Prioritization of habitats and communities for conservation in the Indian Himalayan Region: a state-of-the-art approach from Manali Wildlife Sanctuary

*Man S. Rana and S. S. Samant**

The protected areas of Himachal Pradesh in the Indian Himalayan Region are facing high anthropogenic pressure due to grazing rights. Habitat degradation coupled with overexploitation of sensitive biodiversity elements has caused habitat alteration and rapid decrease in their populations. This has necessitated evaluation and prioritization of habitats and communities and suggest strategies for conservation. The present study has focused on these lines and has identified 13 habitats, 23 forest communities and 24 alpine communities. Each habitat and community has been evaluated for site representation, altitudinal distribution, species richness, native, endemic socio-economically important and threatened species. Based on cumulative values for these attributes, Conservation Priority Index (CPI) for the habitats and communities has been calculated. Amongst habitats, shady moist forest, bouldary, rocky, dry forest and alpine moist slope habitats respectively, showed high CPI, and were hence prioritized for conservation. Amongst communities, Betula utilis, Abies pindrow, Cedrus deodara and Picea smithiana in the forest zone and Rhododendron campanulatum, Rhododendron anthopogon, Cassiope fastigiata–Rhododendron anthopogon mixed, Carex nubigena–Carex setigera mixed and Rhododendron campanulatum–Rhododendron lepidotum mixed communities in the alpine zone respectively, showed high CPI and were hence prioritized for conservation. Regular monitoring of these prioritized habitats and communities is essentially required to understand the structural and functional changes in the natural vegetation and possibilities of habitat alterations due to overexploitation, habitat degradation and invasion by exotic/non-native species. This would help in the proper management of habitats and communities of the Manali Wildlife Sanctuary.

Keywords: Communities, Conservation Priority Index, habitat degradation, protected area network.

THE Indian Himalayan Region (IHR) extends from Jammu & Kashmir in the north to Arunachal Pradesh in the east and supports representative, natural, unique and socio-economically important biodiversity. A total of 18,440 species of flora[1,2] are known from the IHR. The rural communities of the IHR are mostly dependent on biological resources for their sustenance. With the increasing population of the region, demand for economically important species has been increased manifold. This has led to the overexploitation and habitat degradation of the biodiversity elements. Keeping in view the importance and value of biodiversity of the IHR, a Protected Area Network has been established in the form of Biosphere Reserves, National Parks and Wildlife Sanctuaries to conserve the ecosystems, habitats and species respectively. At present, the IHR represents 28 National Parks, 98 Wildlife Sanctuaries and 5 Biosphere Reserves[3–5]. A majority of these Protected Areas (PAs) are unexplored or under-explored. Most of the conservation approaches only identified priority areas like PAs, eco-regions, etc. and only a few efforts were made to evaluate what should be done in the PAs[6]. Therefore, more studies on the assessment and monitoring of biodiversity and other environmental issues in view of its dynamic character are required to set the conservation priorities in PAs.

Biodiversity at its three levels, i.e. genetic, species and ecosystem, is generally accepted. These levels are all

Man S. Rana and S. S. Samant are in the G.B. Pant Institute of Himalayan Environment & Development, Himachal Unit, Mohal-Kullu 175 126, India.
*For correspondence. (e-mail: samantss2@rediffmail.com)

interrelated, yet distinct enough to be studied as separate components. Ecosystem-level theory deals with species distributions and community patterns, the role and function of key species, and combines species functions and interactions. This is the least understood due to complexity of the interactions[7]. Habitat fragmentation and degradation is the most evident cause of extinction of species. Therefore, evaluation of sensitive habitats is needed to conserve the species. In general, a large number of studies have been conducted to delineate the habitats and plant communities[8–13] and biodiversity characterization through remote sensing and geographic information system[14–17]. However, in the PAs only few studies have been carried out[4,18–22]. Further, evaluation of communities for species richness, nativity, endemism, rarity and economic values and their prioritization has not been carried out so far, except for a few studies in the Nanda Devi Biosphere Reserve of the Western Himalayas[4,5,20,23]. Keeping in view the socio-economic and conservation values and other services of a plant community, the present attempt has been made to: (i) assess the habitats and vegetation; (ii) delineate the plant communities of the Manali Wildlife Sanctuary (MWLS); (iii) evaluate the species for conservation (nativity, endemism and rarity) and socio-economic values (utilization pattern); (iv) prioritize habitats and plant communities for conservation, and (v) suggest conservation measures for the prioritized habitats and communities.

Study area

The MWLS lies between 32°13′ and 32°17′N lat. and 77°03′ and 77°10′E long. It is one of the 32 notified Wildlife Sanctuaries of Himachal Pradesh (HP) and is located to the north of Kullu District, HP, northwestern Himalaya (Figure 1). It covers an area of 29.03 km^2 with an altitudinal range, 2030–5100 m amsl[24]. There is no permanent settlement inside the sanctuary. However, there are 20 temporary camping sites called 'thatches' used by the Gaddies during their voyage in summer. More than 30% of the area is inaccessible due to rocky and steep slopes in the forests as well as alpine zones. Soil is black, light brown and dark brown and silty-loam to clayey-loam in texture. The climate of the area is typically temperate, sub-alpine and alpine, and consists of mainly three distinct seasons – summer (mid April–mid June), rainy (mid June–September) and winter (November–March). However, autumn (October) and spring (mid March–mid April) seasons also prevail in the area. The vegetation mainly comprises of temperate, sub-alpine and alpine types. Temperate and sub-alpine forests are mainly dominated by broadleaved and coniferous species, and alpine meadows are dominated by alpine scrubs and herbaceous species.

Methods

Rapid surveys and samplings of the species in each habitat were carried out. The habitats were identified based on the physical characters and dominance of the vegetation. For each site/habitat, georeferences and altitude were observed with the help of Geographical Positioning System (GPS). Sites having closed canopy with high percentage of humus and moisture were considered as moist habitats, whereas low percentage of the same as dry habitats. Sites having more than 50% boulders of the ground cover were considered as bouldery habitat and sites facing high anthropogenic pressure were considered as degraded habitat. For the delineation of communities in the forest zone, a 50 × 50 m plot was selected in each site and habitat, and ten quadrats of 10 × 10 m were laid randomly within the plot. Circumference at breast height (CBH) for trees was measured and numbers of each species were noted. Plants with CBH ≥ 31.5 cm were considered as trees, and woody species having several branches arising from their base as shrubs[25]. For shrubs, 20 quadrats of 5 × 5 m, and for herbs, 20 quadrats of 1 × 1 m were randomly laid within the same plot to collect information on species richness. For sampling of alpine vegetation in each site and habitat, a 20 × 20 m plot was selected and ten quadrats of 5 × 5 m for shrubs and 20 quadrats of

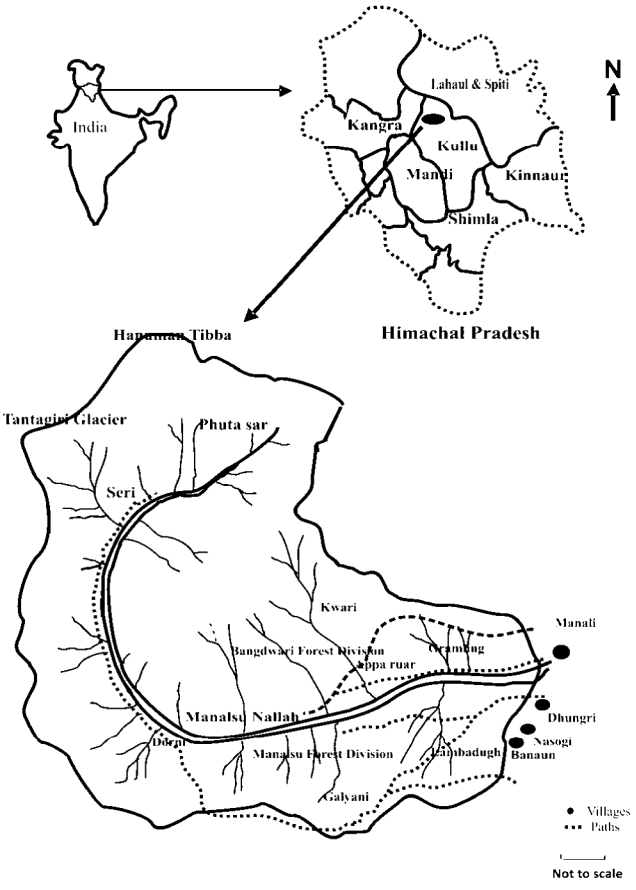

Figure 1. Location map of the Manali Wildlife Sanctuary.

1 × 1 m for herbs were randomly laid. Size of the quadrats for both forest and alpine zones was determined by species area curve method[26]. For collection of data from these quadrats, standard ecological methods were followed[8,18,21]. Data were analysed for Importance Value Index (IVI) following Curtis and McIntosh[27], Kersaw[28], and Mueller and Ellenberge[29]. Tree communities were delineated based on IVI, and shrub and herb communities based on the relative density. Specimens of the species were collected from each quadrat and identified with the help of floras[30–32]. Species richness index was calculated following Menhinick[33], i.e. Species richness (SR) = $S/\sqrt{n}$, where S is the number of species and n the number of individuals.

Species having their origin/first report from the Himalayan region have been considered as natives[2,34–36]. Endemism of the species has been identified based on their distribution[37]. The species restricted to the Himalayan region have been considered as endemic[2,36,38,39]. Information on economically important plants is based on interviews with the local experts and 'vaidhyas', and observation of fresh samples collected and used by the inhabitants of the villages. Among the village experts, one person was hired to survey and collect the useful plant species from the wild habitats. Information on the local names, altitudinal range, life forms, part(s) used, and use value was gathered. Inhabitants use plants/plant part(s) for food (edibles), medicine, fuel, fodder, timber, fibre, making agricultural tools, religious and various other purposes. Species with direct utility for the inhabitants were considered as useful. Fresh samples of the useful species were collected and identified with the help of floras[30–32,40,41]. Threatened species have been identified based on habitat specificity, population size, distribution range, use value, extraction, nativity and endemism of the taxa[18,42–44]. Pearson's correlation in Window's Microsoft Excel was used to determine the relationship between the parameters studied.

Based on distribution range, habitat/community representation, species richness, and native, endemic, threatened and economically important species, the Conservation Priority Index (CPI) has been calculated. The CPI is a cumulative value of scores for all these attributes. The habitats and communities have been prioritized based on CPI values. Attributes used for prioritization of habitats and communities are presented in Table 1. The distribution range (DR) of the habitats and communities has been calculated as follows:

DR_x = Maximum altitude of x community/habitat
– Minimum altitude of x community/habitat.

Results

Habitat and community diversity

Thirteen habitats, i.e. shady moist forest, dry forest, riverine, rocky, bouldary, degraded, camping site, alpine moist slope, alpine dry slope, glacial moraine, scrubbery, water coarse and landslide area were identified throughout the MWLS and sampled for the ecological and economical evaluation of the vegetation (Table 2).

A total of 23 forest (trees 19 and shrubs 4) and 24 alpine (scrubs 10 and herbs 14) communities were identified based on IVI (for trees) and relative density (for shrubs and herbs) from the MWLS between 2154 and 4500 m. The forest zone was represented by evergreen coniferous communities (*Abies pindrow*, *Cedrus deodara*, *Picea smithiana*, *Pinus wallichiana* and *C. deodara–A. pindrow* mixed); broad-leaved evergreen communities (*Quercus floribunda* and *Q. semecarpifolia*); evergreen coniferous and broadleaved communities (*A. pindrow–Q. semecarpifolia* mixed); broadleaved deciduous communities (*Betula utilis*, *Acer caesium*, *Aesculus indica*, *Alnus nitida*, *Ulmus villosa*, *Salix daphnoides*, *A. indica–A. caesium* mixed, *A. caesium–A. nitida* mixed, *Juglans regia–A. caesium* mixed, *Acer cappadocicum–Corylus jacquemontii* mixed and *A. caesium–J. regia* mixed). Shrub communities (*Berberis lycium*, *Indigofera heterantha*, *Rubus foliolosus* and *Indigofera heterantha–Spiraea canescens* mixed) were also recorded in the degraded habitats of the forest zone (Table 3).

Alpine zone was represented by scrub communities (*Salix lindleyana*, *Rhododendron campanulatum*, *Rhododendron anthopogon*, *Rhododendron lepidotum*, *Salix calyculata*, *Berberis jaeschkeana–Rosa sericea* mixed, *Cassiope fastigiata–R. anthopogon* mixed, *R. anthopogon–R. campanulatum* mixed and *Salix denticulata–Rosa macrophylla* mixed) and herb communities (*Carex nivalis–Agrostis munroana* mixed, *Carex nubigena–Carex setigera* mixed, *Poa alpina*, *C. nivalis–C. setigera–Anaphalis contorta* mixed, *C. nubigena–C. setigera–Phleum alpinum* mixed, *Rumex nepalensis–Bromus ramosus–Rumex acetosa* mixed, *C. setigera–A. munroana–Trachydium roylei* mixed, *C. nivalis–Bistorta affinis–Agrostis pilosula–P. alpinum* mixed, *A. pilosula–B. affinis–Leontopodium himalayanum* mixed, *C. nubigena–Gypsophylla cerastioides–Sibbaldia cuneata–Artemisia nilagirica* mixed, *Danthonia cachemyriana–Anaphalis nepalensis* mixed, *Potentilla atrosanguinea–S. cuneata–P. alpinum–Nepeta laevigata* mixed, *P. alpinum–Iris hookeriana–P. atrosanguinea* mixed and *C. nivalis–S. cuneata–T. roylei* mixed; Table 4).

Amongst identified forest communities, the total tree density ranged from 170.0 to 1190.0 Ind ha^{-1} and total basal area from 0.76 to 103.9 m^2 ha^{-1}. *A. pindrow–C. deodara* mixed community had maximum tree density (1190 Ind ha^{-1}), followed by *A. indica–A. caesium* mixed community (625 Ind ha^{-1}), *C. jacquemontii–A. cappadocicum* (570 Ind ha^{-1}) and *A. caesium* (546 Ind ha^{-1}), communities. *A. pindrow* community showed maximum total basal area (103.9 m^2 ha^{-1}), followed by *A. pindrow–Q. semecarpifolia* mixed (76.26 m^2 ha^{-1}) and *C. deodara* (73.92 m^2 ha^{-1}) communities.

Table 1. Attributes used for Conservation Priority Index of the habitats and communities

Score	DR (m)	Site	*H**	SR	N (%)	EN (%)	US (%)	Th (%)
10	<200	1	1	>1.25	>35	>35	>40	>40
8	200–400	2	2	1.00–1.25	30–35	30–35	35–40	35–40
6	401–600	3	3	0.76–1.00	25–30	25–30	30–35	30–35
4	601–800	4	4	0.50–0.75	20–25	20–25	25–30	25–30
2	>800	>4	>4	<0.50	<20	<20	<25	<25

DR, Distribution range; H, No. of habitat(s); SR, Species richness; N, Native; EN, Endemic; US, Useful species and Th, Threatened.
*Attribute not used for habitat prioritization.

Table 2. Attributes used for conservation prioritization of habitats in the Manali Wildlife Sanctuary

Habitat	S	AR (m)	SR	N	EN	Th	US	CPI
Shady moist forest	26	2110–3500	1.22	171	88	52	213	52
Dry forest	5	2200–3400	1.28	103	51	28	148	38
Riverine	6	2000–4400	1.32	60	44	13	61	24
Rocky	10	2200–4500	1.55	93	58	44	96	40
Bouldary	10	2600–4000	0.81	207	129	52	220	50
Degraded	9	2000–2800	1.02	72	26	29	134	30
Camping site	3	2500–4100	0.68	14	8	1	23	20
Alpine moist slope	11	3500–4400	0.67	140	89	25	95	32
Alpine dry slope	5	3500–4500	0.45	96	68	14	71	26
Moraine	2	3700–4500	0.68	22	16	6	14	24
Scrubbery	3	3400–3800	0.66	50	32	22	49	24
Water coarse	2	3500–4500	0.55	20	11	6	13	24
Landslide	1	3700	0.78	7	6	4	6	34

AR, Altitudinal range; S, No. of sites; SR, Species richness; N, Native; EN, Endemic; US, Useful species; Th, Threatened and CPI, Conservation Priority Index.

Amongst identified communities, the total shrub density ranged from 880.0 to 6800.0 Ind ha^{-1}. *S. denticulata–R. macrophylla* mixed community had maximum density (6800 Ind ha^{-1}), followed by *B. jaeschkeana–R. sericea* mixed (7960.0 Ind ha^{-1}), *R. campanulatum* (6336.0 Ind ha^{-1}) and *R. campanulatum–R. lepidotum* mixed (4920.0 Ind ha^{-1}) communities. Among the herb communities, density ranged from 149.0 to 327.1 Ind m^{-2}. *C. nivalis–A. munroana* mixed community had maximum density (327.1 Ind m^{-2}), followed by *C. nivalis–B. affinis–A. pilosula–P. alpinum* mixed (301.7 Ind m^{-2}), *C. nivalis–C. setigera–A. contorta* mixed (272.4 Ind m^{-2}) and *D. cachemyriana–A. nepalensis* mixed (254.0 Ind m^{-2}) communities.

Site representation

Amongst habitats, shady moist forest habitat represented maximum sites (26 sites), followed by rocky, bouldary and alpine, moist slope (ten sites each) and degraded (six sites); the remaining habitats represented less than six sites (Table 2).

Amongst communities, *C. deodara*, *B. utilis* and *P. smithiana* represented maximum sites (six sites each), followed by *A. pindrow*, *A. caesium* and *Q. semecarpifolia* communities (five sites each) and *P. wallichiana* (three sites) in the forest zone (Table 3), whereas *S. lindleyana* and *R. campanulatum* communities represented maximum sites (four sites each), followed by *R. anthopogon* and *C. nivalis–A. munroana* mixed (three sites each) communities in alpine zone. The remaining communities represented less than three sites (Table 4).

Altitudinal distribution

Among the habitats, riverine habitat showed wide distribution range (2000–4400 m), followed by rocky (2200–4500 m), bouldary (2600–4000 m) and camping site (2500–4100 m) habitats. Other habitats showed relatively narrow distribution range (Table 2).

Among the communities, distribution range was maximum (2115–2932 m) for *P. smithiana*, followed by the *C. deodara* (2260–2670 m), *B. utilis* (3259–3630 m) and *A. caesium* (2556–2895 m) in forest zone (Table 3). It was maximum (3360–4120 m) for the *S. lindleyana* community, followed by *P. alpina* (3400–4040 m), *C. nubigena–C. setigera* mixed (3645–4205 m) and *R. anthopogon* (3600–4058 m) in alpine zone (Table 4).

Species richness

Amongst habitats, species richness was highest (1.55) in rocky habitat, followed by riverine (1.32), dry forest

Table 3. Attributes used for conservation prioritization of communities in forest zone of the MWLS

Community type	S	H	AR (m)	SR	N	EN	US	Th	CPI
Abies pindrow	5	2	2575–2815	1.09	65	41	85	21	58
Acer caesium	5	2	2556–2895	1.15	59	34	69	18	48
Aesculus indica	2	1	2481–2521	1.12	40	19	49	13	44
Alnus nitida	1	1	2395	1.09	32	18	43	8	46
Betula utilis	6	2	3259–3630	1.13	72	50	80	22	62
Cedrus deodara	6	2	2260–2670	1.14	63	39	109	19	58
Picea smithiana	6	4	2115–2932	1.16	77	44	110	21	56
Pinus wallichiana	3	3	2218–2451	1.07	45	28	79	17	48
Quercus floribunda	1	1	2163	1.09	15	11	30	8	46
Quercus semecarpifolia	5	3	2787–3118	1.47	63	37	77	16	52
Salix daphnoides	1	1	2645	1.21	19	11	29	5	46
Ulmus villosa	1	1	2530	1.32	29	20	40	4	48
Abies pindrow–Quercus semecarpifolia mixed	1	1	3065	0.78	19	15	29	7	44
Abies pindrow–Cedrus deodara mixed	1	1	2595	1.04	21	11	26	8	46
Aesculus indica–Acer caesium mixed	2	2	2674–2754	0.97	37	24	49	10	42
Alnus nitida–Acer caesium mixed	1	1	2250	0.88	20	11	40	11	44
Corylus jacquemontii–Acer cappadocicum mixed	1	1	2360	1.00	30	17	52	17	46
Juglans regia–Acer caesium mixed	1	1	2574	1.14	23	16	30	6	46
Juglans regia–Ulmus villosa mixed	1	1	2698	0.82	15	12	27	3	44
Berberis lycium	1	1	2164	0.59	10	4	31	3	42
Indigofera heterantha	2	1	2758–2935	0.55	22	13	32	2	40
Rubus foliolosus	1	1	3245	0.84	26	17	26	6	44
Indigofera heterantha–Spiraea canescens mixed	1	1	2395	0.67	18	6	40	4	42

AR, Altitudinal range; H, No. of habitats; S, No. of sites; SR, Species richness; N, Native; EN, Endemic; US, Useful species; Th, Threatened, and CPI, Conservation Priority Index.

(1.28) and shady moist forest (1.22) habitats. The remaining habitats showed <1.22 species richness index (Table 2).

Among the communities, species richness was highest (1.47) in *Q. semecarpifolia*, followed by *U. villosa* (1.32), *S. daphnoides* (1.21), *P. smithiana* (1.16), *A. caesium* (1.15) and *B. utilis* (1.13) in the forest zone (Table 3). Whereas it was highest (0.84) in *R. campanulatum*, followed by *R. anthopogon* (0.83), *B. jaeschkeana–R. sericea* (0.80) and *C. fastigiata–R. anthopogon* mixed (0.69) in the alpine zone (Table 4).

Distribution of native and endemic species

Amongst habitats, bouldary habitat exhibits maximum native (207) and endemic (129) species, followed by shady moist forest (171 native and 88 endemic species) and alpine moist slope (140 native and 89 endemic species) habitats. The remaining habitats had relatively less native and endemic species (Table 2).

Among the communities, maximum native species (77) were found in *P. smithiana*, followed by *B. utilis* (72 spp.), *A. pindrow* (65 spp.), *C. deodara* and *Q. semecarpifolia* (63 spp. each) and endemics in *B. utilis* (50 spp.), followed by *P. smithiana* (44 spp.), *A. pindrow* (41 spp.), *C. deodara* (39 spp.) and *Q. semecarpifolia* (37 spp.) in the forest zone (Table 3). Whereas among alpine communities, maximum native species (67) were in *R. campanulatum*, followed by *R. anthopogon* (46 spp.), *S. lindleyana* (45 spp.), and *C. nivalis–A. munroana* mixed (39 spp.) and endemics in *R. campanulatum* and *R. anthopogon* (38 spp. each), followed by *S. lindleyana* (30 spp.) and *C. fastigiata–R. anthopogon* mixed (28 spp.; Table 4).

Distribution of economically important species

Maximum number (220) of economically important species was distributed in bouldary habitat, followed by shady moist forest (213 spp.), dry forest (148 spp.) and degraded (133 spp.) habitats. The remaining habitats showed less than 133 economically important species (Table 2).

Among the communities, maximum number (110) of economically important species was recorded in *P. smithiana*, followed by *C. deodara* (109 spp.), *A. pindrow* (85 spp.) and *B. utilis* (80 spp.) in the forest zone (Table 3). Whereas it was maximum (64 spp.) in *R. campanulatum*, followed by *R. anthopogon* (48 spp.), *S. lindleyana* (39 spp.) and *C. nivalis–A. munroana* mixed (33 spp.) in the alpine zone (Table 4).

Distribution of threatened species

Amongst the habitats, maximum rare and threatened species (51 spp. each) were distributed in bouldary and shady moist forest habitats, followed by rocky (44 spp.), dry forest and degraded (28 spp. each) habitats. Other habitats showed less than 28 species (Table 2).

Table 4. Attributes used for conservation prioritization of communities in alpine zone of the MWLS

Community type	AR (m)	H	S	SR	N	EN	US	Th	CPI
Lonicera obovata	3440	1	1	0.62	19	11	23	7	42
Rhododendron anthopogon	3600–4058	2	3	0.83	46	38	48	11	56
Rhododendron campanulatum	3340–3540	3	4	0.84	65	38	64	18	66
Rhododendron lepidotum	3620–3880	2	2	0.63	36	27	28	7	42
Salix calyculata	3360	1	1	0.57	14	10	17	1	42
Salix lindleyana	3360–4120	3	4	0.55	45	30	39	11	42
Berberis jaeschkeana–Rosa sericea mixed	3340	1	1	0.80	23	16	22	6	44
Cassiope fastigiata–Rhododendron anthopogon mixed	3837	1	1	0.69	36	28	31	7	52
Rhododendron campanulatum–Rhododendron lepidotum mixed	3770	1	1	0.64	23	18	25	8	44
Salix denticulata–Rosa macrophylla mixed	3540	1	1	0.66	22	13	22	4	42
Carex nivalis–Carex setigera–Anaphalis contorta mixed	3980	1	1	0.48	24	17	19	3	40
Carex nubigena–Carex setigera–Phleum alpinum mixed	3880	1	1	0.53	18	12	22	6	42
Rumex nepalensis–Bromus ramosus–Rumex acetosa mixed	3680	1	1	0.60	23	17	25	3	42
Carex nubigena–Carex setigera mixed	3645–4205	1	2	0.56	31	21	31	3	44
Carex setigera–Agrostis munroana–Trachydium roylei mixed	3748	1	1	0.41	17	12	17	1	40
Carex nivalis–Agrostis munroana mixed	3980–4004	1	3	0.39	39	23	33	5	40
Carex nivalis–Bistorta affinis–Agrostis pilosula–Phleum alpinum mixed	3970	1	1	0.35	20	17	19	3	40
Agrostis pilosula–Bistorta affinis–Leontopodium himalayanum mixed	3870	1	1	0.41	22	15	15	5	40
Carex nubigena–Gypsophylla cerastioides–Sibbaldia cuneata–Artemisia nilagirica mixed	3595	1	1	0.52	21	11	16	2	42
Poa alpina	3400–4040	1	2	0.55	29	22	32	3	40
Potentilla atrosanguinea–Sibbaldia cuneata–Phleum alpinum–Nepeta laevigata mixed	3960	1	1	0.58	22	13	23	4	42
Phleum alpinum–Iris hookeriana–Potentilla atrosanguinea mixed	3575	1	1	0.53	19	14	18	3	42
Carex nivalis–Sibbaldia cuneata–Trachydium roylei mixed	4305	1	1	0.34	14	9	12	3	40
Danthonia cachemyriana–Anaphalis nepalensis mixed	4207–4405	1	2	0.45	24	15	18	5	38

AR, Altitudinal range; H, No. of habitats; S, No. of sites; SR, Species richness; N, Native; EN, Endemic; US, Useful species; Th, Threatened and CPI, Conservation Priority Index.

Table 5. Some notable native, endemic, threatened and economically important species of the prioritized habitats in MWLS

Habitat	Native species	Endemic species	Threatened species	Economically important species
Shady moist forest	*Acer caesium*, *Arisaema jacquemontii*, *Indigofera heterantha*, *Corylus jacquemontii* and *Astilbe rivularis*	*Angelica glauca*, *Ilex dipyrena*, *Aesculus indica*, *Juncus himalensis*, *Nepeta eriostachya* and *Trillidium govanianum*	*Podophyllum hexandrum*, *Lilium polyphyllum*, *Taxus baccata* subsp. *wallichiana*, *Betula utilis* and *Valeriana jatamansi*	*Dactylorrhiza hatagirea*, *Dioscorea deltoidea*, *Indigofera heterantha*, *Berberis lycium* and *Strobilanthes atropurpureus*
Rocky	*Picrorhiza kurrooa*, *Sibbaldia cuneata*, *Rubus paniculatus*, *Rhamnus purpureus* and *Hypericum oblongifolium*	*Daphne papyracea*, *Juniperus indica*, *Heydychium spicatum*, *Viola canescens* and *Roscoea alpina*	*Rhodiola heterodonta*, *Polygonatum multiflorum*, *Bergenia ligulata*, *Bergenia stracheyi* and *Rheum australe*	*Allium humile*, *Lyonia ovalifolia*, *Arnebia benthamii*, *Rhododendron arboreum* and *Corylus jacquemontii*
Bouldary	*Aster falconeri*, *Gerbera gossypina*, *Inula grandiflora*, *Swertia alternifolia* and *Gentianella moorcroftiana*	*Acer acuminatum*, *Strobilanthes wallichii*, *Achyranthes bidentata*, *Cortia depressa* and *Pleurospermum brunonis*	*Thalictrum foliolosum*, *Podophyllum hexandrum*, *Polygonatum multiflorum*, *Polygonatum cirrhifolium* and *Meconopsis aculeata*	*Heracleum candicans*, *Viola biflora*, *Indigofera heterantha*, *Ribes glaciale* and *Elsholtzia fruticosa*
Dry forest	*Ainsliaea aptera*, *Artemisia roxburghiana*, *Senecio chrysanthemoides*, *Anaphalis triplinervis* and *Cardamine impatiens*	*Erigeron bellidiodes*, *Carex foliosa*, *Clematis barbellata*, *Cotoneaster obtusus*, *Rosa macrophylla* and *Spiraea canescens*	*Dioscorea deltoidea*, *Podophyllum hexandrum*, *Delphinium denudatum*, *Berberis aristata* and *Berberis lycium*	*Asparagus filicinus*, *Berberis aristata*, *Pinus wallichiana*, *Picea smithiana* and *Desmodium elegans*
Alpine moist slope	*Trachydium roylei*, *Ligularia amplexicaulis*, *Cremanthodium arnicoides*, *Hackelia uncinata*, and *Geranium wallichianum*	*Bupleurum atroviolaceum*, *Pleurospermum brunonis*, *Selinum tenuifolium*, *Saussurea piptanthera* and *Saussurea heteromalla*	*Aconitum heterophyllum*, *Arnebia benthamii*, *Malaxis mucsifera*, *Rhododendron campanulatum* and *Podophyllum hexandrum*	*Jurinella macrocephala*, *Juniperus indica*, *Aconitum heterophyllum*, *Selinum tenuifolium* and *Rhododendron campanulatum*

Table 6. Some notable native, endemic, threatened and economically important species of the prioritized communities in the forest zone of the MWLS

Community type	Native species	Endemic species	Threatened species	Economically important species
Betula utilis	*Acer acuminatum*, *Acer caesium*, *Syringa emodi*, *Lonicera hispida* and *Phlomis bracteosa*	*Corydalis govaniana*, *Rhododendron lepidotum*, *Rosa macrophylla*, *Sorbus foliolosa* and *Spiraea bella*	*Meconopsis aculeata*, *Malaxis muscifera*, *Polygonatum verticillatum*, *Angelica glauca* and *Aconitum heterophyllum*	*Rhododendron campanulatum*, *Betula utilis*, *Picrorhiza kurrooa*, *Rheum moorcroftianum* and *Juniperus indica*
Abies pindrow	*Taxus baccata* subsp. *wallichiana*, *Acer caesium*, *Cotoneaster acuminatus*, *Indigofera heterantha* and *Rosa macrophylla*	*Aesculus indica*, *Pedicularis bicornuta*, *Habenaria edgeworthii*, *Anemone tetrasepala* and *Pimpinella acuminata*	*Taxus baccata* subsp. *wallichiana*, *Polygonatum multiflorum*, *Polygonatum verticillatum* and *Valeriana jatamansi*	*Abies pindrow*, *Viburnum cotonifolium*, *Rubus biflorus*, *Cotoneaster obtusus* and *Sorbaria tomentosa*
Cedrus deodara	*Acer caesium*, *Plectranthus rugosus*, *Berberis lycium*, *Sorbaria tomentosa* and *Prinsepia utilis*	*Deutzia staminea*, *Carex foliosa*, *Viola canescens*, *Strobilanthes wallichii*, *Agrostis pilosula* and *Senecio graciliflorus*	*Symplocos chinensis*, *Valeriana jatamansi*, *Hedychium spicatum*, *Polygonatum multiflorum* and *Podophyllum hexandrum*	*Picea smithiana*, *Cedrus deodara*, *Bistorta amplexicaulis*, *Rubus ellipticus*, *Ajuga bracteosa* and *Thymus linearis*
Picea smithiana	*Cedrus deodara*, *Pinus wallichiana*, *Asparagus filicinus*, *Indigofera heterantha*, *Taraxacum officinale* and *Primula denticulata*	*Berberis lycium*, *Cotoneaster obtusus*, *Spiraea canescens*, *Carex setigera*, *Fagopyrum dibotrys* and *Rosularia rosulata*	*Taxus baccata* subsp. *wallichiana*, *Heracleum candicans*, *Valeriana jatamansi*, *Thalictrum foliolosum* and *Polygonatum verticillatum*	*Abies pindrow*, *Picea smithiana*, *Fragaria vesca*, *Diplazium esculentum*, *Viola canescens* and *Desmodium elegans*
Acer caesium	*Acer caesium*, *Ulmus villosa*, *Rubus foliolosus*, *Astilbe rivularis*, *Salix denticulata*, *Dipsacus inermis* and *Smilacina purpurea*	*Rosa macrophylla*, *Viburnum cotonifolium*, *Deutzia staminea*, *Impatiens scabrida*, *Carex foliosa* and *Trillidium govanianum*	*Malaxis muscifera*, *Valeriana jatamansi*, *Angelica glauca*, *Heracleum candicans*, *Polygonatum cirrhifolium*, *Thalictrum foliolosum* and *Rhodiola heterodonta*	*Aesculus indica*, *Sorbaria tomentosa*, *Juglans regia*, *Strobilanthes atropurpureus* and *Viola biflora*

Table 7. Some notable native, endemic and near endemic, threatened and economically important species of the prioritized communities in alpine zone of the MWLS

Community type	Native species	Endemic species	Threatened species	Economically important species
Rhododendron campanulatum	*Rhododendron anthopogon*, *Aletris pauciflora*, *Anaphalis contorta*, *Aster himalaicus*, *Carex nivalis* and *Delphinium brunonianum*	*Sorbus foliolosa*, *Lagotis cashmiriana*, *Allium humile*, *Anemone obtusiloba*, *Corydalis govaniana*, *Geum elatum* and *Bistorta amplexicaulis*	*Rhododendron anthopogon*, *Malaxis muscifera*, *Aconitum heterophyllum*, *Bergenia stracheyi*, *Dactylorhiza hatagirea* and *Rheum australe*	*Rhododendron campanulatum*, *Angelica glauca*, *Gaultheria trichophylla*, *Persicaria polystachya*, *Picrorhiza kurrooa*, *Poa alpina*, *Rumex acetosa*, *Selinum vaginatum* and *Thymus linearis*
Rhododendron anthopogon	*Rhododendron lepidotum*, *Salix calyculata*, *Poa himalayana*, *Cyananthus lobatus*, *Bupleurum atroviolaceum* and *Phlomis bracteosa*	*Potentilla atrosanguinea*, *Carex setigera*, *Corydalis govaniana*, *Delphinium vestitum*, *Heracleum wallichii*, *Impatiens sulcata* and *Megacarpaea polyandra*	*Arnebia benthamii*, *Rhueum webbianum*, *Meconopsis aculeata*, *Bergenia stracheyi*, *Picrorhiza kurrooa* and *Rhododendron anthopogon*	*Rhododendron campanulatum*, *Pleurospermum brunonis*, *Selinum tenuifolium*, *Picrorhiza kurrooa* and *Tanacetum dolichophyllum*
Cassiope fastigiata–Rhododendron anthopogon mixed	*Cassiope fastigiata*, *Aletris pauciflora*, *Lectuca lessertiana*, *Leontopodium himalaicum* and *Rhodiola himalensis*	*Anemone tetrasepala*, *Bistosta affinis*, *Pedicularis pectinata*, *Saxifraga brunonis*, *Saxifraga parnassifolia* and *Rhododendron anthopogon*	*Rhododendron anthopogon*, *Meconopsis aculeata*, *Picrorhiza kurrooa* and *Rheum moorcroftianum*	*Rhododendron campanulatum*, *Bergenia stracheyi*, *Swertia angustifolia* and *Phleum himalaicum*
Salix lindleyana	*Salix lindleyana*, *Anaphalis nepalensis*, *Carex setigera*, *Carex nivalis*, *Potentilla argyrophylla* and *Saussurea deltoidea*	*Trachydium roylei*, *Aster falconeri*, *Corydalis cashmeriana*, *Cortia depressa*, *Lagotis cashmiriana*, *Selinum candolii* and *Saxifraga brunonis*	*Aconitum violaceum*, *Rhododendron lepidotum*, *Arnebia benthamii* and *Picrorhiza kurrooa*	*Allium humile*, *Dactylorhiza hatagirea*, *Selinum tenuifolium* and *Swertia petiolata*

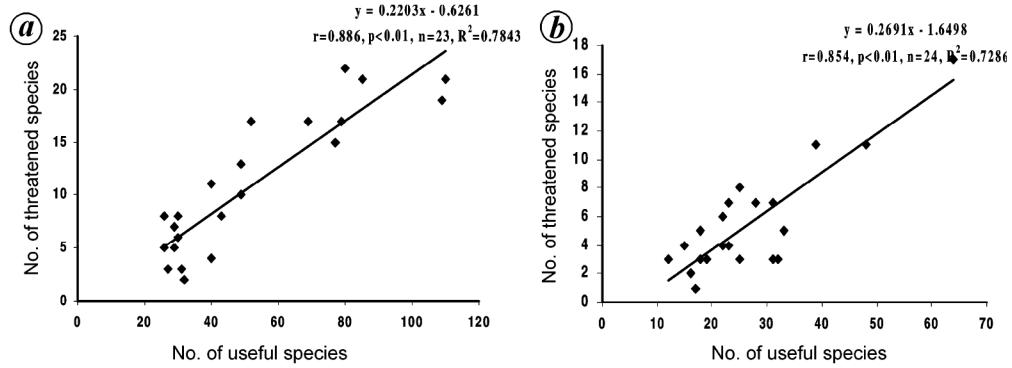

Figure 2. Correlation of useful species with threatened species in (*a*) forest zone and (*b*) alpine zone.

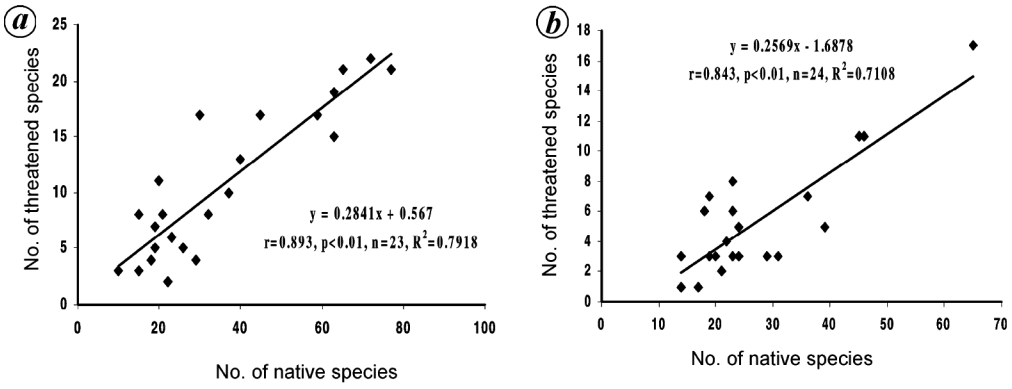

Figure 3. Correlation of native species with threatened species in (*a*) forest zone and (*b*) alpine zone.

Among the communities, maximum threatened species (22) were recorded in *B. utilis*, followed by *A. pindrow* and *P. smithiana* (21 spp. each), and *C. deodara* (19 spp.) in the forest zone (Table 3). Whereas it was maximum (17 spp.) in *R. campanulatum*, followed by *S. lindleyana* and *L. obovata* (8 spp. each), *R. campanulatum–R. lepidotum* mixed (8 spp.), *L. obovata* and *R. lepidotum* (7 spp. each) in the alpine zone (Table 4).

Conservation priority index

Amongst the habitats, shady moist forest, bouldary, dry forest, alpine moist slope and rocky habitats respectively, showed maximum CPI values. The remaining habitats showed comparatively low CPI values (Table 2). Notable native, endemic, economically important and threatened species of prioritized habitats are presented in Table 5.

Among the forest communities, *B. utilis* showed maximum CPI value, followed by *C. deodara*, *P. smithiana* and *A. pindrow* respectively. The remaining communities showed relatively low CPI values (Table 3). Notable native, endemic, economically important and threatened species of prioritized forest communities are presented in Table 6.

Among alpine communities, *R. campanulatum*, *R. anthopogon*, *C. fastigiata–R. anthopogon* mixed, *S. lindleyana*, *C. nubigena–C. setigera* mixed and *R. campanulatum–R. lepidotum* mixed respectively, showed maximum CPI values. The remaining communities showed comparatively low CPI values (Table 4). Notable native, endemic, economically important and threatened species of prioritized alpine communities are presented in Table 7.

Discussion

In view of the rapid loss of biodiversity conservation, prioritization of sensitive biodiversity elements has become essential. There are two basic complementary strategies for conservation of biodiversity, i.e. *in situ* and *ex situ*. Establishment of the Protected Area Network was the basic tenet of *in situ* conservation[45]. In order to avoid the loss of resident species, PAs need management practices for species, populations, habitats and communities in tune with the dynamics of the ecological changes[6]. In the present study, an integrated approach for the conservation prioritization of the habitats and communities has been developed. Presence of 13 habitats, 23 forest communities and 24 alpine communities indicated the unique topography and climate conditions supporting diverse habitats and communities. The MWLS is comparable in terms of forest community diversity with other PAs of the IHR[22,23] and the number of alpine communities (16) is comparable to the reported communities from Ladakh region[13].

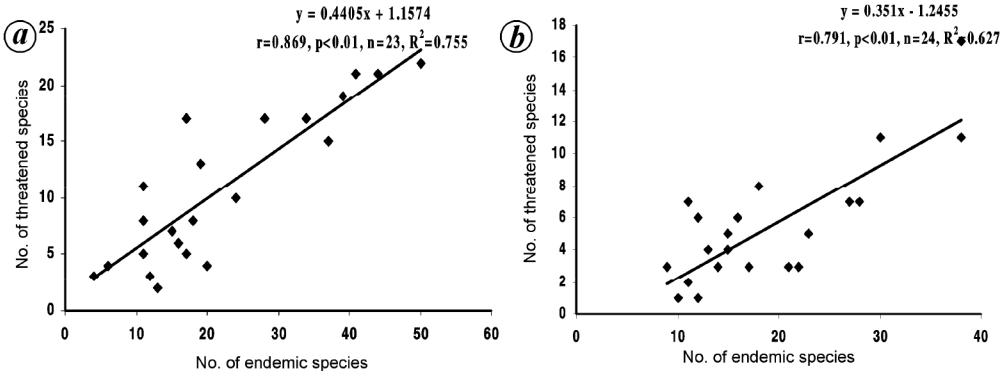

Figure 4. Correlation of endemic species and threatened species in (*a*) forest zone and (*b*) alpine zone.

Total tree density and total basal area ranged from 170.0 to 1190.0 Ind ha^{-1} and 0.76 to 103.9 m^2 ha^{-1} respectively. Communities with medium-range total basal area showed comparatively higher number of native, endemic and threatened species.

Amongst the habitats, high CPI values of shady moist forest, bouldary, dry forest, alpine moist slope and rocky habitats indicated the urgent need for conservation planning. Adequate management planning of these habitats would help in maintaining their conservation and socio-economic values.

Among the forest communities, *B. utilis*, *A. pindrow*, *P. smithiana* and *C. deodara* and among alpine communities, *R. campanulatum*, *R. anthopogon*, *C. fastigiata–R. anthopogon* mixed, *C. nubigena–C. setigera* mixed and *R. campanulatum–R. lepidotum* mixed with high CPI values indicated the need for conservation. Therefore, proper management of these communities would help in maintaining the natural ecosystems of the area. The prioritized habitats and communities possess not only high species richness, but also the highest number of native, endemic, economically important and threatened species. Therefore, any negative impact on these communities will lead to a change in their composition. This may further result into loss of native, endemic and threatened species which are of conservation importance. These important communities were named after the one or two dominant species (e.g. *B. utilis*, *A. pindrow*), which points out that if the dominant species change, the composition of the communities may also change later. This may result in loss of important species. Therefore, regeneration pattern of the dominant species needs to be studied. Regular monitoring of the prioritized habitats and communities is needed to understand the structural and functional changes in the natural vegetation and habitat alterations due to overexploitation, habitat degradation and invasion by exotic/non-native species.

A significant positive correlation was found between the number of useful species and the number of threatened species in the forest ($r = 0.886$, $P < 0.01$, $n = 23$) and alpine ($r = 0.854$, $P < 0.01$, $n = 24$) zones (Figure 2) indicating that the number of threatened species was higher in communities having anthropogenic pressure. Higher number of useful species will lead to pressure on the selective species, resulting in the threat of extinction.

Significant positive correlation of the number of threatened species with native species in the forest zone ($r = 0.893$, $P < 0.01$, $n = 23$) and in alpine zone ($r = 0.843$, $P < 0.01$, $n = 24$; Figure 3) and endemic species in forest zone ($r = 0.869$, $P < 0.01$, $n = 23$) and in the alpine zone ($r = 0.791$, $P < 0.01$, $n = 24$; Figure 4) indicated that the native and endemic species were severely affected due to anthropogenic and environmental stresses.

The high diversity of the native, endemic, economically important and threatened species in the MWLS also indicated the high conservation and socio-economic values of the sanctuary. Frequent monitoring (every year) using random sampling by quadrat method for the trees, shrubs and herbs of the georeferenced plots representing the prioritized habitats and communities is required to understand the dynamics of the habitats and communities and accordingly plan for their management.

1. Singh, D. K. and Hajra, P. K., Floristic diversity. In *Changing Perspectives of Biodiversity Status in the Himalaya* (eds Gujral, G. S. and Sharma, V.), British Council, New Delhi, 1996.
2. Samant, S. S., Dhar, U. and Palni, L. M. S., *Medicinal Plants of Indian Himalaya: Diversity Distribution Potential Values*, Gyanodaya Prakashan, Nainital, 1998.
3. Mathur, V. B., Kathayat, J. S. and Rath, D. P., *Envis Bulletin: Wildlife and Protected Areas*, Wildlife Institute of India, Dehradun, 2000, vol. 3.
4. Joshi, H. C., Assessment of habitat diversity, forest vegetation and human dependence in the buffer zone of Nanda Devi Biosphere Reserve of West Himalaya. Ph D thesis, Kumaon University, Nainital, 2002.
5. Samant, S. S., Joshi, H. C., Arya, S. C. and Pant, S., Studies on the structure, composition and changes of vegetation in Nanda Devi Biosphere Reserve of west Himalaya. Final Technical Report, Ministry of Environment and Forests, New Delhi, 2002.
6. Heywood, V. H. and Iriondo, J. M., Plant conservation: old problems, new perspectives. *Biol. Conserv.*, 2003, **113**, 321–335.
7. Naeem, S. *et al.*, Biodiversity and ecosystem functioning: maintaining natural life support processes. *Issues Ecol.*, 1999, **4**, 1–8.

8. Tewari, J. C. and Singh, S. P., Vegetational analysis of a forest lying in transitional zone between lower and upper Himalayan moist temperate forests. In *The Vegetational Wealth of Himalaya* (ed. Paliwal, G. S.), Puja Publishers, New Delhi, 1981.
9. Saxena, A. K. and Singh, J. S., A phytosociological analysis of woody species in forest communities of a part of Kumaun Himalaya. *Vegetatio*, 1982, **50**, 3–22.
10. Saxena, A. K., Singh, S. P. and Singh, J. S., Population structure of forests of Kumaun Himalaya: implication for management. *J. Environ. Manage.*, 1984, **19**, 307–324.
11. Nautiyal, B. P., Pandey, N. and Bhatt, A. D., Analysis of vegetation pattern in alpine zone in North West Himalaya: a case study of Garhwal Himalaya with special reference to diversity and distributional patterns. *Int. J. Ecol. Environ. Sci.*, 1997, **23**, 49–65.
12. Johnsing, A. J. T., Rawat, G. S., Satyakumar, P. V. and Kuar, J., Prioritization of area for biodiversity conservation of alpine zone in Trans and Greater Himalaya in India. Biodiversity Conservation Prioritization Project in India, WWF, New Delhi, 1998.
13. Rawat, G. S. and Adhikari, B. S., Floristic and distribution of plant communities across moisture and topographic gradient in Tso-Kar basin, Changthang Plateau, Eastern Ladhakh. *Arct. Antarct. Alp. Res.*, 2005, **37**, 539–544.
14. Roy, P. S., *Biodiversity Characterization at Landscape Level using Satellite Remote Sensing and Geographic Information System*, DOS-DBT Users Manual, Indian Institute of Remote Sensing (NRSA), Department of Space, Govt of India, Dehradun, 1999.
15. Roy, P. S., Talukdar, G. and Joshi, P. K., Landscape ecology approach for spatial biodiversity characterisation. *Botanica*, 2001, **51**, 1–17.
16. Chandrashekhar, M. B., Singh, S. and Roy, P. S., Geospatial modelling techniques for rapid assessment of phytodiversity at landscape level in western Himalayas, Himachal Pradesh. *Curr. Sci.*, 2003, **84**, 663–670.
17. Joshi, P. K., Rawat, G. S., Padilya, H. and Roy, P. S., Biodiversity characterization in Nubra Valley, Ladakh with special reference to plant resource conservation and bioprospecting. *Biodivers. Conserv.*, 2006, **15**, 4253–4270.
18. Dhar, U., Rawal, R. S. and Samant, S. S., Structural diversity and representativeness of forest vegetation in a protected area of Kumaun Himalaya, India: implications for conservation. *Biodivers. Conserv.*, 1997, **6**, 1045–1062.
19. Samant, S. S., Dhar, U. and Rawal, R. S., Biodiversity status of a protected area of west Himalaya. 1 – Askot Wildlife Sanctuary. *Int. J. Sust. Dev. World Ecol.*, 1998, **5**, 194–203.
20. Arya, S. C., Assessment of habitat diversity, distribution of vegetation and human dependence in alpine meadows of Nanda Devi Biosphere Reserve of West Himalaya, Ph D thesis, Kumaon University, Nainital, 2002.
21. Samant, S. S. and Joshi, H. C., Floristic diversity, community patterns and changes of vegetation in Nanda Devi National Park. In *Biodiversity Monitoring Expedition Nanda Devi 2003*, Uttarakhand Forest Department, Bishen Singh Mahendra Pal Singh, Dehradun, 2004.
22. Rawat, G. S. and Singh, S. K., Structure and composition of woody vegetation along the altitudinal and human use gradients in Great Himalayan National Park, North-western Himalaya. *Proc. Natl. Acad. Sci., India, Sect. B*, 2006, **76**, 194–202.
23. Joshi, H. C. and Samant, S. S., Assessment of forest vegetation and conservation priorities of communities in a part of Nanda Devi Biosphere Reserve, West Himalaya. Part 1. *Int. J. Sust. Dev. World Ecol.*, 2004, **11**, 326–336.
24. Gulati, A. K., Pandey, S. and Gupta, S., A guide to National Parks and Wildlife Sanctuaries of Himachal Pradesh. Wildlife Wing, Forest Department, Himachal Pradesh, 2004.
25. Saxena, A. K. and Singh, J. S., A phytosociological analysis of woody species in forest communities of a part of Kumaun Himalaya. *Vegetatio*, 1982, **50**, 3–22.
26. Arrhenius, O., Species and area. *J. Ecol.*, 1921, **9**, 95–99.
27. Curtis, J. T. and McIntosh, The interrelation of certain analytic and phytosociological characters. *Ecology*, 1950, **31**, 434–455.
28. Kersaw, K. A., *Quantitative and Dynamic Plant Ecology*, Edward Arnold Limited, London, 1973, 2nd edn.
29. Mueller, D. and Ellenberge, H., *Aims and Methods of Vegetation Ecology*, John Wiley, New York, 1974.
30. Chowdhery, H. J. and Wadhwa, B. M., *Flora of Himachal Pradesh, Vols 1–3*, Botanical Survey of India, Calcutta, 1984.
31. Dhaliwal, D. S. and Sharma, M., *Flora of Kullu District (Himachal Pradesh)*, Bishen Singh Mahendra Pal Singh, Dehra Dun, 1999.
32. Singh, S. K. and Rawat, G. S., *Flora of Great Himalayan National Park, Himachal Pradesh*, Bishen Singh Mahendra Pal Singh, Dehradun, 2000.
33. Menhinick, E. F., A comparison of some species individual diversity indices applied to samples of field insects. *Ecology*, 1964, **45**, 859–861.
34. Anon., *Index Kewensis Plantarum Phanerogamarum Vol. 1–2 (1883–1885) and 15 Suppl. (1886–1970)*, Clarendron Press, Oxford, 1883–1970.
35. Samant, S. S. and Dhar, U., Diversity, endemism and economic potential of wild edible plants of Indian Himalaya. *Int. J. Sust. Dev. World Ecol.*, 1997, **4**, 179–191.
36. Samant, S. S., Joshi, H. C. and Arya, S. C., Diversity, nativity and endemism of vascular plants in Pindari area of Nanda Devi Biosphere Reserve-II. *Himal. Bios. Reserv.*, 2000, **2**, 1–29.
37. Dhar, U. and Samant, S. S., Endemic diversity of Indian Himalaya. I. Ranunculaceae and II. Paeoniaceae. *J. Biogeogr.*, 1993, **20**, 659–668.
38. Samant, S. S., Joshi, H. C., Pant, S. and Arya, S. C., Diversity, nativity and endemism of vascular plants in Valley of Flowers National Park. *Himal. Bios. Reserv.*, 2001, **3**, 1–17.
39. Samant, S. S., Pant, S., Rana, M. S., Lal, M., Singh, A., Sharma, A. and Bhandari, S., Medicinal plants in Himachal Pradesh, North Western Himalaya. *Int. J. Biodivers. Sci. Manage.*, 2007, **3**, 234–251.
40. Khullar, S. P., *An Illustrated Fern Flora of the West Himalaya Vol. I*, International Book Distributors, Dehradun, 1994.
41. Khullar, S. P., *An Illustrated Fern Flora of the West Himalaya Vol. II*, International Book Distributors, Dehradun, 2000.
42. Samant, S. S., Dhar, U. and Rawal, R. S., Conservation of rare endangered plants: The context of Nanda Devi Biosphere Reserve. In *Conservation and Management of Biological Resources in Himalaya* (eds Ramakrishnan, P. S. *et al.*), Oxford and IBH Publishing Company Private Limited, New Delhi, 1996.
43. Ved, D. K., Kinhal, G. A., Ravikumar, K., Prabhakaran, V., Ghate, U., Vijaya Shankar, R. and Indresha, J. H., Conservation assessment and management prioritization for the medicinal plants of Jammu & Kashmir, Himachal Pradesh & Uttaranchal. Foundation for Revitalisation of Local Health Traditions, Bangalore, 2003.
44. Ved, D. K., Kinhal, G. A., Ravikumar, K., Vijaya Shankar, R. and Haridasan, K., Conservation assessment and management prioritization (CAMP) for the wild medicinal plants of North-East India. *Med. Plant Conserv.*, 2005, **11**, 40–44.
45. Singh, J. S., The biodiversity crisis: a multifaceted review. *Curr. Sci.*, 2002, **82**, 638–647.

ACKNOWLEDGEMENTS. We thank Dr L. M. S. Palni, Director and Dr U. Dhar, Ex-Director, G.B. Pant Institute of Himalayan Environment and Development, Kosi-Katarmal, Almora for providing facilities and encouragement. We also thank Dr Manohar Lal, Aman Sharma, Sakshi Bhandari and Karm Dass Thakur for help during field work and manuscript preparation.

Received 26 September 2008; revised accepted 1 June 2009