus polycarpos, Pinus wallichiana, Cedrus deodara, Picea smithiana, Betula utilis and Abies pindrow showed wide range of distribution. However, typical topography, severe climatic conditions and high degree of anthropogenic pressure i.e., collection of fuel, fodder, timber, etc. and grazing by the sheeps of the nomadic shepherd (i.e., gaddies, gujjars and locals) have resulted in rapid loss of biodiversity elements of these communities. According to forest policy 1988 of India, the area under forest in hilly region should be 66% of its geographical area. The recorded area under actual forest cover during year 2003 was 180 km^2 in Lahaul and Spiti district out of total 13,835 km^2, which is too less (Gupta, 2007). Promotion of Afforestation programmes through plantation of native species may help in increasing the vegetation cover in the area.

Conclusion

The present study gives comprehensive information for the first time about the status of forests distributed under different habitats and communities in Lahaul valley a part of proposed CDBR. The recorded species richness under forest communities and habitats was

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relatively less to other Biosphere Reserves of the IHR, may be due to adverse climatic conditions prevailing in the area. The variation in microclimate of an area showed great variability in species richness among different communities, habitats and aspects. The communities and habitats with wide range of distribution represented high species richness, high number of native, endemic, economically important and threatened species. Most communities showed comparatively less regeneration, indicative of great threat to these forests in future. Also, applicability of sustained forest management principles right from the plantation upto harvesting is lacking. As the area under cold desert is about one fourth part of total geographical area in Himachal Pradesh, there is a need to increase area under plantation. The conservation of broad-leaved communities is important for improving soil fertility status and to maintain the ecosystem conducive for regeneration establishment. The native and introduced fast growing hardy species should be planted through social forestry and agroforestry schemes to revive the habitats. Plantation of native and endemic species like *Abies pindrow*, *Fraxinus xanthoxyloides*, *Hippophae salicifolia*, *Pinus wallichiana*, *Cedrus deodara*, *Picea smithiana*, *Populus ciliata*, *Juglans regia*, *Corylus jacquemontii*, *Acer acuminatum* etc., is important to increase the forest cover of the area. *Hippophae salicifolia,* the most demanded species in market for edible and medicinal values, showed high density with less basal area. The pure stand communities like *Hippophae salicifolia* and *Juniperus polycarpos* need much attention for protection against fire, diseases, high anthropogenic and abiotic pressures. The presence of moderately high species richness, native, endemic and threatened species enhances the conservation value of the area. The regular monitoring of communities and habitats with high CPI is essentially required for their proper management. The communities located near habitations showed high anthropogenic pressure than that of distant communities. The protective measures of key stone species against adverse climate should be encouraged for conservation. In a nutshell, it is suggested that proper strategy and policy dealing with conservation management for prioritized communities and habitats should be formulated so that effective management of forests could be achieved in posterity.

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