

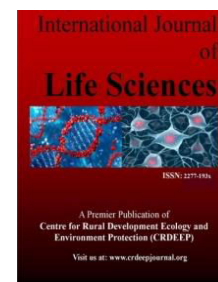
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Full Length Research Paper

## Rarity and Prioritization of Species for Conservation and Management in alpine meadows of Nanda Devi Biosphere Reserve, West Himalaya, India

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## ABSTRACT

Alpine meadows of Indian Himalayan Region are well known for its rich species diversity. These meadows are the home for many native and endemic species. Due to the anthropogenic activities and extraction, population of some of these species is decreasing. Over exploitation and habitat degradation are the two major factors responsible for decrease in the population of the species. The present study was conducted between the year 1998-2000 to find out the diversity, distribution, habitat preference and threat types of rare and endangered plant species in alpine meadows of Nanda Devi Biosphere Reserve, West Himalaya, India. A total of 102 species (8 shrubs, 94 herbs including 10 pteridophytes) belonging to 65 genera and 35 families have been identified as threatened from Pindari, Latakharak, Malari and Milam alpine meadows of NDBR. In the present study, 5 species i.e., *Athyrium duthiei* and *Cypripedium cordigerum* (Rare) and *Allium stracheyi*, *Picrorhiza kurrooa* and *Nardostachys grandiflora* (Vulnerable) have been recorded in the Red Data Book of Indian Plants (Nayar & Sastry 1987, 1988, 1990). Using new IUCN criteria, these species along with others have also been categorized as Critically Rare, Endangered, Vulnerable and Low Risk Near Threatened. Promotion of mass scale propagation through conventional and in vitro methods, rehabilitation in the in situ conditions or akin habitats have been suggested for the conservation and management of rare-endangered species. The study suggests that there is a need of population assessment, habitat monitoring using standard ecological methods and use of standard formats for the population biology study, to develop an appropriate strategy for the conservation and management of rare-endangered species and their habitats.

**Introduction**

The alpine meadows of the Indian Himalayan Region (IHR) are known for the unique species diversity. Due to heavy biotic pressures along with the physical and strategic factors, this unique plant diversity is facing severe threats. The International Union for Conservation of Nature and Natural Resources (IUCN) has estimated about 10% of the vascular plants of the globe under threat. In the IHR, over exploitation and habitat degradation are the two major factors responsible for decrease in the population of the species (Samant *et al.*, 1998a&b). Studies have been carried out to explore and identify the threatened plants of the protected areas of IHR (Pangtey & Samant, 1988; Samant *et al.*, 1993, 1996a&b, 1998a; Samant, 1994a; Pandey & Well, 1997 and Kala *et al.*, 1998). These studies also included the rare-endangered plants of alpine region. The floristic studies carried out in the Nanda Devi Biosphere Reserve have also mentioned the status of species as common, rare, occasional, not common, etc. (Naithani, 1984 & 85; Hajra & Balodi, 1995). However, using different attributes of rarity i.e., habitat preference, population size, distribution range and anthropogenic pressure, only few studies have been carried out in some selected pockets of the Biosphere Reserve (Samant *et al.*, 1996b, 2001; Rawal & Dhar, 1997; Joshi *et al.*, 1999, 2001; Samant, 1999).

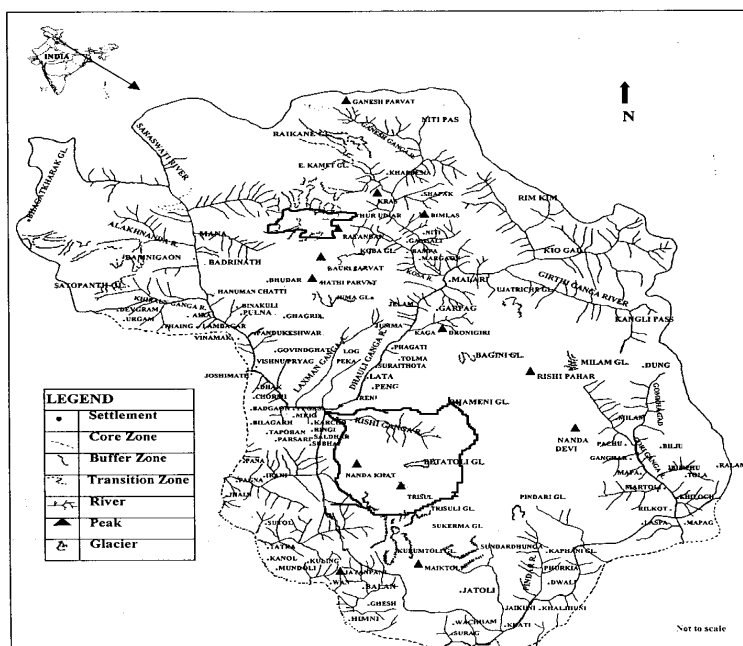
Therefore, present attempt has been made to study the rarity of species of alpine meadows and, prioritize them for conservation.

**Materials and methods***The Study Area*

Nanda Devi Biosphere Reserve (NDBR) (30°05'-31°02'N to 79°12'-80°19'E) covering a total of 6,407.03 km<sup>2</sup> (Core zone 712.12 km<sup>2</sup>; Buffer zone 5,148.57 km<sup>2</sup> and Transition zone 546.34 km<sup>2</sup>), is situated in the northern part of west Himalaya (Fig. 1) and is among the World Heritage Sites. The reserve includes parts of Bageshwar and Pithoragarh districts in Kumaun region, and Chamoli district in Garhwal region. The buffer and transition zones are inhabited by over 100 villages. Most of the inhabitants belong to two main ethnic groups namely Indo-Mongoloid (Bhotia) and Indo-Aryans. They have been using plants as medicine, edible/food, fodder, fuel, timber, agricultural tools and various other purposes (Samant, 1996b; Joshi *et al.*, 1999, 2001). Geologically, the area falls within the Greater Himalaya or Himadri System and Zaskar range. Climatically, the area is dry with low annual precipitation. The core zone of the reserve remains snow covered almost throughout the year except mid May to October. Present study has been conducted in the alpine meadows of Pindari Catchment of the NDBR. It is

located in the northern part of Bageshwar district. The area is inhabited by two buffer zone villages i.e., Khati and Leh Bagar. The major river is Pindar that originates from the Pindari Glacier.

The main tributaries of the river Pindar are Sunderdhunga, Pindar and Kaphni Pindar.



**Fig 1.** Location of Nanda Devi Biosphere Reserve. (Prepared by Lead Office, GBPIHED, Kosi-Katarmal, Almora)

### Methods

Four transects were selected along the trails for identification and selection of sites and habitats. Attempts have been made to select sites on each and every accessible aspect along transects between the range 3000-4270m. In each site, habitat type, altitude, aspect, slope, boulder percentage and dominant species were noted. Habitats were identified on the basis of physical characters (Samant et al., 1998a). The sites having >50% boulders of the ground cover have been identified as bouldery habitat. The field surveys and samplings were carried out during 1998-2000 within selected sites along transects. For the sampling of vegetation 20x20m plot was marked in each site and 20 quadrats (1x1m) in each plot were laid by stratified method. Sampling was done in the peak season i.e., August and September. For the collection of data from these quadrats standard ecological methods (Grieg-Smith, 1957; Kersaw, 1973; Muller-Dombois & Ellenberge, 1974; Dhar et al., 1997a) were followed. In each quadrat phytosociological data were collected for herbaceous species. Shrubs present in each site were noted to update the species composition. Shrubs were considered as the woody species having several branches arising from their base (Saxena & Singh, 1982) and herbs are those plants aerial parts of which survive only one season however, may survive by underground roots/rhizomes/bulbs, etc. From each site, samples of each species were collected and identified in the Institute with the help of florulas and research papers (Naithani, 1984 & 1985; Polunin & Stainton, 1984; Rawat, 1984; Samant 1993, 1999; Pangtey et al.; 1990 and Hajra & Balodi, 1995). Data analysis has been done following standard ecological methods (Grieg-Smith, 1957; Kersaw, 1973; Muller-Dombois & Ellenberge, 1974; and Dhar et al., 1997a). The abundance data of different sites were pooled to get community average in terms of density. Rarity of the species has been identified based on habitat specificity, population size, distribution range and anthropogenic pressure (Samant et al., 1996b) and also, categorization of these species as Critically Rare, Endangered, Vulnerable, etc., has been done following (Samant et al., 1998b). Based on the status and values, these species have been prioritized for conservation and management.

The species, which occurred in the area but not cited in the sampling sites have been also considered for the rarity.

### Results

#### Species diversity

A total of 102 species (8 shrubs, 94 herbs including 10 pteridophytes) belonging to 65 genera and 35 families have been identified as threatened from Pindari, Latakharak, Malari and Milam alpine meadows, of which 62 species, belonging to 45 genera and 27 families were recorded from Pindari area, 38 species belonging to 32 genera and 21 families were recorded from Latakharak area, 30 species belonging to 26 genera and 17 families were recorded from Malari area and 42 species belonging to 30 genera and 22 families were recorded from Milam area (Annexure 1)

#### Distribution pattern

##### Altitudinal distribution

In general along an altitudinal gradient, the maximum rare endangered species were distributed in between 3000-3800m, and this was followed by >3800m (Fig. 2.)

Considering the area wise altitudinal distribution of these species, the maximum rare endangered species were distributed between 3000-3800m zone in all the alpine meadows (i.e., Pindari: 57 spp.; Latakharak: 30 spp.; Malari: 30 spp.; and Milam: 30 spp.) whereas the richness of these species was comparatively low above 3800m (i.e., Pindari: 17 spp.; Latakharak: 23 spp.; Malari: 6 spp.; and Milam: 24 spp.).

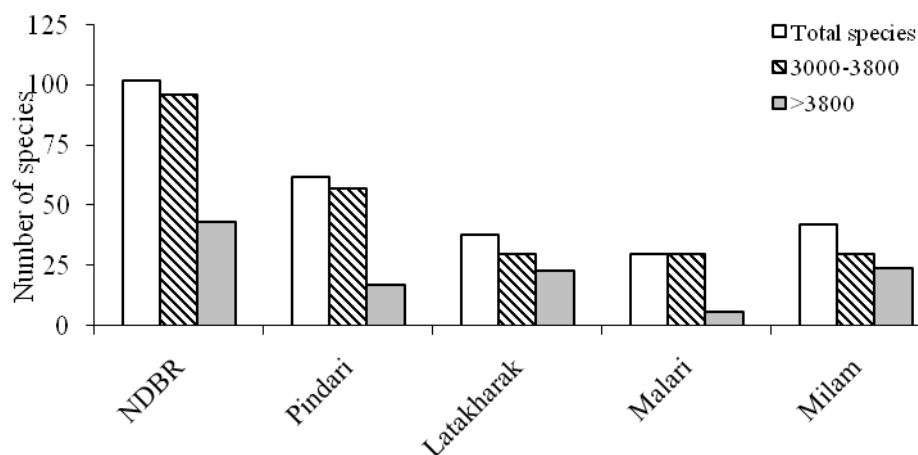
##### Site wise distribution

In general, site wise distribution of the species indicated that 25 species were represented in one site only, 20 species in two sites whereas 54 species in 3 or >3 sites. Three species have not been represented in any of the sampling sites. Among the species, *Rheum australe* (23 sites), *Artemisia maritima* and *Rhododendron anthopogon* (21 sites, each), *Gentiana kurroo* and *Nardostachys grandiflora* (20 sites, each), *Jurinella macrocephala* (15 sites), *Caragana nubigena* (14 sites),

*Polygonum polystachyum* and *Rheum webbianum* (13 sites, each), *Bergenia stracheyi* (12 sites), *Polygonum wilsonii* (11 sites), and *Dactylorhiza hatagirea*, *Morina longifolia* and *Lonicera asperifolia* (10 sites, each) represented the maximum number of sites.

In Pindari area, 23 species were distributed in one site only, 11 species in two sites whereas 26 species in 3 or >3 sites. Two

species have not been found in any of the sampling sites. Among the species *Polygonatum verticillatum*, *Ponerorchis chusua*, *Primula elliptica* and *Artemisia maritima*, (6 sites, each), *Primula reidii*, *Thylacospermum caespitosum*, *Rheum webbianum* and *Gentiana kurroo* (5 sites, each) represented the maximum number of sites.



**Fig. 2.** Altitudinal distribution of rare endangered plants in NDBR

In Latakharak area, 11 species were distributed in one site only, 7 species distributed in two sites whereas 18 species distributed in 3 or >3 sites. Two species were not found in any of the sampling sites. Among the species *Rheum australe* (18 sites), *Nardostachys grandiflora* (16 sites), *Rhododendron anthopogon* (11 sites), *Gentiana kurroo* and *Bergenia stracheyi* (10 sites, each), and *Jurinella macrocephala* (9 sites) represented the maximum number of sites.

In Malari area, 13 species were distributed in one site only, 11 species distributed in two sites whereas 6 species distributed in 3 or >3 sites. Among the species *Artemisia maritima* (7 sites), *Caragana versicolor* (4 sites), *Morina longifolia*, *Rheum webbianum*, *Polystichum wilsonii* and *Rhododendron anthopogon* (3 sites, each) represented the maximum number of sites.

In Milam area, 16 species were distributed in one site only, 10 species distributed in two sites whereas 16 species distributed in 3 or >3 sites. Among the species *Caragana nubigena* (12 sites), *Lonicera asperifolia* (9 sites), *Artemisia maritima* (8 sites), *Gentiana kurroo* (5 sites) and *Allium stracheyi*, *Saxifraga sibirica* and *Rhododendron anthopogon* (4 sites, each) represented the maximum number of sites.

#### Habitat wise distribution

Habitat wise distribution of the species in all the alpine meadows, together indicated that 39 species were distributed in 1 habitat only, 25 species were distributed in two habitats whereas 38 were species distributed in 3 or >3 habitats. Among the species *Artemisia maritima* (8 habitats), *Polystichum wilsonii* and *Rhododendron anthopogon* (7 habitats, each), *Nardostachys grandiflora*, *Rheum australe*, *Rheum webbianum* and *Saussurea obvallata* (6 habitats, each), *Bergenia stracheyi*, *Caragana nubigena*, *Dactylorhiza hatagirea*, *Gentiana kurroo*, *Jurinella macrocephala*, *Polygonatum verticillatum* and *Primula atrodentata* (5 habitats, each), represented the maximum number of habitats (Annexure 1).

In Pindari area, habitat wise distribution of the species indicated that 33 species were distributed in 1 habitat only, 14 species were distributed in two habitats whereas 15 species were distributed in 3 or >3 habitats. Among the species *Artemisia maritima*, *Gentiana kurroo*, *Pleurospermum angelicoides*, *Polygonatum verticillatum*, *Rheum australe* and *Athyrium rubricaula* (4 habitats, each), *Delphinium vestitum*, *Gymnadenia orchidis*, *Jurinella macrocephala*, *Malaxis muscifera*, *Primula elliptica*, *Rheum webbianum*, *Saxifraga sibirica*, *Thylacospermum caespitosum* and *Rhododendron anthopogon* (3 habitats, each) represented the maximum number of habitats (Annexure 1). In Latakharak area, 16 species were distributed in 1 habitat only, 9 species were distributed in two habitats whereas 13 species were distributed in 3 or >3 habitats. Among the species *Nardostachys grandiflora*, *Rheum australe* (6 habitats, each), *Gentiana kurroo*, *Saussurea obvallata*, *Rhododendron anthopogon* (5 habitats, each), *Bergenia stracheyi* (4 habitats), *Allium humile*, *Dactylorhiza hatagirea*, *Jurinella macrocephala*, *Meconopsis aculeata*, *Primula atrodentata*, *Phymatopteris stracheyi* and *Polystichum wilsonii* (3 habitats, each) represented the maximum number of habitats (Annexure 1). In Malari area, 15 species were distributed in 1 habitat only, 9 species were distributed in two habitats whereas 6 species were distributed in 3 or >3 habitats. Among the species *Artemisia maritima*, *Morina longifolia*, *Rheum webbianum*, *Polystichum wilsonii*, *Caragana versicolor* and *Rhododendron anthopogon* (3 habitats, each), *Bergenia stracheyi*, *Heracleum thomsonii*, *Hyssopus officinalis*, *Jurinella macrocephala*, *Polygonatum verticillatum*, *Primula atrodentata*, *Salvia hians*, *Saxifraga asarifolia* and *Dryopteris barbigera* (2 habitats, each) represented the maximum number of habitats (Annexure 1).

In Milam area, 23 species were distributed in 1 habitat only, 10 species were distributed in two habitats whereas 9 species were distributed in 3 or >3 habitats. Among the species *Artemisia maritima* and *Caragana nubigena* (5 habitats, each), *Allium stracheyi* and *Lonicera asperifolia* (4 habitats, each), *Astragalus rhizanthus*, *Dactylorhiza hatagirea*, *Morina longifolia*, *Potentilla*

*eriocarpa* and *Rhododendron anthopogon* (3 habitats, each) represented the maximum number of habitats (Annexure 1).

#### Community wise distribution

In general community wise distribution of rare species ranged from 1-24. In Pindari area maximum rare species were distributed in *Danthonia cachemyriana* community (24 spp.), followed by *Carex stracheyi*-*Poa pratensis*-*Carex haematostoma*-*Aconitum balfourii* mixed (14 spp.) and *Carex nubigena*-*Carex stracheyi* mixed (11 spp.), communities. The least rare species were distributed in *Circaea alpina*-*Kobresia duthiei*-*Cortia depressa*-*Poa alpina* mixed and *Rumex nepalensis*-*Polygonum polystachyum*-*Poa alpina*-*Galium elegans* mixed community (1 spp., each only). In *Cortia depressa*-*Kobresia duthiei* mixed and *Rumex nepalensis*-*Cardamine impatiens* mixed, communities rare species were absent.

In Latakharak area maximum rare species were distributed in *Carex stracheyi* community (24 spp.), followed by *Danthonia cachemyriana*-*Carex stracheyi* mixed (18 spp.) and *Danthonia cachemyriana* mixed (10 spp.), communities. The least rare species were distributed in *Fragaria nubicola*-*Galium acutum*-*Viola biflora*-*Cardamine impatiens* mixed community (1 spp. only). In *Polygonum polystachyum* community the rare species were absent.

In Malari area maximum rare species were distributed in *Danthonia cachemyriana* community (12 spp.), followed by *Carex setosa* and *Saxifraga pulvinaria* (7 spp., each), communities. The least rare species were distributed in *Rumex nepalensis*-*Agrostis munroana*-*Anemone rivularis* mixed, *Rumex nepalensis* mixed and *Saxifraga pulvinaria*-*Danthonia cachemyriana* mixed (1 spp., each), communities. In *Danthonia cachemyriana*-*Kobresia duthiei*-*Calamagrostis emodensis*-*Mentha longifolia* mixed community the rare species were absent.

In Milam area maximum rare species were distributed in *Danthonia cachemyriana* community (20 spp.), followed by *Kobresia duthiei* (11 spp.), *Carex atrata* (9 spp.) and *Danthonia cachemyriana*-*Saxifraga pulvinaria* mixed (8 spp.), communities. The least rare species were distributed in *Rumex nepalensis*-*Poa alpina*-*Calamagrostis emodensis*-*Carex stracheyi* mixed and *Thymus linearis*-*Calamagrostis emodensis*-*Anaphalis contorta*-*Melica persica* mixed (1 spp., each), communities. In *Anaphalis contorta*-*Brachypodium sylvaticum*-*Thymus linearis* mixed and *Poa alpina*-*Carex nubigena*-*Epilobium latifolium* mixed, communities the rare species were absent.

#### Status

In the present study, 5 species i.e., *Athyrium duthiei* and *Cypripedium cordigerum* (Rare) and *Allium stracheyi*, *Picrorhiza kurrooa* and *Nardostachys grandiflora* (Vulnerable) have been recorded in the Red Data Book of Indian Plants (Nayar & Sastry 1987, 1988, 1990). Using new IUCN criteria, these species along with others have also been categorized as Critically Rare (*Aconitum balfourii*, *A. heterophyllum*, *A. violaceum*, *Angelica glauca*, *Arnebia benthamii*, *Dactylorhiza hatagirea*, *Fritillaria roylei*, *Gentiana kurroo*, *Meconopsis aculeata*, *Nardostachys grandiflora* and *Podophyllum hexandrum*); Endangered (*Picrorhiza kurrooa*, *Polygonatum verticillatum*, *Saussurea obvallata* and *Swertia angustifolia*); Vulnerable (*Bergenia ligulata*, *Curculigo orchioides*, *Rheum australe* and *Rhododendron anthopogon*); and Low Risk Near Threatened (*Jurinella macrocephala*). Similarly, other species facing habitat

degradation and over exploitation may be considered under vulnerable category whereas species presently not facing such problems may be considered under Low Risk Near Threatened category (Annexure 1).

#### Discussion

Various studies have been carried out to explore and identify the threatened plants of the protected areas of Indian Himalaya (Pangtey & Samant, 1988; Samant *et al.*, 1993, 1996a& b; 1998a&b, 2000a; Samant, 1994a; Pandey & Well, 1997 and Kala *et al.*, 1998). These studies also include threatened medicinal plants. In most of the studies, identification of threatened species has been carried out using qualitative attributes/observations, only. However, assessment of the status of species using standard format including qualitative as well as quantitative attributes has been suggested by few workers (Samant *et al.*, 1996b, and Airi *et al.*, 1997).

Habitat specificity, population size, distribution range and use pattern play an important role in identification of status of the species. In the present study, two factors i.e., overexploitation and habitat degradation have been causing decrease in the population of a species. Twenty three (23) species were severely affected by both the factors. Conservation of such species merit attention. Similarly, 62 species were suffering from habitat degradation and 17 species from over exploitation. Overexploitation of underground parts i.e., roots/rhizomes/tubers/bulbs of *Aconitum balfourii*, *A. heterophyllum*, *A. violaceum*, *Angelica glauca*, *Arnebia benthamii*, *A. euchroma*, *Bergenia ligulata*, *B. stracheyi*, *Curculigo orchioides*, *Dactylorhiza hatagirea*, *Nardostachys grandiflora*, *Picrorhiza kurrooa*, *Pleurospermum angelicoides*, *Podophyllum hexandrum*, *Polygonatum verticillatum*, *Rheum australe*, *R. webbium*, etc., indicate their early extinction from their natural habitats.

Occurrence of 25 species in only one site and 20 species in two sites again indicates the early extinction of these species if the over exploitation and habitat degradation continue to operate (Annexure 1). Similarly, occurrence of 39 species only in one habitat and 25 species in two habitats indicate their habitat restriction in the area. Similar trend was also found separately in four different areas where most of the species were found in 1 or 2 sites/habitats. Such species have less chances of proliferation than the species with wide range of habitats (Samant *et al.*, 1996b).

Though, *Rheum australe* (23 sites, 6 habitats), *Artemisia maritima* (21 sites, 8 habitats), *Rhododendron anthopogon* (21 sites, 7 habitats), *Gentiana kurroo* (20 sites, 5 habitats), *Nardostachys grandiflora* (20 sites, 6 habitats), *Jurinella macrocephala* (15 sites, 5 habitats), *Caragana nubigena* (14 sites, 5 habitats), *Polygonatum verticillatum* (13 sites, 5 habitats), *Rheum webbium* (13 sites, 6 habitats), *Bergenia stracheyi* (12 sites, 5 habitats), *Polystichum wilsonii* (11 sites, 7 habitats), *Dactylorhiza hatagirea* (10 sites, 5 habitats), *Morina longifolia* (10 sites, 4 habitats), *Lonicera asperifolia* (10 sites, 4 habitats), etc., showed wide range of distribution and habitat preferences but due to over exploitation for various purposes, and also due to habitat degradation, these species are facing high degree of threats. Habitat and community wise distribution of rare species indicate that the species richness was maximum in bouldery, dry and shady moist habitats and in those communities where the tussock and cushion forming species were dominant i.e., *Danthonia cachemyriana*, *Carex stracheyi*, *Carex haematostoma*, *Carex nubigena*, *Carex obscura*, *Carex setosa*,

*Carex atrata*, *Saxifraga pulvinaria*, *Kobresia duthiei*, *Cortia depressa*, etc. These species/habitats/communities represent the maximum part of the alpine meadows, therefore, require much conservation measures. Altitudinal distribution of rare endangered species indicated that the maximum species were found between 3000-3800m zone in all four areas. This may be due to heavy biotic pressure on this zone leading to habitat degradation and ultimately to extinction of the species.

### Conclusion

Species like *Rheum australe*, *Artemisia maritima*, *Rhododendron anthopogon*, *Gentiana kurroo*, *Nardostachys grandiflora*, *Jurinella macrocephala*, *Caragana nubigena*, *Polygonatum verticillatum*, *Rheum webbianum*, *Bergenia stracheyi*, *Polystichum wilsonii*, *Dactylorhiza hatagirea*, *Morina longifolia*, *Lonicera asperifolia* etc., showed wide range of distribution and habitat preferences. Due to over exploitation, habitat degradation and for various purposes these species are facing high degree of threats. Therefore, promotion of mass scale propagation through conventional and in vitro methods, rehabilitation in the in situ conditions or akin habitats may help in conservation and management of these species. Maximum species richness was found in bouldery, dry and shady moist habitats and in those communities where the tussock and cushion forming species were dominant i.e., *Danthonia cachemyriana*, *Carex stracheyi*, *Carex haematostoma*, *Carex nubigena*, *Carex obscura*, *Carex setosa*, *Carex atrata*, *Saxifraga pulvinaria*, *Kobresia duthiei*, *Cortia depressa*, etc. These species/habitats/communities represent the maximum part of the alpine meadows, therefore, require much conservation measures. To develop an appropriate strategy for the conservation and management of all these rare-endangered species and their habitats, population assessment and habitat monitoring using standard ecological methods are urgently required. Further, population biology of all these species needs to be studied using standard format (Samant *et al.*, 1996b, 2001a&b).

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**Annexure 1.** Diversity, distribution, habitat preference and threat types of Rare and Endangered species of vascular plants in the alpine meadows of Nanda Devi Biosphere Reserve

Family/taxa	Altitudinal range (m)	LF	Location/s	SR	Habitat/s	Threat/s
1	2	3	4	5	6	7
<b>Acanthaceae</b>						
<i>Strobilanthes wallichii</i> Nees	3300	H	A	-	4	HD
<b>Alliaceae</b>						
<i>Allium humile</i> Kunth.	3300-4000	H	B	6	1, 3, 8	OE, HD
<i>A. stracheyi</i> Baker	3000-4200	H	D	4	3, 5, 6, 7	OE
<i>A. wallichii</i> Kunth.	3600-4000	H	B	1	3	OE, HD
<b>Apiaceae</b>						
<i>Angelica glauca</i> Edgew.	3200-4000	H	P	1	8	OE
<i>Heracleum thomsonii</i> Cl. ex Hk. f.	3800-3810	H	C	2	1, 3	OE
<i>Pleurospermum angelicoides</i> (DC.) Cl.	3100-3700	H	P	4	1, 3, 4, 8	OE
<i>P. densiflorum</i> (Lindl.) Cl.	3540-4015	H	A, B, C	3	1, 3	OE
<b>Asteraceae</b>						
<i>Arctium lappa</i> L.	3600	H	C	1	3	OE, HD
<i>Artemisia absinthium</i> L.	3760	H	D	1	1	HD
<i>A. gmelinii</i> Web. ex Stechm.	3770-3830	H	D	3	2, 3	HD
<i>A. maritima</i> L.	3200-4500	H	A, C, D	21	1, 2, 3, 5, 6, 7, 8, 9	HD
<i>Jurinella macrocephala</i> (Royle) Aswal et Goel	3300-4500	H	A, B, C	15	1, 3, 6, 8, 9	OE, HD
<i>Lactuca violaeifolia</i> (Decne.) Cl.	3690	H	B	1	4	HD
<i>Saussurea obvallata</i> Wall.	3500-4500	H	A, B, C, D	9	1, 3, 6, 7, 8, 9	OE
<i>S. taraxacifolia</i> Wall.	3600	H	D	1	3	OE
<b>Athyriaceae</b>						
<i>Athyrium atkinsonii</i> Bedd.	3000-3200	Pt	A	2	3, 4	HD
<i>A. duthiei</i> (Bedd.) Bedd.	3680-3685	Pt	B	2	3, 8	HD
<i>A. rubricaula</i> (Edgew.) Bir	3100-3550	Pt	A	4	1, 4, 6, 8	HD
<i>Cystopteris montana</i> (Lam.) Bernh. ex Desv.	3675-4270	Pt	A, B	3	1, 7, 9	HD
<b>Boraginaceae</b>						
<i>Arnebia benthamii</i> (Wall. ex G. Don) John.	3300-3900	H	A, B, D	8	1, 3, 8, 9	OE, HD
<i>A. euchroma</i> (Royle) John.	3600	H	C	1	3	OE, HD
<i>Onosma hispidum</i> Wall.	3200-3360	H	A	3	3, 8	OE, HD
<b>BRASSICACEAE</b>						
<i>Megacarpaea polyandra</i> Benth.	3500-4000	H	A	1	8	OE, HD
<b>Caprifoliaceae</b>						
<i>Lonicera asperifolia</i> (Decne.) Hk. f. & Th.	3340-3850	Sh	C, D	10	1, 3, 6, 9	HD
<b>Caryophyllaceae</b>						
<i>Arenaria neelgherensis</i> Wt. & Arn.	3550-3780	H	D	3	3	HD
<i>A. orbiculata</i> Royle ex Hk.	3550-3820	H	D	3	1, 3	HD
<i>Thylacospermum caespitosum</i> (Camb.) Schisch.	3300-3600	H	A	5	1, 3, 9	HD
<b>Dipsacaceae</b>						
<i>Morina longifolia</i> Wall. ex DC.	3000-4000	H	A, B, C, D	10	1, 3, 6, 9	HD
<b>Dryopteridaceae</b>						
<i>Dryopteris barbigera</i> (Hk.) Ktze. subsp. <i>komarovii</i> Fraser- Jenkins	3550-3790	Pt	A, C	3	1, 3, 7	HD
<i>Polystichum bakerianum</i> (Aitk. ex Cl.) Diels.	3200	Pt	A	1	3	HD

<i>P. wilsonii</i> Christ.	3360-4060	Pt	A, B, C, D	11	1, 2, 3, 6, 7, 8, 9	HD
<b>Elaeagnaceae</b>						
<i>Hippophae tibetana</i> Schlecht.	3880	Sh	D	1	1	HD
<b>Ephedraceae</b>						
<i>Ephedra gerardiana</i> Wall. ex Stapf.	3900	Sh	D	1	9	OE
<b>Ericaceae</b>						
<i>Rhododendron anthopogon</i> D. Don	3000-4500	Sh	A, B, C, D	21	1, 3, 4, 6, 7, 8, 9	OE
<b>Fabaceae</b>						
<i>Astragalus chlorostachys</i> Lindl.	3740	H	D	1	3	HD
<i>A. melanostachys</i> Benth. ex Bunge	3000-3100	H	A	2	4	HD
<i>A. rhizanthus</i> Royle ex Benth.	3470-4270	H	A, C, D	6	3, 7, 8, 9	HD
<i>Caragana nubigena</i> Bunge	3440-4140	H	C, D	14	1, 3, 6, 8, 9	HD
<i>C. versicolor</i> (Wall.) Benth.	3220-3340	Sh	C	4	2, 7, 9	HD
<b>Fumariaceae</b>						
<i>Corydalis flabellata</i> Edgew.	3250	H	C	1	9	HD
<i>C. meifolia</i> Wall.	3300-3630	H	A, C	5	6, 9	HD
<i>C. thyriflora</i> Prain	3300-3685	H	A, B	5	3, 6	HD
<b>Gentianaceae</b>						
<i>Gentiana kurroo</i> Royle	3340-4060	H	A, B, D	20	1, 3, 6, 8, 9	HD
<i>Swertia angustifolia</i> Buch.-Ham.	3200-3800	H	A, B	2	1, 3	OE, HD
<i>S. ciliata</i> (D. Don) Burt.	3560-3925	H	A, B	4	3, 8	OE, HD
<b>Hypoxidaceae</b>						
<i>Curculigo orchiooides</i> Gaertn.	3200-3400	H	A	2	3	OE, HD
<b>Lamiaceae</b>						
<i>Hyssopus officinalis</i> L.	3340-3440	H	C	2	3, 9	HD
<i>Salvia hians</i> Royle ex Benth.	3600-3830	H	C, D	3	1, 2, 3	HD
<b>Liliaceae</b>						
<i>Clintonia udensis</i> Traut. & Mey.	3000-3100	H	A	2	4	HD
<i>Fritillaria roylei</i> D. Don ex Hk.	3800	H	B	-	3	OE, HD
<i>Lloydia serotina</i> (L.) Reichb.	3600-4270	H	A, B	4	3, 8	HD
<i>Nomocharis nana</i> (Klotzsch) E. H. Wilson	3750-4075	H	B	5	1, 3	HD
<i>Polygonatum verticillatum</i> (L.) All.	3000-4000	H	A, B, C	13	1, 3, 4, 8, 9	OE, HD
<i>Trillidium govanianum</i> Kunth.	3000-3800	H	A	1	4	OE, HD
<b>Orchidaceae</b>						
<i>Cypripedium cordigerum</i> D. Don	3600	H	A	1	7	HD
<i>Dactylorhiza hatagirea</i> (D. Don) Soo	3000-4000	H	A, B, D	10	3, 4, 5, 7, 8	OE, HD
<i>Gymnadenia orchidis</i> L.	3360-4010	H	A, B, D	6	1, 3, 8, 9	HD
<i>Malaxis muscifera</i> (Lindl.) Ktz.	3100-3750	H	A, B, C	7	1, 3, 4, 8	OE, HD
<i>Ponerorchis chusua</i> D. Don	3310-4270	H	A, B, C	8	1, 3, 7	HD
<b>Orobanchaceae</b>						
<i>Boschniachia himalaica</i> Hk. & Th. ex Hk.f.	3640	H	C	1	3	HD
<b>Papaveraceae</b>						
<i>Dicentra roylei</i> Hk. f. & Th.	3200-3630	H	A, D	2	2, 5	HD
<i>Meconopsis aculeata</i> Royle	3500-4500	H	A, B, D	8	1, 6, 7	OE
<i>M. paniculata</i> (Don) Prain	3340-3600	H	A	4	1, 7	OE, HD
<b>Podophyllaceae</b>						
<i>Podophyllum hexandrum</i> Royle	3100-3700	H	A	2	1, 4	OE
<b>Polygonaceae</b>						
<i>Rheum australe</i> D. Don	3400-4300	H	A, B, C	23	1, 3, 6, 7, 8, 9	OE
<i>R. moorcroftianum</i> Royle	3510-4140	H	D	2	7	OE
<i>R. speciforme</i> Royle	3500-4300	H	A, D	5	7, 8	OE
<i>R. webbianum</i> Royle	3500-4300	H	A, B, C, D	13	1, 2, 6, 7, 8, 9	OE
<b>Polypodiaceae</b>						
<i>Phymatopteris stracheyi</i> (Ching) Pichi –Sermoli	3000-3750	Pt	A, B	4	1, 3, 4, 8	HD
<b>Primulaceae</b>						
<i>Primula atrodentata</i> Sm.	3440-4060	H	B, C, D	6	1, 3, 6, 8, 9	HD
<i>P. edgeworthii</i> (Hk. f.) Pax.	3300-3540	H	A	3	6	HD
<i>P. elliptica</i> Royle	3380-4270	H	A, B, C	9	1, 3, 6, 8	HD
<i>P. glomerata</i> Pax.	3200-3750	H	A, B	2	1, 3	HD
<i>P. involucrata</i> Wall. ex Duby	3400-3560	H	A	2	5, 6	HD
<i>P. reidii</i> Duthie	3550-4270	H	A	5	1, 7	HD
<i>P. rotundifolia</i> Wall. ex Roxb.	3300-4270	H	A	2	6, 8	HD

<b>Ranunculaceae</b>							
<i>Aconitum balfourii</i> Stapf.	3200-4500	H	A, B	2	4, 8	OE, HD	
<i>A. heterophyllum</i> Wall. ex Royle	3200-3700	H	A, D	3	3, 8	OE, HD	
<i>A. voilaceum</i> Jacq.	3900-4000	H	A, B	-	8	OE, HD	
<i>Anemone biflora</i> DC.	3200-3600	H	A	3	8	HD	
<i>Callianthemum pimpinelloides</i> (D. Don) Hk.f.&Th.	4060	H	D	1	8	HD	
<i>Delphinium vestitum</i> Wall. ex Royle	3200-4700	H	A	4	1, 3, 8	HD	
<i>Ranunculus natans</i> Mey.	3740	H	D	1	5	HD	
<i>R. pulchellus</i> Mey.	3630-3740	H	D	2	5	HD	
<i>R. trichophyllum</i> Chaix	3540	H	D	1	6	HD	
<i>R. tricuspis</i> (Maxim.) Hand.-Mazz.	3740	H	D	2	5	HD	
<i>Trollius acaulis</i> Lindl.	4140	H	D	1	9	HD	
<b>Rosaceae</b>							
<i>Potentilla bifurca</i> L.	3770-3780	H	D	2	3	HD	
<i>P. eriocarpa</i> Wall. ex Lehm.	3750-3770	Sh	D	3	1, 3, 8	HD	
<i>Rosa webbiana</i> Wall. ex Royle	3520-3540	Sh	D	2	6	HD	
<b>Saxifragaceae</b>							
<i>Bergenia ligulata</i> (Wall.) Engl.	3100-3500	H	A	1	4	OE, HD	
<i>B. stracheyi</i> (Hk.f. & Th.) Engl.	3500-4500	H	B, C	12	1, 3, 6, 7, 9	OE, HD	
<i>Saxifraga asarifolia</i> Sternb.	3600-3790	H	A, C	3	6, 7, 8	HD	
<i>S. flagellaris</i> Willd. ex Sternb.	3780-3940	H	D	2	3, 8	HD	
<i>S. sibirica</i> L.	3340-4270	H	A, B, D	9	1, 6, 7	HD	
<b>Scrophulariaceae</b>							
<i>Picrorhiza kurrooa</i> Royle ex Benth.	3000-4500	H	A, B, D	8	6, 7, 8, 9	OE	
<b>Solanaceae</b>							
<i>Hyoscyamus niger</i> L	3200-3700	H	C	1	2	OE, HD	
<b>Tamariaceae</b>							
<i>Myricaria elegans</i> Royle	3000-3600	Sh	A	1	6	HD	
<b>Valerianaceae</b>							
<i>Nardostachys grandiflora</i> DC.	3500-4200	H	A, B, D	20	1, 3, 6, 7, 8, 9	OE	
<b>Woodsiaceae</b>							
<i>Woodsia elongata</i> Hk.	4270	Pt	A	1	7	HD	
<i>W. lanosa</i> Hk.	3750	Pt	B	1	1	HD	

**Abbreviations used:** A= Pindari alpine meadows; B= Latakharak alpine meadows; C= Malari alpine meadows; D= Milam alpine meadows; H= Herb; Sh= Shrub; P= Pteridophyte; LF= Life form; SR= Site representation; OE= Over Exploitation; HD= Habitat Degradation; 1= Bouldery; 2= Camping site; 3= Dry; 4= Forest edge; 5= Marsh-wet land; 6= Riverine; 7= Rocky; 8= Shady moist; and 9= Shrubberries