



RESEARCH ARTICLE

RAPID BIODIVERSITY SURVEY OF KYONGNOSLA ALPINE SANCTUARY, SIKKIM, INDIA

\*Sabita Dahal, Nimesh Chamling, Anjana Pradhan, Suraj Subba, Meena Tamang  
and Dorjee Chewang Bhutia

Sikkim Biodiversity Conservation and Forest Management Project, Forests, Environment and Wildlife  
Management Department, Forest Secretariat Building, Deorali, Gangtok-737101, Sikkim, India

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ABSTRACT

Rapid Biodiversity Survey of Kyongnosla Alpine Sanctuary (3000 - 4200m) records an occurrence of 151 floral species, of which, population assessment of 71 species was done. There were only three trees species recorded from the sub-alpine area of the sanctuary, namely *Abies densa*, *Acer pectinatum* and *Betula utilis* out of which *Acer pectinatum* and *Betula utilis* were found rare in the area. Some high valued and globally threatened medicinal plants of the Himalayas including seven species of *Aconitums* were recorded namely *Aconitum violaceum*, *A.novoluridum*, *A.palmatum*, *A.disectum*, *A.ferox*, *A.spicatum* and *A.laciniatum*, of which *A.novoluridum*, *A.violaceum* and *A.laciniatum* were re-discovered after more than a century after the monographic work of Stapf during 1905 on Aconites of India, which was based on the collections made by earlier worker (Hooker, 1854). Some other threatened medicinal plants species such as *Neopicrorhiza scrophularia*, *Gymnadenia orchidis*, *Fritillaria cirrhosa*, *Sassurea gossipiphora*, *Sassurea obvallata*, *Rheum nobile*, *Allium prattii*, *Sinopodophyllum hexandrum*, *polygonatum singalilense*, *Valeriana jatamansii*, *V.hardwickii*, *Veratrilla baillonii*, *Gentiana elwesii*, etc. were recorded from the area with very less number of population, for which immediate conservation measures are recommended. Apart from floral species, an inventory of faunal species was done which records an occurrence of 9 mammalian species and 20 bird species through direct and indirect evidences.

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INTRODUCTION

India is known for rich repository of plant wealth having more than 17,500 wild plant species and of these over 4,000 species have medicinal values (Ayensu, 1996). Sikkim being an integral part of eastern Himalaya with an area of 7096km<sup>2</sup> falls under Himalayan (2) Bio-geographic zone and Central Himalaya (2c) biotic province. Its altitude varies from 225m in the south to 6100m in the north and north-east and 8598m in the north-west and constitutes a diverse habitat for both flora and fauna. India is one of the twelve mega diversity centers of the world. Himalayan region of India, especially the North-Eastern part including Sikkim state have been the repository of medicinal plants in conventional use since long directly or indirectly in the modern medicine system, hence plays an imperative role in the cultural and economic expansion of the region ([www.nmpb.nic.in](http://www.nmpb.nic.in)). Sikkim state harbour over 4500 species of flowering plants, 410 pteridophytes (Kholia, 2014),

over 16 species of conifers, 39 species of Rhododendrons (Dahal et al., 2017), Bamboos over 20 species, medicinal plants 490 species (Sharma & Sharma, 2010), Primulas over 30 species, Mammals over 144 species, Birds 550 species, fishes over 48 species, butterflies over 600 species. An account of the rich biodiversity of the state has been provided by Hooker JD (1872-1897), Stapf .O (1905), Kumar S and Singh V (2001), Gammie GA (1893), Polunin. O and Stainton. A (1984), Lucksom S.Z. (2007), Sharma & Sharma (2010), Hooker JD (1849), Arrawatia and Tambe (2011), Ali. S (1989), Kholia (2010), Kholia (2014), Das (2009), Maiti and Maiti (2007), S (2015-16), Pradhan & Badola (2008), Pradhan KC (2008), Pradhan UC and Lachungpa ST (1990), Pradhan BK et al (2013), Pradhan BK et al. (2015), Dahal (2015-16) in the form of flora, orchids, medicinal plants, Rhododendrons, ferns and ferns allies, avifauna, mushrooms etc. In order to protect such a rich bio-resources of the state, 46.93% of the total geographical area of Sikkim has been brought under the Protected Area Network (PAN) within the four broadly classified vegetation zones viz.; Tropical, Temperate, Sub-alpine and Alpine regions. Recently during 2015, Forest, Environment and Wildlife Management, Government of Sikkim have come out with the Rapid Biodiversity Survey

\*Corresponding author: Sabita Dahal,

Sikkim Biodiversity Conservation and Forest Management Project, Forests, Environment and Wildlife Management Department, Forest Secretariat Building, Deorali, Gangtok-737101, Sikkim, India.

Report – I and Rapid Biodiversity Survey Report –II after conducting Rapid Biodiversity Survey along various sampling paths in Fambong Lho Wildlife Sanctuary (East Sikkim), Khangchendzonga Biosphere Reserve (West Sikkim & North Sikkim), Maenam Wildlife Sanctuary (South Sikkim), Shingba Rhododendron Sanctuary (North Sikkim) etc. Of the seven protected areas of Sikkim, Kyongnosla Alpine Sanctuary is the one having rich diversity of sub-alpine to alpine biological wealth, but has remain unexplored till date. Rapid Biodiversity Assessment approach is a tool developed by Conservation International for Systematic biodiversity data collection and has been well accepted throughout the world. It is a medium of quickly collecting information on the floral and faunal species present in a given area and provides key information that can be used to manage and protect species of conservation concern and overall biodiversity. Under Biodiversity Conservation Component of SBFP (Sikkim Biodiversity Conservation and Forest Management Project), Rapid Biodiversity Survey is being carried out in different protected areas, buffer zones and reserve forests of Sikkim to develop baseline information on key biological elements in the forest for long term monitoring and evaluation of the impacts of changes in the forest, and biodiversity management and to identify critical areas that require immediate protection and bring the data set so produced under the Geo Spatial platform. As sub - alpine and alpine forests are considered to be potentially prone to the adverse effects of climate change, present study also provide important baseline information for future evaluation of the impact of climate change on sub-alpine and alpine forest communities.

### Study Area

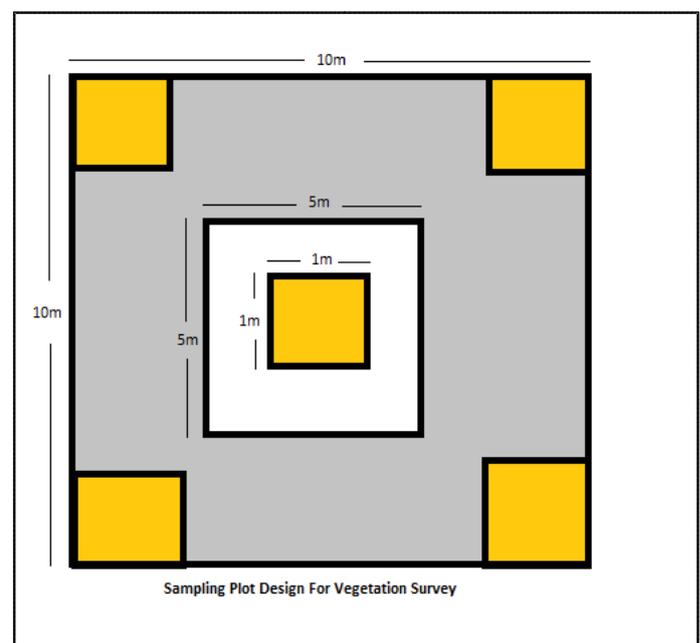
The current field survey was carried out along Nakchok – 17<sup>th</sup> mile Sampling path in Kyongnosla Alpine Sanctuary in the Eastern Himalaya of Sikkim (Figure 1) during the month of August 2016. The area of the sanctuary is 31 km<sup>2</sup> and is located between 3000 meters to 4200 meters. The forest types of the sanctuary were represented by sub alpine – alpine type (Plate 1). In the east, the boundary of the sanctuary extend along the Rong-chu ridge upto Natso; in the west, it runs along the Kyongnosla ridge towards north ending near Kyongnosla police check post at J.N.Road; in the north, it runs from Natso peak along the bridge upto Kyongnosla ridge and in the south the sanctuary runs along the J.N.Road starting from 5<sup>th</sup> mile check post extending upto Rangchu ridge. The slope angle of the area ranged between mild (5 degree) to stiff (50 degree) and was faced towards E, N, NW and NE aspect (Annexure I). The sanctuary is one of the wildlife protected areas of Sikkim which was first notified as the Kyongnosla Alpine Wildlife Sanctuary by the Government of India vide Notification No. 45/WL/83/625 dated 29.08.84; extended vide 45/WL/F/92/1585/F & WL dated 05.12.1992. This sanctuary belongs to the bio-geographical zone 2C (Central Himalaya) as recognized by Wildlife Institute of India, Dehradun. The area around the sanctuary is notified as the Eco-Sensitive Zone by the Central Government with the purpose of protecting and conserving the biodiversity of the sanctuary and its environment. The extent of this zone varies from 25 m to 200 m from the boundary of the Sanctuary. It is bounded by 27°22'5" N latitude and 88°41'54" E longitude towards east; 27°23'41" N latitude and 88°42'48" E longitude towards west; 27°25'13" N latitude and 88°43'49" E longitude towards north; and 27°22'36" N latitude and 88°43'50" E longitude towards south. The sanctuary constitutes a diverse habitat for both flora and fauna and is an

abode to the wide range of topographical landscape harbors some rare, endangered species, high value and the rare medicinal plants, and the lower elevation is occupied with tall *Junipers*, *Rhododendron* thickets with scattered *Abies densa* and somewhere with bamboo thickets. The major significance of this sanctuary is the number of scheduled animals it harbors [specified in Schedule I of the Wildlife (Protection) Act, 1972] which are given maximum protection in the National level as well as having the main inhabitant in the form of Red Panda and different species of Gallinaceous Birds and Pheasants.

### Methodology

Inventory and monitoring of the biodiversity of Kyongnosla Alpine Sanctuary were done using Rapid Biodiversity Survey Techniques (RBST). Prior to field work, literatures were scrutinised to have a general idea about the biodiversity of the area (Polunin and Stainton, 1984; Stainton, 1988; Hooker, 1871-1897; Sharma and Sharma, 2010; Dahal S. 2015-16; Arrawatia & Tambe, 2011; Lachungpa *et al.*, 2007; Kholia, 2010 & 2014; Das 2009; etc.) including web references such as ([www.efloras.org](http://www.efloras.org); [www.flowersofindia.net](http://www.flowersofindia.net) etc.). The checklist of the species (both flora and fauna) was prepared and was taken to the field to confirm their presence in the study area. During the field work, general listing of all the species occurring in the area (both flora and fauna) were made to have fair knowledge on the biodiversity of the area.

In the field, the quantitative as well as qualitative data on floral biodiversity was recorded using a Standard Quadrat Sampling method, wherein, a random plot of 10m x 10m were established which was followed by lying of plot after every 0.5 to 0.6 km approximate distance. Within the plot, all the tree species were listed and the individual tree width CBH > 30 cm (1.3 m above the ground) was measured. Within the mother plot, a quadrat of 5m x 5m was laid in the centre to record the number of saplings present; the same quadrat was used to record the percent cover of the shrub species. 5 number of 1m x 1m quadrat were laid; 2 at the alternate corners of the 5m x 5m quadrat and 1 at the centre for recording the percent cover of the herb species; the same quadrat was used to record the number of seedlings.



General listing of all the species (flora) encountered along the sampling plots as well as outside were also done to have fair idea on the species availability in the area. Parameters such as coordinates and altitude of each sample plots were recorded using hand held GPS; slope aspect and slope angle of each plots were also recorded.

In case of trees, recorded data were analyzed for density, frequency, abundance, basal area etc. Importance value index (IVI) was determined as the sum of percentage density and percentage basal area. Species diversity for each plot was determined with the Shannon and Wiener information function, which reads as  $H' = -\sum(n_i/N) \log_2 n_i/N$ , where 'ni' represents total number of individuals of particular species, and 'N' represents total number of individuals of all species. Species richness was calculated using Margalef's index as  $I = (S-1)/\ln(N)$ , where 'S'=the number of species in the sample and 'N'=the total number of individuals in the sample. Species evenness was determined by Shannon index of evenness as,  $E = H'/\ln(S)$  where 'H'=Shannon' Index of diversity and 'S'=number of species in the sample. Concentration of dominance was measured by Simpson's Index, which reads as,  $D = \sum(n_i/N)^2$  where, 'ni' represents total number of individuals of particular species and 'N' represents total number of individuals of all species. In case of shrubs and herbs, populations were calculated in terms of Average Percent Cover.

To record the faunal element occur in the area, trail sampling (walking through the trail) and sign surveys (records of digging sign, foraging sign, hoof mark, etc.) were made. During the survey, direct evidences like call sound and indirect evidences like feather, pellets, scats, droppings etc. were recorded. Photo capture was also done, depending upon the feasibility.

## RESULTS

### Flora

During the survey, a total of 21 plots were laid covering 0.21 ha area (Annexure I; Figure 1), from which 2 tree, 6 small tree/ large shrubs, 13 shrubs / shrublets and 107 herb species were recorded and are marked with (\*) in Annexure II. A general checklist of 151 species of the area (including the areas outside of the plots) were prepared of which, herbs represented the highest number of species (127 species) followed by small trees / shrubs / shrublets (23 species). Trees were very sparse; hence only 3 species were recorded from the area namely *Abies densa*, *Betula utilis* and *Acer pectinatum* (Table 1). Family wise analysis revealed that belonging to the herb category Asteraceae was the dominant family, followed by Polygonaceae, Geraniaceae, Scrophulariaceae, Rosaceae (Graph 1), while in the case of small trees /shrubs/shrublets, Ericaceae appeared as the dominant family followed by Berberadaceae, Salicaceae, Cupressaceae and Grossulariaceae. Distribution of number of species along the altitudinal gradient shows no any significant relation; however the highest number of species (13 nos) were recorded in the altitude of 3601m (Graph 2). The number of species per plot for tree, small tree / large shrub, shrub / scrub and herb species ranged between 0 and 1, 0 and 2, 0 and 4 and 2 and 10 respectively; nonetheless, species were completely absent from 71.43% (Tree), 42.46% (small tree / large shrub), 23.81% (shrub / scrublets) and 0.00% (herb) of the total plots (Graph 3). Out of three species

of trees recorded from the area, from sub-alpine part of the sanctuary, only *Abies densa* and *Betula utilis* were recorded from the sample plots. *Abies densa* was thinly scattered in the area, hence, only 11 individual recorded from the entire sampling site; present only in 4 plots (plot 7, plot 11, plot 12, plot 13) of the 21 plots. Its cumulative adult stem density found comparatively low ( $52.38 \pm 58.35$  ind/ha; Rel. Den.: 78.57%; IVI: 237.64). In case of *Betula utilis*, only 3 individual were recorded, which was only from the lower sub-alpine belt, and was recorded from 2 plots (Plot 19 & plot 21). In the remaining plots, the trees were completely absent. The cumulative adult stem density of *Betula utilis* were  $14.29 \pm 33.81$  ind/ha; Rel. Den.: 100%; IVI: 207.58 [Table 2] as well as the total basal cover (TBC:  $9.22 \text{ m}^2/\text{ha}$ ; Rel. Dom.: 7.58%).

**Table 1. Diversity of Floral species in Kyongnosla Alpine Sanctuary, East Sikkim**

Habit	Species	Genus	Family
Trees	3	3	3
Small trees / large shrubs	6	5	4
Shrubs/ shrublets	18	7	5
Herbs (Climber/ Epiphytes/ Bamboos/ Ferns)	129	75	34
Total	130	84	42

**Table 2. Availability and distribution of Tree species in Kyongnosla Alpine Sanctuary, East Sikkim**

Species	Adult			
	Density (Ind/ha) $\pm$ SE	TBC (m <sup>2</sup> /ha)	A/F ratio	IVI
<i>Abies densa</i> Griff.	$52.38 \pm 58.35$	112.33	0.14	237.6496
<i>Betula utilis</i> .D.Don	$14.29 \pm 33.81$	9.22	0.16	55.0885

**Table 3. Species diversity and distribution in Kyongnosla Alpine Sanctuary, East Sikkim**

Parameters	Trees
Diversity Index (H)	0.52
Concentration of Dominance (D)	0.01
Species richness index (I)	1.62
Species evenness index (E)	-0.75

**Table 4. Availability and distribution of large shrubs or Small Trees in Kyongnosla Alpine Sanctuary, East Sikkim**

Species	Average % Cover / 25 m <sup>2</sup>	Frequency %
<i>Salix sikkimensis</i>	0.48	4.76
<i>Juniperus</i> sp. (Tall Juniper)	7.14	33.33
<i>Rhododendron hodgsonii</i>	2.86	4.76
<i>Rhododendron thomsonii</i>	9.05	28.57
<i>Lyonia ovalifolia</i>	1.19	4.76

**Table 5. Availability and distribution of shrubs and shrublets in Kyongnosla Alpine Sanctuary, East Sikkim**

Sl.No	Species	Average % Cover / 5 m <sup>2</sup>	Frequency %
1	<i>Rhododendron lanatum</i> Hook.f.	0.48	4.76
2	<i>Rhododendron campanulatum</i> D.Don subsp <i>aeruginosum</i> (Hook.f.)	0.95	14.29
3	<i>Rhododendron anthopogon</i> D.Don	2.62	19.05
4	<i>Rhododendron setosum</i> D.Don	0.71	9.52
5	<i>Cassiope fastigiata</i> (Wall.) D.Don	1.19	14.29
6	<i>Berberis insignis</i> Hook.f.& Thomson	0.24	4.76
7	<i>Berberis angulosa</i> Wall.ex Hook.f. & Thomson	3.81	19.05
8	<i>Rhododendron hypenanthum</i> Balf.f.	2.14	9.52
9	<i>Juniperus coxii</i> A.B.Jackson	2.38	14.29
10	<i>Juniperus recurva</i> Buch.-Ham.ex D.Don	0.48	4.76
10	<i>Rosa sericea</i> Lindl.	5.24	42.86

**Table 6. Availability and distribution of herbs in Kyongnosla Alpine Sanctuary, East Sikkim**

Sl. No.	Species	% cover	% frequency
1	<i>Aconitum palmatum</i> D.Don	0.48	4.76
2	<i>Aconitum novoluridum</i> Munz.	0.71	4.76
3	<i>Aconitum violaceum</i> Jacquem.ex Stapf	0.24	4.76
4	<i>Aconitum dissectum</i> D.Don	0.48	9.52
5	<i>Aconitum laciniatum</i> (Bruhl) Stapf.	0.95	14.29
6	<i>Anaphalis contorta</i> D.Don	0.95	9.52
7	<i>Anaphalis triplinervis</i> (Sims) Cl.	1.19	19.05
8	<i>Arisaema jacquemontii</i> Bl.	0.71	14.29
9	<i>Bergenia purpurascens</i> (Hook. & Thoms.) Engler	0.71	9.52
10	<i>Bistorta affinis</i> (D.Don) Greene	0.71	9.52
11	<i>Cerastium</i> sp	0.48	9.52
12	<i>Dracocephalum heterophyllum</i> Edgeworth ex Benth.	0.95	9.52
13	<i>Codonopsis foetans</i> Hook. & Thoms.	0.71	9.52
14	<i>Codonopsis clematidea</i> (Schrenk) Cl.	1.43	19.05
15	<i>Clematis napaulensis</i> DC	0.48	9.52
16	Ferns	6.19	33.33
17	<i>Fragaria nubicola</i> Lindley ex Lacaita	0.71	9.52
18	<i>Gentiana elwesii</i> Cl.	0.48	4.76
19	<i>Geranium wallichianum</i> Don ex. Sw.	0.71	9.52
20	<i>Acomastylis elata</i> var. <i>elata</i> Wall. ex G. Don	1.67	23.81
21	<i>Impatiens racemosa</i> DC.	1.43	9.52
22	<i>Impatiens urticifolia</i> Wall.	0.48	9.52
23	<i>Iris clarkei</i> Baker ex Hook.f.	11.19	33.33
24	<i>Juncus alpinoarticulatus</i> Chaix.	1.76	19.05
25	<i>Juncus himalensis</i> Klotzsch.	2.14	28.57
26	<i>Juncus thomsonii</i> Buchenau	1.19	19.05
27	<i>Lagotis crassifolia</i> Prain	1.43	4.76
28	<i>Ligularia fischeri</i> (Ledeb.) Turcz.	1.90	14.29
29	<i>Lobelia</i> sp.	0.95	9.52
30	<i>Nardostachys jatamansi</i> (D.Don) DC.A.	0.24	4.76
31	<i>Pedicularis oederi</i> Vahl	0.48	4.76
32	<i>Pedicularis longiflora</i> Rudolph.	0.24	4.76
33	<i>Pedicularis siphonantha</i> D.Don	2.38	23.81
34	<i>Pedicularis trichoglossa</i> Hook.	0.24	4.76
35	<i>Pleurospermum hookeri</i> Cl.	0.24	4.76
36	<i>Persicaria wallichii</i> Greuter & Burdet	3.33	28.57
37	<i>Polygonum vacciniifolium</i> Wall. ex Meisner	1.90	19.05
38	<i>Ponerorchis chusua</i> D.Don	0.48	4.76
39	<i>Potentilla arbuscula</i> D.Don	0.71	4.76
40	<i>Potentilla cuneata</i> Wall. ex Lehm.	0.71	9.52
41	<i>Potentilla peduncularis</i> D.Don	0.71	9.52
42	<i>Rheum acuminatum</i> Hook.f.& Thoms .ex Hook.	1.43	4.76
43	<i>Rhodiola cretinii</i> (Raymond-Hamet)	0.71	9.52
44	<i>Veratrum bailonii</i> Franchet	1.19	9.52
45	<i>Sedum roseum</i> (L.) Scop.	0.24	4.76
46	<i>Saxifraga brachypoda</i> D.Don	0.95	4.76
47	<i>Sassurea nepalensis</i> Sprengel	0.24	4.76
48	<i>Sassurea obvallata</i> (DC.) Edgew.	1.90	4.76
49	<i>Selenium wallichianum</i> (DC.) Raizada &	0.48	9.52
50	<i>Senecio graciliflorus</i> DC.	0.48	4.76
51	<i>Senecio raphanifolius</i> Wall.ex DC.	3.10	14.29
52	<i>Soro-seris hookeriana</i> (Cl.) Stebbins	0.24	4.76
53	<i>Thalictrum reniforme</i> Wallich	0.71	9.52
54	<i>Valeriana hardwickii</i> Wall.	0.71	14.29

In terms of frequency of occurrence, *Abies densa* were recorded occurring more frequently than *Betula utilis* i.e., Rel. Freq. of *Abies densa* is 66.67% and of *Betula utilis* is 26.07%. In case of trees, the sampled area was not much rich in terms of tree species richness ( $I = 1.62$ ) and recorded low species diversity ( $H = 0.52$ ) [Table 3]. The abundance to frequency ratio revealed that, the adult individuals of *Abies densa* (A/F ratio: 0.14) and of *Betula utilis* (A/F ratio: 0.16) shows contagious distribution. Saplings and seedlings of the trees were not recorded from the sampling plots.

The small tree/large shrub recorded from the sample plots are *Lyonia ovalifolia*, *R. hodgsonii*, *R. thomsonii*, *Juniperus* sp.

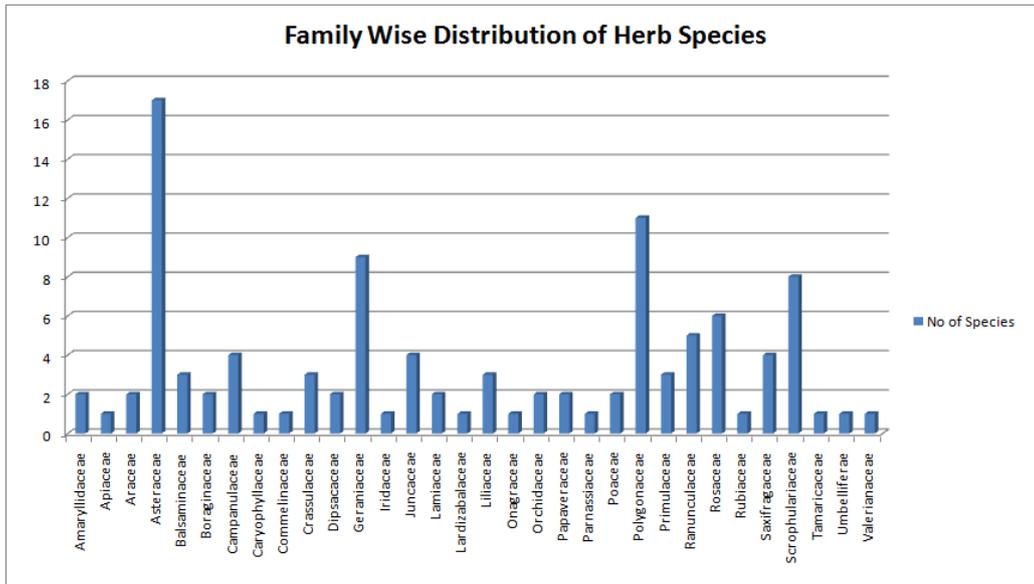
and *Salix sikkimensis*. Of the 5 small tree / large shrub species present, *Juniperus* sp. (Tall Juniper) had the highest frequency of occurrence (33.33%) followed by *Rhododendron thomsonii* (28.57 %) and the species like *Salix sikkimensis*, *Lyonia ovalifolia*, *Rhododendron hodgsonii* had the lowest frequency of occurrences (3.13% each) [Table 4, Graph 4]; In respect to percent cover, *Rhododendron thomsonii* was dominant (average percent cover /25 m<sup>2</sup>: 9.05 % followed by *Juniperus* sp. (7.14%), *Rhododendron hodgsonii* (2.86%), and *Lyonia ovalifolia* (1.19%). *Salix sikkimensis* (0.48%) had very low average percent cover. Of the 10 shrubs or shrublets recorded from the sample plots, *Rosa sericea* had wide availability in the area and was recorded from 42.86% of the sampled area. The density in terms of percent cover for the recorded shrubs or shrublets were comparatively low i.e. 5.28% (*Rosa sericea*), 3.81% (*Berberis angulosa*), 2.62% (*Rhododendron anthopogon*) 2.14% (*Rhododendron hypenanthum*), 1.19% (*Cassiope fastigiata*) to 0.48% (*Juniperus recurva* and *Rhododendron lanatum*) [Table 5, Graph 5]. In the case of herbaceous species, a total of 54 species were recorded from 21 plots, of which, *Iris clarkei* and the different species of ferns had the highest frequency of occurrences (33.33%) followed by *Juncus himalensis*, *Pedicularis siphonantha* and *Persicaria wallichii* (28.57%). Other species such as *Soro-seris hookerana*, *Senecio gracilifolium*, *Sassurea obvallata*, *Sassurea nepalensis*, *Ponerorchis chusua*, *Potentilla arbuscula*, *Rheum acuminatum*, *Pleurospermum hookeri*, *Pedicularis trichoglossa*, *Nardostachys jatamansi*, *Lagotis crassifolia*, *Gentiana elwesii* etc. had low frequency of occurrences upto 4.76%. With regard to average density in terms of percent cover, *Iris clarkei* (average percent cover /m<sup>2</sup>: 11.19%) was dominant over other herbs species; however, species such as *Aconitum palmatum*, *A.laciniatum*, *A.dissectum*, *A.novoluridum*, *A.violaceum*, *Gentiana elwesii*, *Anaphalis contorta*, *Dracocephalum heterophyllum*, *Clematis napaulensis*, *Codonopsis foetans*, *Nardostachys jatamansi*, *Pedicularis oederi*, *Pedicularis longiflora*, *Pedicularis trichoglossa*, *Pleurospermum hookeri*, *Ponerorchis chusua*, *Sassurea nepalensis*, *Sassurea obvallata*, *Senecio gracilifolium*, *Soro-seris hookerana*, *Valeriana hardwickii* etc. (average percent cover /m<sup>2</sup> ranging from 0.24% to 0.95%) (Table 6) appeared rarely with very less number of populations in the study area.

## Fauna

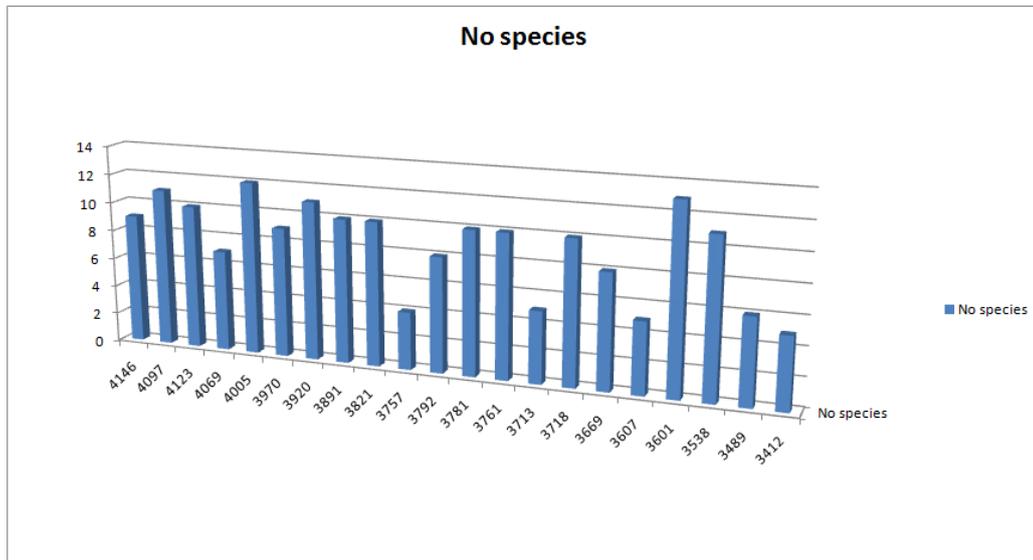
During the survey, the existence of a total of 20 bird species belonging to 3 order and 11 families were recorded (Table 7). Similarly existence of total number of 9 mammalian species was witnessed through direct and indirect evidences (Table 8). The maximum numbers of scats encountered in the area gives an evidence of the existence of good number of population of red fox and yellow-throated marten.

## DISCUSSION

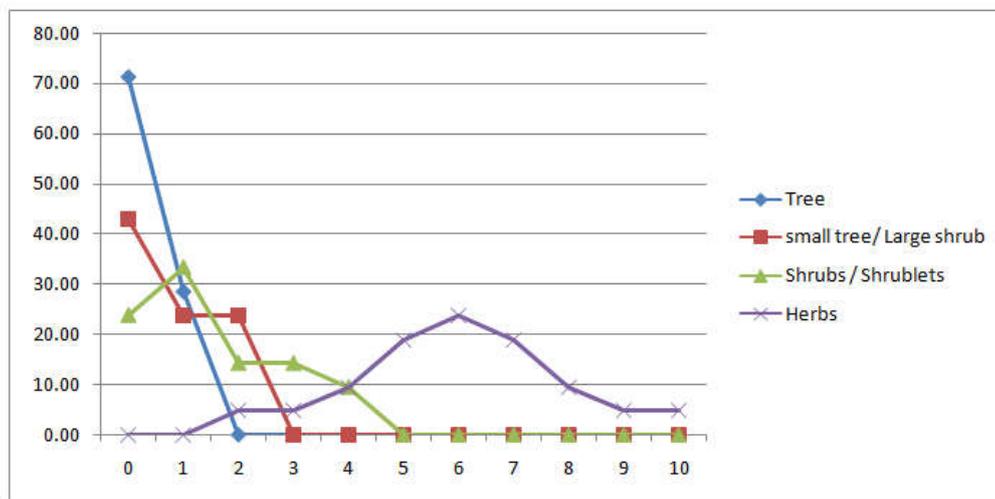
Till today, Kyongnosla Alpine Sanctuary remain unexplored which, during the present study, found to be rich in terms of the diversity of the species. Wide range of habitat diversity the sanctuary harbour, in the form of several rare, endangered species along with high value medicinal plants, tall *Junipers*, scattered *Abies densa* and thickets of *Rhododendrons*. The lower elevation is occupied mainly with bushy bamboo thickets and junipers.



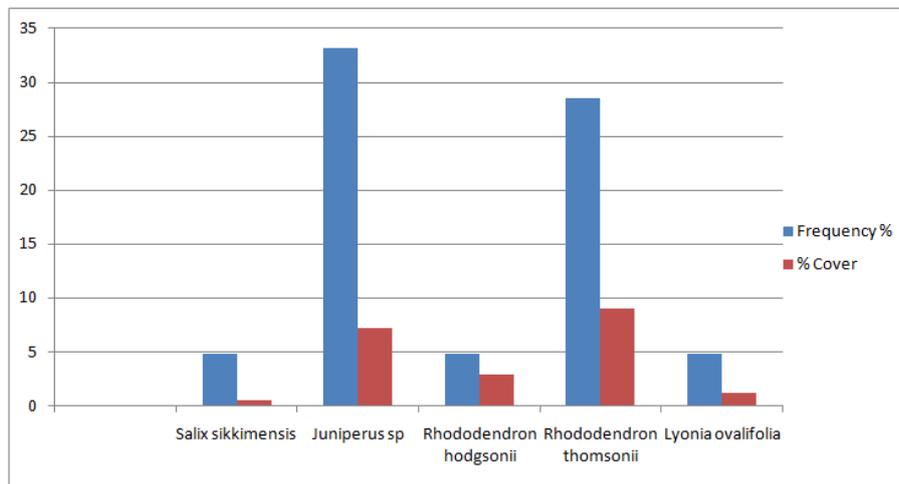
Graph 1. Family-wise distribution of herb species



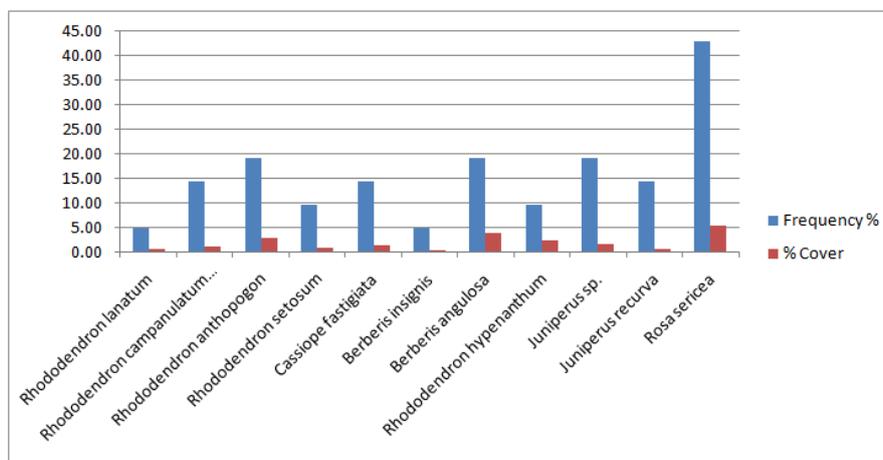
Graph 2. Altitudinal distribution of species in the sampling site



Graph 3. Species availability in the different sampling site



Graph 4. Status of large shrubs or small trees in the sampling site



Graph 5. Status of Shrubs or shrublets in the sampling site

Table 7. Checklist of Avi-fauna in Kyongnosla Alpine Wildlife Sanctuary

Sl. No	Common Name	Scientific Name	Family	Order	Evidence
1.	Blood pheasant	<i>Ithaginis cruentus</i>	Phasianidae	Galliformes	PC, DS
2.	Satyr tragopan	<i>Tragopan satyra</i>	Phasianidae	Galliformes	PC,
3.	Black-faced Laughingthrush	<i>Garrulax affinis</i>	Turdidae	Passeriformes	PC, DS
4.	Red-headed Bullfinch	<i>Pyrrhula erythrocephala</i>	Fringillidae	Passeriformes	PC
5.	Dark breasted Rosefinch	<i>Carpodacus nipalensis</i>	Fringillidae	Passeriformes	PC
6.	Plain Mountain Finch	<i>Leucosticte nemoricola</i>	Fringillidae	Passeriformes	PC
7.	White-capped Redstart	<i>Phoenicurus leucocephalus</i>	Muscicapidae	Passeriformes	PC
8.	Fire-tailed Sunbird	<i>Aethopyga ignicauda</i>	Nectariniidae	Passeriformes	PC
9.	House Crow	<i>Corvus splendens</i>	Corvidae	Passeriformes	PC, DS
10.	House Sparrow	<i>Passer domesticus</i>	Passeridae	Passeriformes	PC, DS
11.	Green-backed tit	<i>Parus monticolus</i>	Paridae	Passeriformes	PC
12.	Blue Whistling Thrush	<i>Myophonus caeruleus</i>	Muscicapidae	Passeriformes	PC, DS
13.	Common Myna	<i>Acridotheres tristis</i>	Sturnidae	Passeriformes	PC, DS
14.	Rock Dove	<i>Columba livia</i>	Columbidae	Columbiformes	PC, DS
15.	Oriental turtle dove	<i>Streptopelia orientalis</i>	Columbidae	Columbiformes	PC, DS
16.	Green Pigeon	<i>Treron</i>	Columbidae	Columbiformes	PC, DS
17.	Kalij Pheasant	<i>Lophura leucomelanos</i>	Phasianidae	Galliformes	PC
18.	Ashy Throated Warbler	<i>Phylloscopus maculipennis</i>	Sylviidae	Passeriformes	PC
19.	Red Billed Chough	<i>Pyrrhocorax pyrrhocorax</i>	Corvidae	Passeriformes	PC
20.	Snow Pigeon	<i>Columba leuconota</i>	Columbidae	Columbiformes	PC

PC: Photo Capture, DS: Direct Sighting

Table 8. Checklist of other faunal species of Kyongnosla Alpine Sanctuary

Sl. No.	Common Name	Scientific Name	Family	Evidence <sup>1</sup>	IUCN Status <sup>2</sup>
1.	Musk Deer (Kasturi mriga)	<i>Moschus chrysogaster</i>	Moschidae	SI	EN
2.	Barking deer (Mriga)	<i>Muntiacus muntjak</i>	Cervidae	P	LC
3.	Bear (Bhalu)	<i>Ursus thibetanus</i>	Ursidae	SI	VU
4.	Red panda (Pude kudo)	<i>Ailurus fulgens</i>	Ailuridae	SI	EN
5.	Red fox	<i>Vulpes vulpes</i>	Canidae	S	LC
6.	Yellow-throated Marten (Malsapra)	<i>Martes flavigula</i>	Mustelidae	SI, S	LC
7.	Pika	<i>Ochotona sp.</i>	Ochotonidae	DS	LC
8.	Goral	<i>Naemorhedus goral</i>	Bovidae	SI	NT
9.	Serow (Thar)	<i>Capricornis thar</i>	Bovidae	HM, P	NT
10.	Wild dog (Dhole)	<i>Cuon alpinus</i>	Canidae	SI	EN

<sup>1</sup>SI: Secondary Information, DS: Direct Sighting HM: Hoof mark, P: Pellet, S: Scat<sup>2</sup>EN: Endangered, LC: Least concern, VU: Vulnerable, NT: Near threatened

Forest being sub alpine to alpine type, herbs are the most predominant taxa in the area, followed by shrubs and shrublets. Commonly available herbaceous species in the sanctuary are *Bergenia purpureascens*, *Bistorta amplexicauli*, *Rheum acuminatum*, *Nardostachys jatamansi*, *Sassurea nepalensis*, *Potentilla arbuscula*, *P.peduncularis*, *Pedicularis siphonantha*, *Rhododendron hodgsonii*, *R.thomsonii*, *R.campanulatum*, *R.lanatum*, *Juniperus recurva*, *J.coxii*, *Codonopsis clematidea*, *Clematis napaulensis*, *Arisaema jacquemontii*, *Acomastylis elata* var *elata*, *Iris clarkei*, *Ligularia fischeri*, *Juncus himalensis*, *Juncus thomsonii*, *Juncus alpinoarticulatus*, *Persicaria wallichii*, *Polygonum vacciniifolium*, *Senecio raphanifolium*, *Valeriana hardwickii*, etc. which are abundantly flourishing in the area. Several species of rare and high value medicinal herbs were also recorded from the area during the present survey such as *Aconitum ferox*, *A.disectum*, *A.novoluridum*, *A.violaceum*, *A.palmatum*, *Gentiana elwesii*, *Neopicrorhiza scrophularia*, *Sassurea obvallata*, *Lagotis crassifolia*, *Bergenia purpurascens*, *Valeriana jatamansi*, *V.hardwickii*, *Codonopsis foetans*, *Polygonatum cirrhifolium*, *Polygonatum verticillatum*, *Panax bipinnatifidus* etc. Small trees or the large shrubs available in the area are *Rhododendron hodgsonii*, *Rhododendron thomsonii*, *Juniperus* sp., *Salix sikkimensis*, *Lyonia ovalifolia* etc. The commonly available shrubs and/ or shrublets were *Rhododendron campanulatum* subsp *aeruginosum*, *Rhododendron campanulatum* subsp *campanulatum*, *Rhododendron lanatum*, *Rhododendron anthopogon*, *Rhododendron hypenanthum*, *Rhododendron ciliatum*, *Berberis angulosa*, *Berberis insignis*, *Cassiope fastigiata*, *Gaultheria trichophylla*, *Gaultheria nummularioides* etc. Some species such as *Aconitum*, the taxa of the highly potential medicinal plant of the Himalayas but not much attention paid by the taxonomist so far have been re-discovered from the area after more than a century after the monographic work of Stapf, O. during 1905 with seven species namely *Aconitum laciniatum*, *Aconitum novoluridum*, *Aconitum bisma*, *Aconitum disectum*, *Aconitum ferox*, *Aconitum violaceum* and *Aconitum spicatum* with comparatively good number of population except few such as *A.novoluridum* and *A.violaceum*, which were observed very rare in the area. *Aconitum laciniatum* was re-discovered from Tamzey valley and surrounding areas (Dahal *et al.* 2017), which is very near to the present study area. This species was reported earlier from the subalpine and alpine Himalayas of Sikkim and adjoining Tibet (Stape, 1905). During the present study, *Aconitum novoluridum* and *A.violaceum* were rediscovered after the monographic work of Stape, 1905, along with the other aconitum species including *A.laciniatum*. The present collection of these species after more than a century reveals rarity of this species in its natural habitat. High altitude Gentians (Gentianaceae) such as *Gentiana elwesii*, *G.algida*, *G.prolata*, *G.sikkimensis*, *G.stylophora*, *Swertia hookeri*, *Veratrilla baillonii* and *Halenia elliptica* were recorded from the area. A population of *Veratrilla baillonii*, a Tibetan medicinal herb, discovered from the area (ca. 4100m), which was recently discovered for the first time from Sikkim Himalaya from Tamze valley by one of the author (Dahal *et al.* 2017) during the course of the floristic study of MPCAs of Sikkim. Till date the species was reported only from the western Himalaya. *Gentiana elwesii*, a rare medicinal herb witnessed in the area during the present study; on scrutiny of literature, its record of occurrence found only in Lachung to Yumthang in North Sikkim (Hooker, 1885) and in Tamze valley in East Sikkim (Dahal *et al.* 2017). Species of *Sassurea*

*viz. Sassurea gossipiphora*, *S.obvallata*, *S. scandens* & *S. nepalensis* were recorded of which *S.obvallata* and *S.gossipiphora* are the highly threatened medicinal herbs of the Himalayas which are also found occurring in upper part of Kyongnosla Alpine Sanctuary, and in Tamze valley. However, some herbs including high value medicinal herbs such as *Neopicrorhiza scrophularia*, *Gymnadenia orchidis*, *Fritillaria* sp., *Sassurea gossipiphora*, *Sassurea obvallata*, *Rheum nobile*, *Allium prattii*, *Sinopodophyllum hexandrum*, *polygonatum singalilense*, *Valeriana jatamansii*, *V.hardwickii* etc. were recorded very rare in the area. The occurrence of very few individual of *Betula utilis* and *Acer pectinatum* (which is only from the area outside the sample plots) reveals rarity of this species in the area.

Other than floral species, the sanctuary also provides diverse habitat for faunal species such as Serow, Musk Deer, Goral, Himalayan Black Bear, Blood Pheasant, Leopard, Lesser Cats and Himalayan Marmot. In addition, the sanctuary is also home to Satyr Tragopan, Common Langur, Tibetan Fox, Martens Weasel and Impeyan Pheasant. A wide variety of avifauna, which includes Blood Pheasant, Monal Pheasant, Tragopan, Rose finches, Red-billed Chough, Forktails and Laughing Thrushes also resides in the area. Direct sightings of House Crow, House Sparrow, Blue Whistling Thrush, Common Myna, Rock Dove, Oriental turtle dove, Green Pigeon, Kalij Pheasant, Ashy Throated Warbler, Snow Pigeon, and Red Billed Chough were achieved during the present Rapid Biodiversity Survey. Checklist of other faunal species such as Musk Deer, Barking deer, Bear, Red panda, Red fox, Yellow-throated Marten, Pika, Goral, Serow and Wild dog were prepared through secondary information, direct sightings, hoof marks, pellets, scats etc.

## Conclusion

From the conservation point of view the present study has remarkable relevance in preservation of subalpine and alpine gene bank of Sikkim in the form of protected area, as present survey witnessed an occurrence of more than 151 floral species, including some globally rare and threatened species (both medicinal and otherwise) such as species of *Aconitum*, *Gentiana elwesii*, *Veratrilla baillonii*, *Rheum nobile*, *Nardostachys jatamansi*, *Neopicrorhiza scrophularia*, *Gymnadenia orchidis*, *Sassurea obvallata*, *S.gossipiphora* etc. Since the area is far away from the human habitation, the anthropogenic pressure is still not marked and hence biodiversity of the area still remain intact to some extent. However, some of the species were recorded very rare in the area which may be due to some natural factors; hence proper management is needed to maintain the gene bank of these species in their natural habitat. Natural disturbances including the impact of climate change needs to be studied well, which will be useful for the policy makers and forest managers in framing effective strategies in managing and conserving the species and their natural habitat. The better conservation of biological resources can be done by *ex-situ* conservation through tissue culture, and in case of medicinal plants, awareness should be done among the growers on establishment of herbal nurseries, developing cultivation technologies and commercial cultivation of rare and high value species.

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### Annexure I. Site characteristics of the sampling plots along Nakchok -17<sup>th</sup> Mile at Kyongnosla Alpine Sanctuary, East Sikkim. (KAS= Kyongnosla Alpine Sanctuary)

Plots code	Forest Type	Altitude (M)	GPS		Slope (degree)	Slope Aspect	Disturbances
			Lat	Long			
KAS 1	Alpine Forest	4146	27°23'49.7"	88°46'25.1"	15	E	Nil
KAS 2	Alpine Forest	4097	27°23'48.5"	88°46'014"	30	E	Nil
KAS 3	Alpine Forest	4123	27°23'49.7"	88°46'04.8"	40	E	Nil
KAS 4	Alpine Forest	4069	27°23'45.4"	88°46'02.6"	20	E	Nil
KAS 5	Alpine Forest	4005	27°23'48.2"	88°45'47.8"	15	N	Nil
KAS 6	Sub-Alpine Forest	3970	27°23'37.8"	88°45'02.3"	10	NW	Nil
KAS 7	Sub-Alpine Forest	3920	27°23'39.7"	88°45'13.2"	10	NW	Nil
KAS 8	Sub-Alpine Forest	3891	27°23'42.4"	88°45'07.2"	30	N	Nil
KAS 9	Sub-Alpine Forest	3821	27°23'40.5"	88°45'02.5"	40	N	Nil
KAS 10	Sub-Alpine Forest	3757	27°23'33.8"	88°44'58.8"	30	NE	Nil
KAS 11	Sub-Alpine Forest	3792	27°23'27.9"	88°44'53.2"	40	NE	Nil
KAS 12	Sub-Alpine Forest	3781	27°23'02.4"	88°44'43.2"	30	E	Nil
KAS 13	Sub-Alpine Forest	3761	27°23'25.9"	88°44'35.7"	35	E	Nil
KAS 14	Sub-Alpine Forest	3713	27°23'27.3"	88°44'33.1"	20	E	Nil
KAS 15	Sub-Alpine Forest	3718	27°23'22.4"	88°44'27.6"	45	N	Nil
KAS 16	Sub-Alpine Forest	3669	27°23'18.1"	88°44'18.1"	30	NW	Nil
KAS 17	Sub-Alpine Forest	3607	27°23'12.9"	88°44'06.1"	5	E	Nil
KAS 18	Sub-Alpine Forest	3601	27°23'03.5"	88°43'59.2"	40	E	Nil
KAS 19	Sub-Alpine Forest	3538	27°22'05.9"	88°43'54.3"	45	E	Nil
KAS20	Sub-Alpine Forest	3489	27°22'54.8"	88°43'50.8"	50	E	Nil
KAS21	Sub-Alpine Forest	3412	27°22'45.1"	88°43'46.2"	10	E	Nil

## Annexure – II: Floral species recorded in Kyongnosla Alpine Sanctuary and surrounding areas in East Sikkim

S.No.	Botanical name	Family	Altitudinal range (m)
<b>TREE</b>			
1	* <i>Abies densa</i> Griff.	Pinaceae	2450-4000
2	<i>Acer pectinatum</i> wall.ex G.Nicholson	Aceraceae	2300-3800
3	* <i>Betula utilis</i> D.don	Betulaceae	2500-3800
<b>SMALL TREES / LARGE SHRUBS</b>			
1	* <i>Juniperus</i> sp.	Cupressaceae	-
2	* <i>Lyonia ovalifolia</i> (Wallich) Drude	Ericaceae	300-3400
3	* <i>Rhododendron hodgsonii</i> Hook.f.	Ericaceae	3000-4000
4	* <i>Rhododendron thomsonii</i> Hook.f.	Ericaceae	2900-4000
5	* <i>Salix sikkimensis</i> Andersson	Saicaceae	3700-4500
<b>SHRUBS / SHRUBLETS</b>			
1	* <i>Berberis angulosa</i> Wall.	Berberidaceae	3400-4500
2	* <i>Berberis insignis</i> Hook.f.& Thomson	Berberidaceae	2000-4000
3	* <i>Cassiope fastigiata</i> (Wallich) D.Don	Ericaceae	2800-4500
4	<i>Cassiope selaginoides</i> Hook. & Thoms.	Ericaceae	3000-5000
5	<i>Gaultheria nummularioides</i> D.Don	Ericaceae	2700-4500
6	<i>Gaultheria trichophylla</i> Royle	Ericaceae	2700-4500
7	* <i>Juniperus coxii</i> A.B.Jackson	Cupressaceae	-
8	* <i>Juniperus recurva</i> Buch-Ham ex D.Don	Cupressaceae	2500-4600
9	* <i>Rhododendron anthopogon</i> D.Don	Ericaceae	3500-4500
	<i>Rhododendron barbatum</i> Wall. ex G.Don	Ericaceae	300-3700
10	* <i>Rhododendron campanulatum</i> D.Don subsp sp. <i>campanulatum</i> D.Don	Ericaceae	3300-4000
11	<i>Rhododendron campanulatum</i> D.Don subsp <i>aeruginosum</i> Hook.f.	Ericaceae	4000-4500
12	* <i>Rhododendron hypenanthum</i> Balf.f.	Ericaceae	3500-4500
13	* <i>Rhododendron lanatum</i> Hook.f.	Ericaceae	3000-4000
14	* <i>Rhododendron setosum</i> D.Don	Ericaceae	3500-5500
15	<i>Rhododendron lepidotum</i> Wall. ex G.Don	Ericaceae	2500-5000
16	<i>Ribes griffithii</i> Hook.f.& Thomson	Grossulariaceae	2600-4200
17	<i>Ribes himalense</i> Royle ex Decne.	Grossulariaceae	1500-4200
18	* <i>Rosa sericea</i> Lindley	Rosaceae	2100-4500
<b>HERBS</b>			
1.	* <i>Acomastylis elata</i> var. <i>elata</i> Wall. ex G. Don	Rosaceae	3500-5400
2.	<i>Aconitum dissectum</i> D.Don	Ranunculaceae	3300-4800
3.	<i>Aconitum ferox</i> Wall.ex Ser.	Ranunculaceae	2100-3600
4.	* <i>Aconitum laciniatum</i> (Bruhl) Stapf	Ranunculaceae	3200-4000
5.	<i>Aconitum novoluridum</i> Munz.	Ranunculaceae	3800-4500
6.	<i>Aconitum palmatum</i> D.Don	Ranunculaceae	3000-5000
7.	<i>Aconitum violaceum</i> Jacquem.ex Stapf	Ranunculaceae	3600-4800
8.	<i>Aletris pauciflora</i> (Klotzsch) Hand.- Mazz.	Liliaceae	3000-4300
9.	<i>Allium prattii</i> C.H.Wright	Amaryllidaceae	2400-4300
10.	<i>Allium wallichii</i> Kunth	Amaryllidaceae	2800-4300
11.	* <i>Anaphalis contorta</i> D.Don	Asteraceae	2200-3800
12.	* <i>Anaphalis triplinervis</i> (Sims) C.B.Clarke	Asteraceae	1800-3300
13.	<i>Arisaema erubescens</i> (Wall.) Schott	Araceae	2300-3000
14.	<i>Arisaema griffithii</i> Schott	Araceae	2400-3200
15.	* <i>Arisaema jacquemontii</i> Schott	Araceae	2400-3000
16.	<i>Artemisia</i> sp	Asteraceae	-
17.	<i>Astilbe rivularis</i> Buch.-Ham. Ex D.Don	Saxifragaceae	1800-3300
18.	<i>Bergenia ciliata</i> (Haw.) Sternb.	Saxifragaceae	1800-4300
19.	* <i>Bergenia purpurascens</i> (Hook. & Thomson) Engler	Saxifragaceae	2700-4800
20.	* <i>Bistorta affinis</i> (D.Don) Greene	Polygonaceae	4000-4900
21.	<i>Bistorta amplexicaulii</i> (D.Don) Greene	Polygonaceae	2100-4800
22.	<i>Calceolaria tripartita</i> Ruiz & Pav.	Scrophulariaceae	1800-3200
23.	* <i>Cerastium</i> sp	Asteraceae	-
24.	* <i>Clematis napaulensis</i> DC.	Ranunculaceae	ca.3000
25.	* <i>Codonopsis clematidea</i> (Schrenk) Cl.	Campanulaceae	2000-4000
26.	* <i>Codonopsis foetens</i> Hook. & Thoms.	Campanulaceae	3900-4600
27.	<i>Corydalis elegans</i> Wallich ex Hooker	Papaveraceae	3800-5000
28.	<i>Cynanthus inflatus</i> Hook.f.& Thoms.	Campanulaceae	1900-4900
29.	<i>Cynoglossum zeylanicum</i> (Vahl) Thunb. ex Lehm	Boraginaceae	1200-4100
30.	<i>Cynotis vaga</i> (Loureiro) Schultes	Commelinaceae	Upto 3300
31.	* <i>Dracocephalum heterophyllum</i> Edgeworth ex Bentham	Lamiaceae	1100-5000
32.	<i>Dubyaea hispida</i> Candolle	Asteraceae	2700-4500
33.	<i>Epilobium wallichianum</i> Haussknecht	Onagraceae	1800-4100
34.	<i>Erigeron multiradiatus</i> (Lindl.ex DC.) Benth.ex Cl.	Asteraceae	2300-4600
35.	<i>Euphorbia wallichii</i> Hook.f.	Euphorbiaceae	1800-4500
36.	* <i>Fragaria nubicola</i> Lindley ex Lacaite	Rosaceae	1800-3800
37.	<i>Fritillaria cirrhosa</i> D. Don	Liliaceae	3200-4600
38.	<i>Galinsoga parviflora</i> Cavanilles	Asteraceae	850-3900
39.	<i>Galium</i> sp	Rubiaceae	-
40.	<i>Gentiana algida</i> Pallas	Gentianaceae	1200-5200
41.	* <i>Gentiana elwesii</i> C.B.Clarke	Gentianaceae	ca.4097
42.	<i>Gentiana prolata</i> I.B.Balfour	Gentianaceae	3400-4500
43.	<i>Gentiana sikkimensis</i> C.B.Clarke	Gentianaceae	ca.3900
44.	<i>Gentiana stylophora</i> C.B.Clarke	Gentianaceae	3000-4400
45.	* <i>Geranium wallichianum</i> Don ex. Sw.	Geraniaceae	2900-4000
46.	<i>Gymnadenia orchidis</i> Lindl.	Orchidaceae	2800-4200

Continue.....

47.	<i>Halenia elliptica</i> D.Don	Gentianaceae	700-4100
48.	<i>Impatiens bicornuta</i> Wall.	Balsaminaceae	2500-3100
49.	* <i>Impatiens racemosa</i> Candolle	Balsaminaceae	1200-3400
50.	<i>Impatiens radiata</i> Hook.	Balsaminaceae	2100-3500
51.	* <i>Impatiens urticifolia</i> Wallich	Balsaminaceae	2700-3800
52.	* <i>Iris clarkei</i> Baker ex Hook.f.	Iridaceae	3000-4000
53.	<i>Juncus inflexus</i> L.	Juncaceae	1800-3200
54.	* <i>Juncus alpinoarticulatus</i> Chaix	Juncaceae	ca.3200
55.	* <i>Juncus himalensis</i> Klotzsch	Juncaceae	2400-4300
56.	* <i>Juncus thomsonii</i> Buchenau	Juncaceae	2800-5000
57.	<i>Jurinea dolomiaea</i> – Boiss Boiss	Asteraceae	3200-4000
58.	* <i>Lagotis crassifolia</i> Prain	Scrophulariaceae	3900-5000
59.	<i>Ligularia amplexicaulis</i> DC	Asteraceae	300-4300
60.	<i>Ligularia fischeri</i> (Ledebour) Turczaninow	Asteraceae	ca.3100
61.	<i>Lilium nanum</i> Klotzsch & Garcke	Liliaceae	3300-4300
62.	* <i>Lobelia</i> sp	Campanulaceae	-
63.	<i>Maharanga emodi</i> (Wallich) A de Candolle	Boraginaceae	1800-3300
64.	<i>Meconopsis horridula</i> Hook.f.& Thoms.	Papaveraceae	3500-5500
65.	<i>Meconopsis paniculata</i> (D.Don) Prain	Papaveraceae	3000-4400
66.	<i>Meconopsis simplicifolia</i> (D.Don) Walpers	Papaveraceae	3300-5300
67.	<i>Myricaria rosea</i> W.W.Smith	Tamaricaceae	2600-4800
68.	* <i>Nardostachys jatamansii</i> (D.Don) Candolle	Valerianaceae	2500-5000
69.	<i>Neopicrorhiza scrophulariiflora</i> (Pennell	Scrophulariaceae	3600-4400
70.	<i>Nepeta floccosa</i> Benth.	Lamiaceae	2700-4000
71.	<i>Oxyria digyna</i> (L.) Hill	Polygonaceae	2400-5000
72.	<i>Parnassia nubicola</i> Wall.ex Royle	Parnassiaceae	3000-4500
73.	* <i>Pedicularis longiflora</i> Rudolph	Scrophulariaceae	2100-5300
74.	<i>Pedicularis megalantha</i> D.Don	Scrophulariaceae	2300-4300
75.	* <i>Pedicularis oederi</i> Vahl.	Scrophulariaceae	2600-5400
76.	* <i>Pedicularis siphonantha</i> D.Don	Scrophulariaceae	3000-4600
77.	* <i>Pedicularis trichoglossa</i> Hook.	Scrophulariaceae	3500-5000
78.	* <i>Persicaria wallichii</i> Greuter & Burdet	Polygonaceae	2500-3500
79.	* <i>Pleurospermum hookeri</i> C.B.Clarke	Apiaceae	2700-5400
80.	<i>Polygonatum cathcartii</i> Baker	Polygonaceae	2500-3500
81.	<i>Polygonatum cirrhifolium</i> (Wallich) Royle	Polygonaceae	1500-3800
82.	<i>Polygonatum singalilense</i> H.Hara	Asparagaceae	ca.3800
83.	<i>Polygonatum verticellatum</i> (L.) All.	Polygonaceae	1500-3700
84.	* <i>Polygonum vacciniifolium</i> Wall. ex Meisner	Polygonaceae	300-4200
85.	* <i>Ponerorchis chusua</i> D.Don	Orchidaceae	500-4500
86.	* <i>Potentilla arbuscula</i> D.Don	Rosaceae	2500-5500
87.	* <i>Potentilla cuneata</i> Wallich ex Lehm.	Rosaceae	2400-5500
88.	* <i>Potentilla peduncularis</i> D.Don	Rosaceae	3000-4500
89.	<i>Primula capitata</i> Hook.	Primulaceae	2800-4300
90.	<i>Primula primulina</i> (Spreng.)H.Hara	Primulaceae	3600-4500
91.	<i>Primula reticulata</i> Wallich	Primulaceae	3300-4800
92.	<i>Primula sikkimensis</i> Hook.f.	Primulaceae	3300-4400
93.	* <i>Rheum acuminatum</i> Hook.f.& Thoms.ex Hook.	Polygonaceae	3600-4300
94.	<i>Rheum nobile</i> Hook.f. & Thoms.	Polygonaceae	3600-4500
95.	* <i>Rhodiola cretinii</i> (Raymond-Hamet)	Crassulaceae	3700-4400
96.	* <i>Rhodiola himalensis</i> (D. Don) S. H. Fu	Crassulaceae	2800-4500
97.	<i>Sassurea gossiphora</i> D.Don	Asteraceae	4300-5600
98.	* <i>Sassurea nepalensis</i> Sprengel	Asteraceae	3200-4900
99.	* <i>Sassurea obvallata</i> (DC.) Edgew.	Asteraceae	3600-4500
100.	<i>Sassurea simpsoniana</i> (Field & Gard.) Lipschitz	Asteraceae	4000-5200
101.	<i>Satyrium nepalense</i> D.Don	Orchidaceae	1500-4000
102.	* <i>Saxifraga brachypoda</i> D.Don	Saxifragaceae	3600-4800
103.	<i>Saxifraga engleriana</i> Harry Smith	Saxifragaceae	4000-5000
104.	<i>Saxifraga stenophylla</i> Royle	Saxifragaceae	3600-5000
105.	<i>Scutellaria discolor</i> Colebr.	Lamiaceae	ca.3100
106.	* <i>Sedum roseum</i> (L.) Scop.	Crassulaceae	ca.3800
107.	* <i>Selenium wallichianum</i> (DC.) Raizada & H.O.Saxena	Umbelliferae	2700-4000
108.	* <i>Senecio graciliflorus</i> DC.	Asteraceae	2400-4000
109.	* <i>Senecio raphanifolius</i> Wall.ex DC.	Asteraceae	2700-4400
110.	<i>Senecio scandens</i> Buch.Ham. ex D. Don	Asteraceae	1800-3600
111.	<i>Silene nigrescens</i> L.	Caryophyllaceae	300-4800
112.	<i>Sinopodophyllum hexandrum</i> (Royle) T.S.Ying	Lardizabalaceae	2400-4500
113.	* <i>Soroseris hookeriana</i> (C.B. Clarke) Stebbins	Asteraceae	4300-5500
114.	<i>Stellaria</i> sp.	Caryophyllaceae	-
115.	<i>Swertia hookeri</i> C.B.Clarke	Gentianaceae	3600-4300
116.	<i>Tanacetum</i> sp.	Asteraceae	-
117.	<i>Taraxacum officinale</i> Weber	Asteraceae	3800-5000
118.	<i>Thalictrum cultratum</i> Wallich	Ranunculaceae	2400-4200
119.	<i>Thalictrum foliolosum</i> DC.	Ranunculaceae	1500-3500
120.	* <i>Thalictrum reniforme</i> Wallich	Ranunculaceae	2800-3500
121.	<i>Thamnocalamus</i> sp.	Poaceae	
122.	<i>Torenia</i> sp.	Scrophulariaceae	
123.	* <i>Valeriana hardwickii</i> Wallich	Dipsacaceae	1500-4000
124.	<i>Valeriana jatamansii</i> Jones	Dipsacaceae	1500-3600
125.	* <i>Veratrilla bailonii</i> Franchet	Gentianaceae	3200-4600

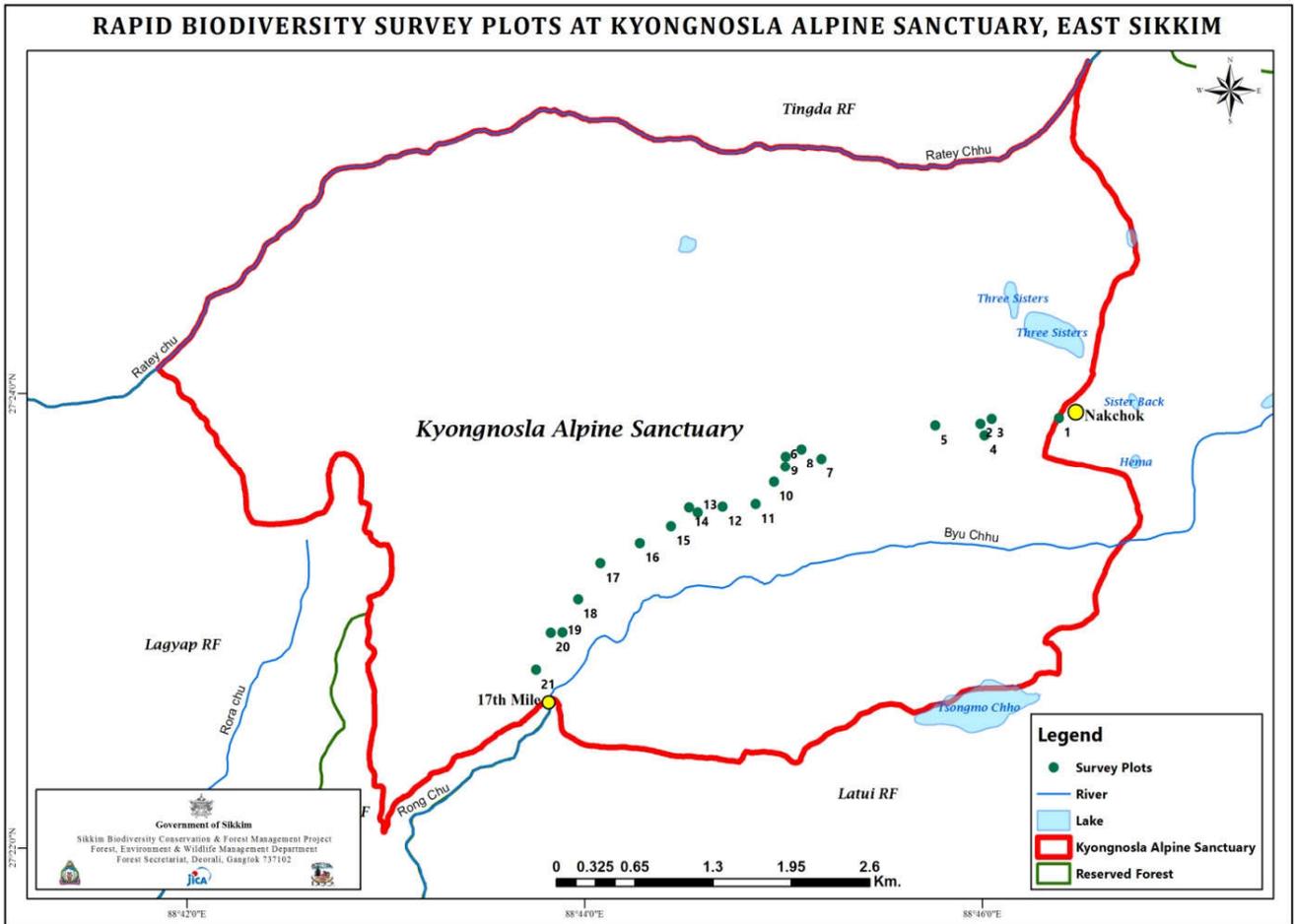


Plate 1: Forest types of Kyongnosla Alpine Sanctuary, East Sikkim



A. Alpine Pasture at Nagchok;  
Lake: Jhor Pokhari



B. Sub-Alpine Forest dominated by Rhododendrons and Iris, and scattered *Abies densa*



C. Sub-alpine forest dominated by *Rhododendron hodgsonii* and *R.thomsonii*



D. Lower belt (Sub-alpine) dominated by shrubby Bamboo and Juniper.



*Rheum nobile* Hook.f. & Thoms.



*Sassurea obvallata* (DC.) Edgew.

Plate 2: Activities of SBFP Survey Team at Kyongnosla Alpine Sanctuary



A



B



C

A: Taking field observation and capturing photographs; B: Measuring CBH of tree; C: Collecting sample of an unidentified species.

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