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Diversity, representativeness and biotic pressure on plant species along alpine timberline of western Arunachal Pradesh in the Eastern Himalaya, India

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The timberline being an ecotone area is considered to be among the most prominent vegetation zones in high-mountain areas. However, the timberline in the Eastern Himalaya has not been studied adequately though it supports rich vegetation and is considered one of the most important hotspots of biodiversity. More humid conditions in the Eastern Himalayan timberline compared to Western Himalaya provide a more conducive environment for tree growth and as a result the upper limit of timberline in this sector goes up to 4570 m, which is much higher in comparison to timberline limit of 3600 m in the Western Himalayan region. We recorded a total of 122 plant species from

timberline zone belonging to 29 families with 56 species being common to areas above and below the timberline zone. It is interesting to note that 77% of the total recorded plants was found distributed within the Himalayan region, while 28% was confined to Eastern Himalayan region only. Eleven species required significant conservation measures. Collection of firewood by herders and unregulated grazing by local communities were found to be the most common threats in the study sites. Considering most of these areas are under traditional control of local communities, pro-community approach for conservation of biodiversity of these areas has also been discussed.

Keywords: Biodiversity hotspot, ecotone, endemic, grazing.

THE timberline which represents transition from forest to treeless alpine areas is a distinct boundary within the altitudinal zonation of vegetation, which also forms one of the most fundamental ecological boundary¹. The extent of timberline varies from region to region as it is an oscillating zone and not a sharp line. Such areas are considered the cradle of temperate and alpine floral elements that are highly diverse in vegetation composition. These areas are considered sensitive to biotic pressure that can bring substantial changes in alpine and temperate vegetation². In India, the extent of timberline in the Eastern Himalaya encompasses a large area in West Kameng and Tawang districts in Arunachal Pradesh and is mostly distributed along the area between 3900 and 4200 m altitude³. The alpine and temperate regions in the Eastern Himalaya are considered among the richest vegetation zones in the world⁴. More humid conditions in the Eastern Himalaya compared to the Western Himalaya provide a more conducive environment for tree growth and as a result the upper limit of tree vegetation in this sector goes up to 4570 m compared to 3600 m in the Western Himalaya⁵. The region contains a globally significant array of unique flora and fauna with high proportion of endemism^{6–10}. The state of Arunachal Pradesh, due to varied climatic conditions and altitude, is also known for its rich vegetation with unique ecosystem ranging from tropical belt to the snow-clad alpine mountains⁹. Although there have been several studies of general vegetation types of Arunachal Pradesh^{5,11–13}, documentation of plant diversity from the timberline area is still lacking from the region. The timberline is among the most sensitive ecotone¹⁴; unfortunately it is under tremendous biotic pressure for diverse needs². There is a need to analyse some basic information related to distribution and diversity of plants, their representativeness, and broad significance of species so that suitable conservation measures could be taken for protecting the timberline area. In this communication, an attempt has been made to document the plants collected from the area in and around the timberline zone of West Kameng and Tawang districts.

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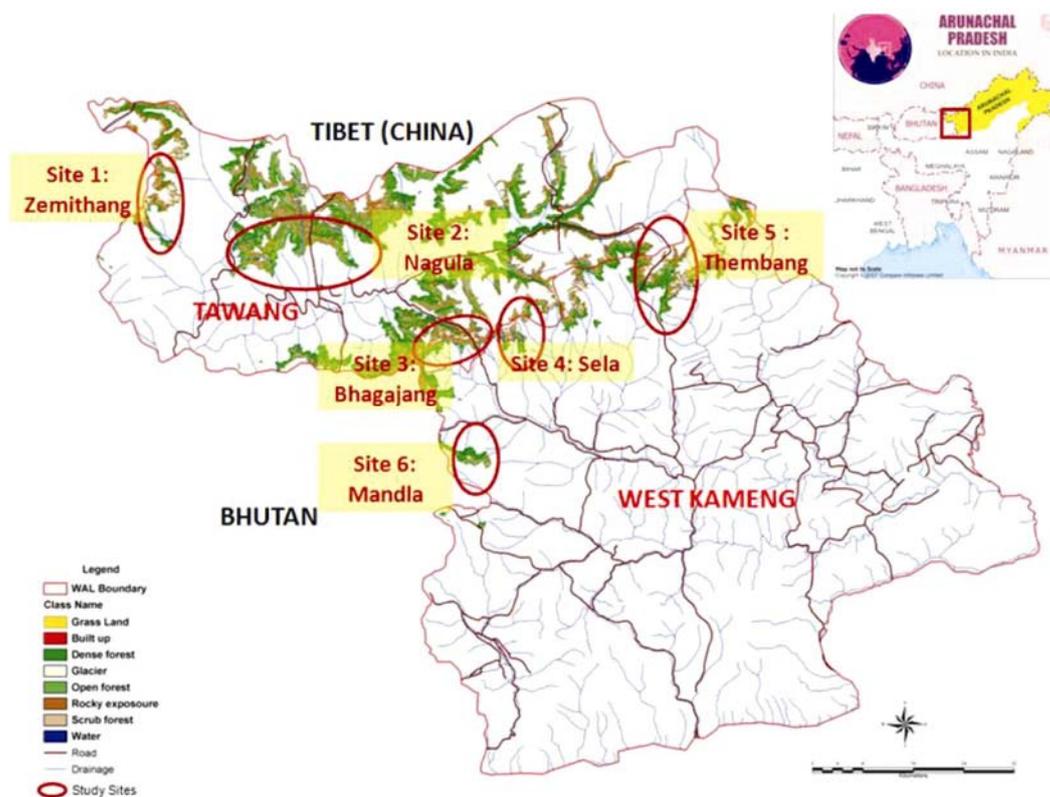


Figure 1. Map of the timberline zone of Tawang and West Kameng districts of Arunachal Pradesh and the six survey sites.

The study region (West Kameng and Tawang districts) covers an area of 9594 km². The area is bounded by China in the north, Bhutan in the west and East Kameng district in the east and Assam in the south (Figure 1). It harbours an extremely rich floral and faunal diversity comprising many endangered animals and plants^{15–18}. The area falls within the Eastern Himalaya part of Himalaya biodiversity hotspot, which also includes parts of Nepal, Bhutan, the Indian states of West Bengal, Sikkim, Assam, southeast Tibet (China) and northern Myanmar. The area is well recognized in various national and international conservation priority-setting exercises. It lies within the global biodiversity hotspot of the Himalaya and in the ‘Ecosystem profile of Eastern Himalaya’ prepared for Critical Ecosystem Partnership Funding. It is a part of Tawang–Bumdeling Landscape with five sites identified as high priority for conservation. It is a part of WWF’s Eastern Himalaya broadleaved and conifer ecoregion and is one of the six priority landscapes identified by WWF in Eastern Himalaya covering India, Bhutan and Nepal⁴. Five sites from the landscape have also been identified under the Important Bird Area programme¹⁹. In the Arunachal Pradesh State Biodiversity Strategy and Action Plan prepared to develop National Biodiversity Strategy and Action Plan according to the commitment of India to Convention on Biodiversity (CBD), three sites from this landscape have been prioritized for conservation initia-

tive²⁰. However, the area is also under severe pressure due to various anthropogenic activities such as collection of medicinal plants, timber, grazing and forest fire²¹.

The study was carried out during 2008–2011 by identifying six different sites along the timberline in Tawang and West Kameng districts (Figure 1). Plant specimens and photographs were collected in a random manner during the reconnaissance surveys. Most of the collections were made during March–June and August–November months of the year as during peak winter (December–February) and monsoon (end of June and July), the area is inaccessible for field study. High-resolution photographs of the plants found at flowering stage were taken for identification and pictorial documentation. Voucher specimens of plants which could not be identified in the sites, were collected and kept in a herbarium according to the standard field and herbaria practices. The specimens were later identified with the help of experts of State Forest Research Institute, Itanagar; Wildlife Institute of India, Dehradun, and Botanical Survey of India, Itanagar. Available books^{22–24} and websites of Global Biodiversity Information Facility, eFloras, Kew Royal Botanic Garden, ICIMOD and NBC were also consulted for information regarding distribution. The distribution of each recorded species from area below and above timberline zone has been assessed according to their availability below 3900 and above 4200 m altitude through field survey.

Table 1. Occurrence of flowering plants along the timberline (TL) zone and their distribution along Himalaya biodiversity hotspots

Confined to Eastern Himalaya part of Himalaya biodiversity hotspot	Distributed across Himalaya biodiversity hotspot	Distributed beyond Himalaya biodiversity hotspot
Plants distributed along and above TL zone		
<i>Aconitum ferox</i> Wallich ex Seringe	<i>Bergenia stracheyi</i> (Hook. f. & Thoms) Engl.	<i>Bergenia purpurascens</i> (Hook. F. & Thoms) Engl.
<i>Pedicularis alaschanica</i> Maxim.	<i>Bistorta vivipara</i> (L.) Gray	<i>Tillaea pharnaceoides</i> Hochst.ex Britt.
<i>Primula poluninii</i> Fletcher	<i>Delphinium brunonianum</i> Royle	<i>Nomocharis nana</i> (Klotzsch) E. H. Wilson
<i>Rhododendron lepidotum</i> var.	<i>Epilobium royleanum</i> Hausskn	
<i>Rhododendron lepidotum</i> var. <i>lepidotum</i> Wall. ex G. Don	<i>Fritillaria cirrhosa</i> D. Don	
<i>Rhododendron thomsonii</i> var.	<i>Juniperous indica</i> Bertol.	
<i>Saussurea globossa</i> Chen	<i>Primula reptans</i> Hook. f. ex Watt	
<i>Sorooseris pumila</i> Stebbins	<i>Saussurea gossypiphora</i> D. Don	
	<i>Saussurea obvallata</i> (DC) Edgew.	
	<i>Saxifraga jacquemontiana</i> Decne.	
	<i>Sibbaldia cuneata</i> Hornem. ex Kuntze	
Plants distributed along and below TL zone		
<i>Berberis concinna</i> Hook. f.	<i>Abies densa</i> Griffith ex R. Parker	<i>Diphylax urceolata</i> (C.B. Clarke) Hook.f.
<i>Berberis erythroclada</i> Ahrendt	<i>Aconitum hookeri</i> Stapf	<i>Fragaria daltoniana</i> Gay
<i>Berberis koehneana</i> C.K. Schneider	<i>Anaphalis nubigena</i> DC	<i>Fragaria nubicola</i> (Hook. f.) Lindl. ex Lacaita
<i>Berberis mucrifolia</i> Ahrendt	<i>Berberis angulosa</i> Wallich ex Hook f. & Thoms	<i>Halenia elliptica</i> D. Don
<i>Nardostachys grandiflora</i> DC.	<i>Cassiope fastigiata</i> (Wallich) D. Don	<i>Ophiopogon intermedius</i> D. Don
<i>Pedicularis flexuosa</i> Hook. f.	<i>Cirsium griffithii</i> Boiss.	<i>Sorbus microphylla</i> Wenzig
<i>Rhododendron camelliflorum</i> Hook. f.	<i>Koenigia delicatula</i> L.	<i>Stertopus simplex</i> D. Don
<i>Rhododendron campylocarpum</i> Hook. f.	<i>Mecconopsis paniculata</i> Prain	
<i>Rhododendron candelabrum</i> Hook. f.	<i>Megacodon stylophorus</i> (C.B. Clarke) Harry Smith	
<i>Rhododendron cinnabarium</i> Hook. f.	<i>Persicaria polystachya</i> (Wall. ex Meisn.) H. Gross	
<i>Rhododendron hodgsonii</i> Hook. f.	<i>Polygonatum multiflorum</i> (L.) All	
<i>Rhododendron neivum</i> Hook. f.	<i>Polygonatum verticellatum</i> (L.) All.	
<i>Rhododendron sikkimense</i> U.C. Pradhan & S.T. Lachungpa	<i>Potentilla fruticosa</i> L.	
<i>Rhododendron thomsonii</i> var.	<i>Primula edgeworthii</i> (Hook. f.) Pax	
<i>Senecio laetus</i> Edgew	<i>Prunella vulgaris</i> L.	
	<i>Rhodiola quadrifida</i> (Pall.) Fisch. & C. A. Mey.	
	<i>Selinum vaginatum</i> (Edgew.) C.B. Clarke	
	<i>Senecio chrysanthemoides</i> (Decne.) Benth.ex Hook.f.	
	<i>Senecio rufinervis</i> DC	
	<i>Smilacina purpurea</i> Wallich	
	<i>Viburnum nervosum</i> D. Don	
	<i>Viola biflora</i> L.	
Plants distributed along, below and above TL zone		
<i>Cremanthodium oblongatum</i> C.B. Clarke	<i>Anaphalis nepalensis</i> Spreng.	<i>Allium wallichii</i> Kunth
<i>Cremanthodium purpureifolium</i> Kitman	<i>Bistorta macrophylla</i> (D. Don) Sojak	<i>Bistorta affinis</i> (D. Don) Greene
<i>Cremanthodium reniforme</i> (DC.) Benth	<i>Cortia depressa</i> (D. Don) Norman	<i>Corydalis juncea</i> Wallich
<i>Cyananthus incanus</i> Hook.f. & Thomas	<i>Corydalis cashmeriana</i> Royle	<i>Cyananthus inflatus</i> Hook. f. et Thomas.
<i>Lignariella hobsonii</i> (Pearson) Baehni	<i>Epilobium latifolium</i> L.	<i>Cyananthus lobatus</i> Wallich ex Benth.
<i>Pycnophilnthisopsis bhutanica</i> Jafri	<i>Erigeron multiradiatus</i> (Lindl. ex DC.) Benth. ex C.B. Clarke	<i>Gaultheria trichophylla</i> Royle
<i>Rhododendron campanulatum</i> × <i>barbaratum</i>	<i>Gentiana carinata</i> Griseb	<i>Gentiana elwesii</i> C.B. Clarke
<i>Rhododendron bhutanense</i> S.D. Long	<i>Leontopodium stracheyi</i> (Hook.f.) C.B. Clarke ex Hemsley	<i>Gentiana phyllocalyx</i> C.B. Clarke
<i>Rhododendron wightii</i> Hook. f.	<i>Mecconopsis bella</i> Prain	<i>Morina nepalensis</i> D. Don
<i>Saussurea nepalensis</i> Sprengel	<i>Picrorhiza kurroa</i> Royle ex Benth	<i>Pedicularis siphonantha</i> D. Don
<i>Saussurea yakla</i> C.B. Clarke	<i>Pleurospermum candollei</i> (DC.) C.B. Clarke	<i>Potentilla coriandrifolia</i> D. Don
	<i>Potentilla microphylla</i> D. Don	<i>Potentilla plurijuga</i> Hand. – Mazz
	<i>Potentilla peduncularis</i> D. Don	<i>Primula glomerata</i> Pax
	<i>Potentilla polyphylla</i> Wall. Ex Lehm	<i>Primula sikkimensis</i> Hook.f.
	<i>Primula capitata</i> Hook.f.	<i>Rheum nobile</i> Hook.f. & Thoms

(Contd...)

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Table 1. (Contd...)

Confined to Eastern Himalaya part of Himalaya biodiversity hotspot	Distributed across Himalaya biodiversity hotspot	Distributed beyond Himalaya biodiversity hotspot
	<i>Primula denticulata</i> Smith	<i>Rhododendron lepidotum</i> Wallich ex G. Don
	<i>Primula megalocarpa</i> Bara.	<i>Rhododendron thomsonii</i> Hook . f.
	<i>Primula obliqua</i> W. W. Smith	<i>Silene nigrescens</i> (Edgew.) Majumder
	<i>Primula primulina</i> (Sprengel) Hara	
	<i>Rheum acuminatum</i> Hook.f. & Thoms. ex Hook	
	<i>Rhododendron anthopogon</i> D. Don	
	<i>Rhododendron campanulatum</i> D. Don	
	<i>Rhododendron setosum</i> D. Don	
	<i>Swertia speciosa</i> D. Don	
	<i>Swertia hookeri</i> C.B. Clarke	
	<i>Swertia multicaulis</i> D. Don	
	<i>Swertia petiolata</i> D. Don	



Figure 2. Few flowering plants recorded from timberline zone of high conservation significance.

Information regarding conservation status of the species has been prepared according to IUCN Red List, CITES list and *Indian Red Data Book*. Different types of threats and pressure on the plant species found in the fragile timberline area have been analysed based on field observations and interaction with the local villagers.

The alpine timberline ecotone of the present study site is mostly confined within the altitude range 3900–4200 m amsl, which is higher compared to the Western Himalayan region due to high humidity. The timberline area of the present study site in the eastern part of the Himalaya biodiversity hotspot supports highly fragile ecosystems with rich biodiversity unique to the region. The indigenous communities of the present study sites have been traditionally managing the resources available in and around the timberline zone as their traditional livestock-based economy is directly dependent on the health

of the alpine pasture of the area. However, presently due to high commercial demand for medicinal plants found in these areas and various developmental works in progress, pressure on the timberline zone has started increasing gradually.

A total of 122 plant species were recorded from the timberline zone in this study of which 22 have been recorded above the timberline zone, 44 below the timberline zone and 56 both below and above the timberline zone (Table 1). *Rhododendron* has been found to be most dominant genus in the timberline zone. Of the 4 species recorded, 4 varieties and 1 hybrid for *Rhododendron*, 8 of them have been also recorded from area below the timberline, 3 above the timberline and 8 common to both below and above the timberline zone. With 10 species, *Primula* was the second most dominant genus in timberline zone and 7 species have been found to be common to

Table 2. Distribution of plants under different families in the study sites

Family	Above and within TL		Below and with TL		Above, below and within TL		Total	
	Genus	Species/varieties/ hybrid	Genus	Species/varieties/ hybrid	Genus	Species/varieties/ hybrid	Genus	Species/varieties/ hybrid
Amaryllidaceae	0	0	0	0	1	1	1	1
Apiaceae	0	0	1	1	2	2	3	3
Asteraceae	2	4	3	5	5	8	8	17
Berberidaceae	0	0	1	5	0	0	1	5
Brassicaceae	0	0	0	0	1	1	1	1
Campanulaceae	0	0	0	0	1	3	1	3
Caprifoliaceae	0	0	1	1	0	0	1	1
Capparidaceae	0	0	0	0	1	1	1	1
Caryophyllaceae	0	0	0	0	1	1	1	1
Crassulaceae	1	1	1	1	0	0	2	2
Cupressaceae	1	1	0	0	0	0	1	1
Dipsacaceae	0	0	0	0	1	1	1	1
Ericaceae	1	3	2	9	2	9	3	21
Fumariaceae	0	0	0	0	1	2	1	2
Gentianaceae	0	0	2	2	2	7	4	9
Lamiaceae	0	0	1	1	0	0	1	1
Liliaceae	2	2	3	3	0	0	5	5
Onagraceae	1	1	0	0	1	1	1	2
Orchidaceae	0	0	1	1	0	0	1	1
Papaveraceae	0	0	1	1	1	1	2	2
Pinaceae	0	0	1	1	0	0	1	1
Polygonaceae	1	1	3	4	2	4	5	9
Primulaceae	1	2	1	1	1	7	1	10
Ranunculaceae	2	2	1	1	0	0	2	3
Rosaceae	1	1	3	4	1	5	4	10
Saxifragaceae	2	3	0	0	0	0	2	3
Scrophulariaceae	1	1	1	1	2	2	2	4
Valerinaceae	0	0	1	1	0	0	1	1
Violaceae	0	0	1	1	0	0	1	1
Total	16	22	29	44	26	56	59	122

area below and above the timberline zone. Besides, 5 *Berberis* species were also recorded and all are distributed in the area below the timberline also. The genera recorded above the timberline zone but absent below it are *Gentiana* and *Cyananthus* (Table 1).

On analysis of distribution of the plants recorded from the timberline zone along the Himalaya biodiversity hotspot, it has been found that 94 occurred in the hotspot, of which 34 are confined to Eastern Himalaya region only. Only 28 of the recorded plant species are also found in areas beyond Himalaya biodiversity hotspot (Table 1). Out of 22 plants recorded along and above the timberline zone, 86% is confined to the Himalaya biodiversity hotspot, of which 36% is confined to Eastern Himalaya region. Of the 56 plants found growing both below and above timberline zone, 32% is found to be distributed in areas beyond the Himalaya biodiversity hotspot (Table 1).

Out of the total 18 *Rhododendron* plants recorded, 17 are available only in the Himalaya biodiversity hotspot, of which 14 are confined to Eastern Himalaya region. All the 5 *Berberis* species recorded are found only in the Himalaya biodiversity hotspot and 4 of them are confined

to Eastern Himalaya region. Similarly, out of 10 *Primula* species recorded, 2 are available in areas beyond the Himalaya biodiversity hotspot and only 1 is confined to the Eastern Himalaya region (Table 1).

From the timberline zone of the study sites, 122 plants belonging to 29 families have been recorded. Of the total 59 genera recorded, 29 have been found growing in the area below the timberline zone and 56 were found both below and above the timberline zone. Ericaceae with 21 plants belonging to 3 genera, 16 species, 4 varieties and 1 hybrid, was found to be the most dominant family among all, followed by Asteraceae with a total 17 species belonging to 8 genera and Primulaceae with 1 genus and 10 species. Only six families, Asteraceae, Ericaceae, Polygonaceae, Primulaceae, Rosaceae and Scrophulariaceae have been found to be common in all the three zones, while plants belonging to the family Cupressaceae have been recorded only from the areas above and within timberline zone (Table 2).

Among the identified plants, 11 plants have been found to be of high conservation significance. *Saussurea obvallata* and *Rheum nobile* in which flowers are enclosed by enlarged, transparent, leafy bracts are considered as

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Table 3. Plants of high conservation significance recorded along timberline area of western Arunachal Pradesh

Plant	Family	Conservation significance
<i>Aconitum ferox</i> Wallich ex Seringe	Ranunculaceae	Vulnerable (Nayar and Sastry ²⁵)
<i>Nardostachys grandiflora</i> DC	Valerianaceae	CITES App – II, Vulnerable (Nayar and Sastry ²⁵)
<i>Picrorhiza kurrooa</i> Royle ex Benth	Scrophulariaceae	Vulnerable (Nayar and Sastry ²⁵)
<i>Primula poluninii</i> Fletcher	Primulaceae	Reported endemic to Nepal
<i>Rheum nobile</i> Hook. f. & Thoms.	Polygonaceae	Biologically curious plant (Hegde ²⁰)
<i>Rhododendron campylocarpum</i> Hook. f.	Ericaceae	Rare (Mao <i>et al.</i> ³²)
<i>Rhododendron neivium</i> Hook. f.	Ericaceae	Endemic to Bhutan and Sikkim (Pradhan and Lachungpa ²⁴)
<i>Rhododendron sikkimense</i> U.C. Pradhan & S.T. Lachungpa	Ericaceae	Endemic to Sikkim (Pradhan and Lachungpa ²⁴)
<i>Saussurea globossa</i> Chen	Asteraceae	Reported only from China
<i>Saussurea obvallata</i> (DC) Edgew.	Asteraceae	Biologically curious plant (Hegde ²⁰)
<i>Saussurea yakla</i> C.B. Clarke	Asteraceae	Reported endemic to Sikkim

biologically curious plants²⁰. *Rhododendron neivium*, which was earlier considered to be endemic to Bhutan and Sikkim and *R. sikkimense* as endemic to Sikkim²⁴, have also been recorded from the timberline zone of western Arunachal Pradesh. According to the *Red Data Book of Indian Aconitum ferox*, *Nardostachys grandiflora* and *Picrorhiza kurrooa* are vulnerable²⁵. Besides, *N. grandiflora* has been also listed in CITES Appendix II. Besides, according to the available secondary information, occurrence of *Saussurea yakla*, which was considered to be endemic to Sikkim, is the first report from the state, while *Saussurea globossa* has been reported earlier only from China, and *Primula poluninii* reported as endemic to Nepal is a first report from India (Table 3).

The Monpa community of West Kameng and Tawang districts, living in high-altitude areas has been utilizing the natural pastures for grazing yak and sheep for more than 1000 years. Brokpa, the pastoral community of Monpa tribes seasonally moves with yak and sheep from lower elevation to higher elevation in summer and again back to lower elevation in winter. Brokpas normally spend 6–7 months (April–October) in the summer grazing grounds, the alpine pasture available within altitude range 4000 to 4400 m approximately along the timberline with their livestock, mainly yak, sheep and ponies. The area in and around the timberline zone supports many rare and threatened medicinal plants which are of high commercial demand. Thus higher economic benefit herders have been found getting involved in collecting rare medicinal plants like *Aconitum*, *Picrorhiza* and *Cordyceps*. There is a traditional taxation system, which has been a useful tool for monitoring the number of livestock going for summer grazing every year and also the area being used for grazing to ensure sustainable grazing. However, as this traditional management system was framed long back when issues related to collection of medicinal plants for commercial purpose were absent, the herders nowadays are taking advantage of the gap for additional economic benefit. Apart from this, there is pressure on shrubs and tree species to meet firewood demands of the herders, various developmental works which are in progress,

mainly construction of road and establishment of army camps in the area. Also, increase in the number of pilgrims visiting the lakes in the adjoining areas of the timberline which are considered as sacred by local Buddhist communities is putting high pressure on the rich floristic diversity of the area (Table 4).

An analysis of the different types of pressure and threat on flowering plants recorded from the timberline zone of the six study sites, shows that collection of firewood by herders and unregulated grazing are common to all the sites. In Bhagajang where the number of pilgrims visiting sacred lakes every year has increased after the construction of road, collection pressure on available *Rhododendron* species for firewood has been found to be high. Construction of road in Mandla and Bhagajang, and maintenance and widening of road at Sela and Nagula have also been found to be exerting pressure on the plants found in these areas. It has been found that flowering plants of the timberline area of Zemithang are least disturbed, whereas in Mandla they are highly disturbed compared to other sites (Table 4).

The timberline zone is considered the most sensitive ecosystem that forms the transition zone between alpine vegetation and temperate forests. Delineation of the timberline zone has implications for management and conservation of biodiversity in high-altitude areas. The high-altitude area of Himalaya is rich in representative and endemic biodiversity elements^{26–28}. Though Himalayan plant endemics are well marked at species and subspecies level, a compendium of Himalayan biotic endemism is not available¹⁰. Out of the total 122 plants collected from timberline zone, 56 have been found to present both below and above the timberline zone. Flowering plants recorded from the present study sites represent unique floral diversity of Himalaya biodiversity hotspot and also the Eastern Himalaya part of the biodiversity hotspot as 77% of total plants recorded is found only within the hotspot, of which 28% is confined to Eastern Himalaya. Among the plants collected during the study, 11 species have been found to be of high conservation significance, out of which 3 species are first

Table 4. Different types of pressure and threat on the flowering plants in the study sites

Study site	Types of pressure and threat							
	Firewood collection			Unregulated grazing	Defense installation	Unregulated tourism	Road works	Collection of NTFPs
	By herders	By pilgrims	By others					
Site 1: Zemithang	{	×	×	{	×	×	×	×
Site 2: Nagula	{	×	{	{	{	{	{	×
Site 3: Bhagajang	{	{	×	{	×	{	{	{
Site 4: Sela	{	×	{	{	×	{	{	×
Site 5: Thembang	{	×	×	{	×	×	×	{
Site 6: Mandla	{	×	{	{	{	{	{	{

records from the state and 2 species are first reports from India.

The Monpa community of western Arunachal Pradesh till a few decades ago used to live more or less in isolation due to geographical barriers formed by hills and mountains²⁹. Based on available diverse natural resources in the area under their jurisdiction along a wide altitude range from 1200 m to above 6000 m, traditionally they used to have subsistence economy based mainly on primitive type of agriculture supplemented by animal husbandry. But since the last two decades they are caught in the web of development which has transformed their society substantially³⁰. As a result, many of the traditional management practices of natural resources have started eroding at a fast rate and also many of the community members have started getting involved in activities which are putting serious pressure on the rich biodiversity of the area³¹.

Considering that the position and composition of timberline areas of the Himalaya are important indicators to understand the impact of climate change and pressure due to various anthropogenic activities long-term coordinated work on timberline of Himalaya is urgently required. In this regard it is important to initiate long-term detailed seasonal surveys for complete documentation of floristic diversity of the timberline zone of the Himalaya, including the present study sites.

In addition, 60% of the total forest area of Arunachal Pradesh is under the traditional control of local indigenous communities and this includes a major part of the entire timberline areas of the state. The local indigenous communities of the state are wary of using the existing Protected Area (PA) legislation according to the Wildlife (Protection) Act of India, as the current categories of PA under this Act curtail the traditional and customary ownership and user rights of the local communities over the forest area. Thus there is need to develop a mechanism which ensures active involvement of local communities by empowering them through different conservation activities. There is also a need to link such conservation initiatives with the economic development of the local

communities³¹. For long-term success at a large scale, suitable policy for empowering local communities to take up conservation activities by ensuring direct benefit to them from community-based ecotourism and sustainable utilization of NTFPs is required.

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