VEGETATION CHARACTERISTICS AND PATTERNS OF LIVESTOCK GRAZING IN CHANGTHANG PLATEAU, EASTERN LADAKH

By

G. S. Rawat & B. S. Adhikari

Submitted to

International Centre for Integrated Mountain Development

Kathmandu, Nepal

&

Wildlife Institute of India, Dehra Dun, Uttaranchal, India

May, 2002

Vegetation Characteristics and Patterns of Livestock Grazing in Changthang Plateau, Eastern Ladakh

Abstract

The Changthang plateau in the eastern Ladakh, covering an area of ca. 21,000 km^2 and mean altitude of ca. 4500 m above sea level, forms the western extension of the Tibetan plateau. Owing to cold arid environment, unique geology and palaeo-history this area harbours interesting assemblages of flora and fauna. Besides, the area supports a reasonably high biomass of domestic livestock comprising sheep, goats, yaks, donkeys and horses belonging to the Changpa herders, a nomadic pastoral community. According to official estimates the number of livestock in the area has almost doubled since 1970s. Although livestock grazing has been an age-old practice on this plateau, very little baseline information exists on the vegetation characteristics, ecology and current herding practices in these rangelands.

We studied the floristic structure, community composition and availability of forage (graminoids, forbs and shrubs) in ca. 300 km^2 area of Tso Kar basin, Changthang plateau during August-September 2001. Changpa herders were interviewed to get information on their livestock holding patterns and patterns of seasonal movement. 142 sites covering various landscape units, viz., sandy plains, marsh meadows, moist meadows, scrub steppe on the lower and higher slopes, fell-fields, and stream courses were intensively searched for the vascular plants. Each site was sampled for plant species, % cover, and abundance using 10 random quadrates of one m^2. In all 232 species of vascular plants belonging to 38 families and 101 genera were collected and recorded from the study area. Poaceae (39 species), Asteraceae (27 species), Cyperaceae (25 species), Brassicaceae (14 species), Fabaceae (12 species) and Ranunculaceae (12 species) were the dominant families. Analysis of Raunkiaer's life-forms reveals that the area is dominated by two growth forms viz., Hemi-cryptophytes (largely perennial grasses and sedges, and (ii) Chamaephytic i.e., dwarf herbs and matted shrubs whose shoots die back periodically (23.47 %). Various landscape units have been compared in terms of Prominence Value (an index of forage availability) of graminoids, forbs and shrubs. It is interesting to note that the study area had a very high (1:2) monocot : dicot ratio. We believe that the current stocking densities of livestock in the study area are at the peak and condition of rangelands are still good. Further immigration of refugee herders, increase in the livestock population and ill planned developmental activities may cause rapid degradation of pastures thereby hampering both the pastoral practices and wildlife in the region. Conservation implications of the findings and need for participatory approach of the rangeland management have been discussed.

1. 0 INTRODUCTION

The Changthang plateau in the eastern Ladakh represents an important bio-geographic province within Indian trans-Himalaya (Rodgers & Panwar 1988). This tableland forms the western extension of Tibetan plateau and lies mostly above 4500 m above sea level (asl). Consisting of ancient Tethyan sea-bed that has undergone frequent phases of glaciation and aridity, this region exhibits harsh climatic conditions and unique assemblages of flora and fauna. Much of the plateau comprises lake basins of varying size, sandy plains and rolling mountains fringed by snow peaks. The internal drainage in some of the basins has resulted in concentration of salts and minerals over the millennia making the water bodies brackish. Less than 1% of the geographical area on the plateau is cultivated and most of the vegetated zone is used by migratory pastoral communities i.e., *Changpa* herders as grazing ground. *Changpas* rear goats, sheep, yaks, and horses. Despite a poor vegetation cover, relatively low standing biomass and high anthropogenic pressure, this area sustains a considerably high livestock population. According to the Animal Husbandry Department (AHD) Ladakh' the population of sheep and goats in the area has almost doubled since 1970s (Anon. 1998). Currently the estimated number of sheep and goats in Changthang is *ca*.185686. Of this, goats and sheep account for 64 % and 36% respectively. Steady increase in the livestock population in the area is mainly attributed to influx of nomadic herders from Tibet during recent decades and perhaps better health care by the government agencies. The local *Pashmina* goats yield fine quality under wool (*Pashmina),* which is currently sold in the area at the rate of Rs. 300 – 500 per kg. It is estimated that *Pashmina* wool alone generates an annual revenue of Rs. 10 million in Changthang. There has been a tendency among herders to rear more goats compared to sheep since past few years in the wake of socio-economic changes (Rigzin Samphel, *personal communication*). The herders and AHD officials, in recent years have begun to raise concern over degradation of pastures, resultant shortage of forage, and mass mortality of livestock during severe winters. The area continues to support diverse but low populations of typical trans-Himalayan mammalian fauna and several species of migratory waterfowl including black-necked crane (*Grus nigricollis*) and Bar-headed goose (*Anser indicus*).

At present the *Changpa* herders of Changthang are at the crossroad of rapid socio-economic changes and age old pastoral practice. So far, moderate populations of herders and their livestock have co-existed with wildlife in the area. However, steady increase in the livestock number, limited areas for livestock grazing, rapid increase in the tourism and related developmental activities have caused pressure on the land and resultant conflicts between herders, wildlife managers and development agencies in the area. Despite the immense conservation significance of these rangelands as key wild habitat and as source of livelihood for *Changpa* herders, no ecological studies have been conducted in this area till date. A few studies on the floristics of the region include Kachroo et al., 1977, Chaurasia & Singh 1997, and Murti 2001. Schweinfurth (1957), Hartmann (1987), Rawat *et al*., (2000) have conducted vegetation surveys in some parts of Indian trans-Himalaya. Misri (1993), Jina (1995) and Chaudhury (2001) have conducted socio-economic surveys on the pastoral communities of Changthang. Richard (1999) deals with the rangelands and livestock as a niche opportunity for this region. Systematic surveys on various components of biodiversity in Changthang have started only recently (Anon. 2001).

Baseline studies on the vegetation characteristics, rangeland conditions, current stocking densities and patterns of livestock use would be very valuable in formulating a comprehensive conservation plan for the area. Keeping this in view, we conducted a short survey of the rangelands in the Tso Kar basin of Changthang plateau, eastern Ladakh.

Objectives

The objectives of the survey were as follows:

i. To prepare a floristic inventory of the intensive study area of Tso Kar,
ii. To study the vegetation structure and composition across various landscape units and along various environmental gradients,
iii. To assess the condition of rangelands in terms of forage availability and cover, and
iv. To study the patterns of rangeland use by the *Changpa* herders.

2.0 STUDY AREA

The survey was conducted in Rupshu plains of Changthang in eastern Ladakh (Fig. 1). The study area is divisible into More Plains and Tso Kar basin. The intensive study area lies approximately between 33º10' to 33º30' N latitudes and 77º55' to 78º 20' E longitudes, covering an area of ca. 300 km^2 and an altitudinal range of *ca*. 4400 m to 5800 m asl. The area is flanked by the Zanskar ranges in the south, Sumdo Nala, a tributary of Indus in the west, Tanglang La (5400 m asl), a high mountain pass, and the ridge extending from it in the north. Meteorological data for the study area are not available but it is regarded as colder and drier compared to other parts of Ladakh. A considerable proportion of the study area is flat with extensive sandy plains. The remaining area is gently undulating broken by few moraines and scree slopes. Tso Kar, a broad pan shaped basin, has two large water bodies adjacent to each other, *viz*., Tso Kar (*ca*. 19.5 km^2 , 4534 m) and Startsapuk Tso (*ca*. 2.5 km^2, 4545 m). While Tso Kar, a dumbbell shaped brackish water lake receives drainage from most of the basin, Tsarstapuk is a fresh water lake drained mainly by two perennial streams. Tsarstapuk also drains into the former lake. The northwestern and eastern banks of Tso Kar are rich in deposits of borax and common salt and hence unfavorable for plant growth except a few salt tolerant species such as *Axyris amaranthoides*, and *Sueda microsperma*.

The vegetation of the study area can be broadly grouped in to scrub formations, desert steppe and marsh meadows. The major plant communities include *Caragana-Eurotia, Artemisia-Tanacetum*, *Stipa-Oxytropis-Alyssum,* and *Carex melanantha-Leymus secalinus*. Very high altitudes (>5000 m) have sparse fell-field communities with moss or cushion-like growth forms, e.g., *Thylacospermum caespitosum, Arenaria bryophylla*, *Androsace sarmentosa*, and a variety of lichens. Stream banks and marsh meadows around both the lakes (except areas of borax and salt deposits) exhibit a characteristic sedge dominated vegetation represented by species of *Carex, Kobresia, Scirpus, Triglochin, Pucciniella, Ranunculus* and *Polygonum*. The shallow parts of Startsapuk support dense growth of aquatic plants such as *Hippuris vulgaris*, *Potamogeton pectinatus*, *P. perfoliatus*, *Zannichellia palustris*, and *Ranunculus natans*.

The soil texture in the study area varies from sandy to sandy loam and to limited extent clayey. The physico-chemical properties of soil under various landscape units in the study area is given in the following table.

Landscape Unit	**Texture**				**pH**	**WHC**	**OC**	**N**
	Sand	**Silt**	**Clay**	**Type**		**(%)**	**(%)**	**(%)**
Camping sites (*Leymus* patches)	98.4	0	1.6	Sandy	8.3	20.4	0.042	0.005
Lower slopes (*Caragana-Elymus*)	98.2	0.2	1.6	Sandy	8.2	20.8	0.048	0.005
Lower slopes (*Eurotia-Elymus*)	84.4	8	7.6	Loamy Sand	8.4	24.3	0.156	0.017
Lower slopes (*Euratia-Caragana*)	80.6	5.5	14	Sandy Loam	8.2	27.5	0.262	0.029
Lower slopes (bouldery)	91.4	3.4	5.2	Sandy	8.3	23.7	0.222	0.025
Middle slopes (*Caragana* scrub)	92.8	3.2	4	Sandy	8.1	20.6	0.121	0.013
Higher slopes (black soil)	87.4	5.2	7.4	Loamy Sand	8.0	27.8	0.51	0.057
Higher slopes (maroon soil)	74.7	13	12	Sandy Loam	7.9	24.5	0.06	0.007
Alluvial fans (*Eurotia – Artemisia*)	86.4	6.3	7.3	Loamy Sand	8.1	28.6	0.375	0.042
Alluvial fans (*Stipa – Elymus*)	98.4	0.3	1.3	Sandy	8.0	19.6	0.034	0.004
Valley bottom (*Carex* patches)	70.8	11	18	Sandy Clay	9.3	43.6	1.68	0.198
Sandy plains (*Stipa-Oxytropis*)	98	0.2	1.8	Sandy	7.9	22.6	0.124	0.014
Moist meadows (grass-sedge)	88.2	5.2	6.6	Sandy Clay	9.1	30.9	0.442	0.049
Marsh meadows (*Scirpus*)	93.8	2.2	4	Sandy	9.2	109.2	5.3	0.623

The water holding capacity of marsh meadows was very high (109.2%) largely due to high organic carbon. The soil under most of the landscape units was basic in nature (pH from 7.9-9.3).

The wild herbivores in the study area include Tibetan wild ass (*Equus kiang*), Ladakh urial or shapu (*Ovis orientalis vignei*), Tibetan argali or Nyan (*Ovis ammon hodgsoni*), Himalayan marmot (*Marmota bobak*) and Tibetan woolly hare (*Lepus oiostolus*). Royle's vole (*Alticola roylei*) and two species of pika (*Ochotona* spp.) are

among the common rodents in the meadows. The wild predators reported from the study area include snow leopard (*Uncia uncia*) and Tibetan wolf (*Canis lupus chanko*). Historically the area formed the distribution range of wild yak *Bos grunniens* and Tibetan antelope *Pantholops hodgsoni* (Bhatnagar 2001). Besides, the marsh meadows on the banks of both the lakes are used by a large number of migratory birds during summer including threatened black-necked crane (Singh & Jaypal 2001).

Administratively the study area lies in the Nyoma block of Ladakh district. Three major grazing units fall within the intensive study area *viz.*, Samad, Kharnak and Puga Valley (part of north Korzok). The total population of herders in Samad and Kharnak grazing units is 617. These belong to 92 families of *Changpas* and 24 Tibetan refugee families. The latter have been sharing the pastures with the *Changpas* since past 15 - 20 years. It is estimated that about 10,000 sheep and goats, 1200 yaks, and *ca*. 188 horses graze in these areas (Table 1). In recent years there has been rapid fluctuation in the number of livestock especially goats and sheep in the study area owing to mass mortality during severe winters (Figure 2). The Ladakh Autonomous Hill Council has started mobile schools for the *Changpa* herders and nearly 50 % of the children below 12 years of age attend school in the study area. The herders depend on *Amchis* (local healers) for their health care but the number of Amchis in the study area is very low (only two within Kharnak and Samad area).

Table 1: Human and Livestock Population in the Tso Kar Basin, Eastern Ladakh. (Source: Block Development Office, Nyoma)

Population Parameter	Samad Grazing Unit*	Kharnak Grazing Unit*
Total Families	61	55
Males	79	112
Females	77	106
Children	142	101
Total population	298	319
Mean Family size (±S.D.)	5.4±2.4	5.8±3.3
Sheep	2241	1552
Goats	2939	4344
Yaks	601	609
Horses	96	92
Mean LS holding/ Family (±S.D.)	106.9±62.2	121.8±91.6
Total LS population	5877	6587
Approximate area	500	300

* A grazing unit is defined as traditional sub-divisions of pastures in Changthang. At present there are four grazing units in the Nyoma block viz., Samad, Kharnak, Korzok and Hanle. Size of the unit may vary from block to block.

3.0 METHODS

i. The study area was traversed on foot as well as by vehicle, wherever feasible. The plant species were collected and recorded systematically from all the habitats and landforms. The species were categorized according to their growth habits (life-forms), habitats, forage value and any other ethnobotanical importance. We used the standard literature *viz*., Polunin & Stainton (1990), Aswal & Mehrotra (1997), and Murti (2001) for the field identification. Voucher specimens were collected for confirmation from the National Herbaria based at Dehra Dun.

ii. The study area was stratified into various landscape units for random sampling. We used random quadrates of 1 m^2 (10 at each site) following standard methods (Mueller-

Dombois & Ellenberg 1974; Kent & Coker 1992). At each sample site we recorded altitude, geographical coordinates using Global Positioning System (GPS), aspect, terrain, soil type, and vegetation cover. The data on the abundance (number) of individual species were recorded within each quadrate along with their approximate % cover. The number of sites sampled under each landscape unit / type are given below:

Landscape Units	No. of sites
1. Steppe on higher slopes	27
2. Sandy plains	25
3. Lower (<4700 m) slopes	17
4. Scrub vegetation	16
5. Moist meadow	16
6. Marsh meadow	14
7. Livestock camp sites	12
9. Fell fields and snowline	8
10. Alluvial fans (Valley Bottom)	7

iii. We interviewed the *Changpa* herders in order to get the information on the patterns of rangeland use and seasonal movement pattern. Plant specimens collected from the area (herbarium sheets) were shown to the herders to get information on the local names, uses, and preference ratings (in terms of palatability) by their livestock. Information on human and livestock population was obtained from the Block Development Office, Nyoma.

iv. We used simple measures such as density (individual plants m^{-2}), diversity (Shannon-Wiener index or H'), and richness (Menhinick's Index) as given in Maguran (1988) to describe the vegetation characteristics within various landscape units. The plant communities were classified using two way indicator species analysis (TWINSPAN; Hill 1979), a computer based polythetic divisive clustering package. Availability of

forage under various categories, *viz.*, graminoids (grasses and sedges), forbs and shrubs were compared for various landscape units using Prominence Value Index (Dinerstein 1979) as follows:

Prominence Value = % Cover x √ % Frequency

4.0 RESULTS

4.1 Floristic Structure and Composition:

i. In total 232 species of vascular plants were collected and recorded from the study area. They belong to 28 families and 101 genera. The dominant families include Poaceae (39 species), Asteraceae (27 species), Cyperaceae (25 species), Brassicaceae (16 species), and Fabaceae (12 species). An analysis of total vascular flora recorded from the study area is given in the Table 4.1 a below:

Table 4.1a: Summary of the vascular plants recorded in the Tso Kar Basin, Eastern Ladakh:

Group	Families	Genera	Species
Dicots	30	74	157
Monocots	7	26	74
Gymnosperms	1	1	1
Tso Kar	38	101	232
*Ladakh	51	190	611

* (Kachroo et al. 1977)

The list of vascular plants collected and recorded from the study area are given in Appendix-I. The number of genera and species within different families is given in Table 4.1b.

ii. The ratio of monocots to dicots in the area is 1: 2.1. This ratio is very high compared to reported ratio of Ladakh flora as a whole (1:8.30; Kachroo *et al*., 1977), alpine zone of Kumaon Himalaya (1:5.2; Rawat 1984), Deosai Plains (1:3.6; Woods *et al*., 1999), and the Valley of Flowers (1:4.2; Kala *et al*., 1998). Such a high proportion of monocots in the area may be attributed to a long history of grazing by ungulates on the plateau and ability of grasses and sedges to withstand heavy grazing.

iii. As the area represents a cold desert environment, certain groups of plants such as orchids, ferns, and liverworts were completely absent. Low diversity of *Astragalus, Pedicularis, Juncus* and high ecotypic variation among *Elymus, Poa, Artemisia, Oxytropis, Carex* and *Kobresia* are the interesting features of flora. *Hippuris vulgaris, Alyssum canescens, Zannichellia palustris,* and *Microula tibetica* are little known or new for India.

iv. The flora is dominated by Hemi-cryptophytic (graminoids) and Chamaephytic (dwarf herbs with perennial rhizome/ root stock) life forms having approximately 57 and 23% species respectively. The herbaceous dicots are generally aromatic (23%), dwarf, cushionoid (17.3%) or woolly and hairy (12%). A comparative account of life form spectrum for the study area, Ladakh and world is given in Table 4.1c.

Table 4.1b: Composition of Vascular Plants in Tso Kar Basin, Eastern Ladakh.

Family	Genera	Species
Dicotyledons		
Amaranthaceae	1	2
Apiaceae	3	4
Asteraceae	9	27
Boraginaceae	2	2
Brassicaceae	9	14
Caprifoliaceae	1	1
Caryophyllaceae	4	13
Chenopodiaceae	5	7
Crassulaceae	1	3
Euphorbiaceae	1	1
Fabaceae	4	12
Fumariaceae	1	3
Gentianaceae	3	5
Geraniaceae	1	1
Hippuridaceae	1	1
Lamiaceae	5	10
Malvaceae	1	1
Parnassiaceae	1	1
Plantaginaceae	1	1
Polygonaceae	2	6
Potamogetonaceae	1	2
Primulaceae	2	3
Ranunculaceae	4	12
Rosaceae	2	9
Salicaceae	1	1
Saxifragaceae	1	2
Scrophulariaceae	3	8
Solanaceae	2	2
Tamaricaceae	1	1
Urticaceae	1	1
Violaceae	1	1
Monocotyledones		
Amaryllidaceae	1	3
Cyperaceae	4	25
Poaceae	17	39
Juncaceae	1	2
Juncaginaceae	1	2
Zannichelliaceae	1	1
Gymnospermae		
Ephedraceae	1	1
Total	101	232

4.1c: Life Form Spectrum of the Changthang Flora

Life form class^	Life form Spectra (% species)		
	Changthang	Ladakh*	Normal**
Phanerophytes (Ph)	-	2.62	28
Nannophanerophytes (N)	0.93	4.84	15
Chamaephytes (Ch)	23.47	26.83	9
Hemicryptophytes (H)	56.52	9.61	26
Geophytes (G)	4.78	21.31	4
Hydrphytes (HH)	2. 17	0.62	2
Therophytes (T)	11.73	33.18	13

* Kachroo *et al*. 1977; ** Raunkaier 1934

^ *Phanerophytes = Trees > 2 m high; Nannophanerophytes = small trees < 2 m high; Chamaephytes = Woody or herbaceous perennials with buds close to the ground; Hemicryptophytes = Rosette or tussock forming plants in which above ground parts die back during unfavourable period e.g., graminoids; Geophytes = Plants with sub-terranean bulbs, tubers or thick rhizomes; Hydrphytes = Aquatic plants; Therophytes = Annual herbs which survive the unfavorable period as sees. (Kent & Coker 1992 for more details).*

Based on the growth habits the plant species in the study area are divisible into graminoids (66 species), dwarf shrubs and undershrubs (16 species), aquatic and semi-aquatic herbs (12 species), tuberous herbs (4 species), perennial herbs with thick underground root stock (40 species), woolly and cottony herbs (15), dwarf cushionoid herbs (22), prostrate herbs (32) and annual or biennial herbs (27).

4.2 Vegetation Characteristics

i. Four distinct physiognomic units of vegetation were discernible in the study area, *viz*., (a) scrub steppe (*Caragana-Eurotia, Artemisia,* and *Tanacetum* formations), (b) desert steppe (*Stipa-Alyssum-Oxytropis, Leymus secalinus* and *Carex melanantha* types), (c) wet and marsh meadows dominated by sedges, and (iv) cushionoid vegetation or fell-fields at higher altitudes (>4800 m). The scrub steppe, desert steppe, sedge meadows

and fell-fields formed approximately 20, 40, 5 and 10% of the land surface in the intensive study area respectively. The remaining 25% area falls under steep rocky, scree slopes and snow fields. The vegetation in all the physiognomic units was characteristically low (<50 cm in height) and sparse as in other parts of trans-Himalaya.

ii. The four physiognomic units of vegetation identified above, if seen along the microtopographic and other environmental gradients, can be divided into nine habitat types or landscape units, *viz*., marsh meadows, moist meadows, sandy plains, alluvial fans, lower (grassy) slopes, fell-fields and livestock camps. These categories varied considerably in terms of % cover, density, species richness and diversity (Table 4.2a).

iii. Highest vegetation cover during peak of the growing season was recorded within marsh meadows (92.00$\pm$5.6%) and lowest within the desert steppe (36.6 $\pm$ 12.5%). Highest stem densities were observed in marsh meadows (544 $\pm$ 300.5 m^{-2}) followed by moist meadows (507$\pm$ 376.2 m^{-2}). Such a high density is largely due to dominance of tussock and tiller forming sedges in these landscape units. Plant densities (m^{-2}) were low in alluvial fans (14 $\pm$4.1) and scrub steppe (23 $\pm$4.0). Species richness was lowest around livestock camps (4.8 $\pm$ 1.7) followed by lower slopes (6.2$\pm$2.5), sandy plains (6.6 $\pm$ 2.9) and alluvial fans (6.8 $\pm$ 2.2). Although moist and marsh meadows had highest values of species richness, the higher slopes dominated by a variety of grasses and forbs had equally high species diversity (Table 4.2 a). Species diversity within scrub vegetation was also high (H'= 1.53) compared to various other landscape units.

Table 4.2a: Vegetation parameters across various landscape units in Tso Kar basin.

Habitat type	Sites (#)	Total Species	Cover (%)	Density (m^{-2})	Species Richness	Diversity
Marsh meadow	*14*	52	92±5.6	544±300.5	11±4.1	1.37±0.5
Moist meadow	*16*	43	89±11.2	507±376.2	12±4.2	1.55±0.5
Sandy plains	*25*	56	49±22.7	80±110.1	6.6±2.9	1.09±0.6
Alluvial fans	*7*	17	30±9.1	14±4.1	6.8±2.2	1.25±0.3
Lower slope	*17*	*33*	47±13.6	34±6.2	6.2±2.5	1.16±0.3
Scrub steppe	*16*	*18*	31±9.5	23±4.0	9.3±1.5	1.53±0.3
Higher slopes	*27*	*55*	40±16.5	59±13.8	9.2±2.5	1.55±0.4
Fell fields	*8*	*17*	38±10.4	38±5.2	8.8±1.0	1.49±0.1
Livestock camps	*12*	*26*	42±12.5	83±79.8	4.8±1.7	0.6±0.4

iv. A total of 16 plant communities were segregated in the study area using TWINSPAN. Distribution of these communities with respect to three major environmental gradients, *viz*., soil moisture, altitude and micro-topography are depicted in Fig. 3. In terms of area coverage the desert steppe, *i.e*., *Stipa-Alyssum-Oxytropis* and scrub steppe (*Caragana-Poa*) were most extensive. Communities I – VI (*Scirpus–Carex, Scirpus-Carex-Ranunculus, , Scirpus-Kobresia-Ranunculus, Pucciniella-Polygonum-Carex, Polygonum-Munuarta-Carex* and *Carex-Polygonum-Elymus*) were confined to moist and wet (marsh) meadows along the gradients of moisture in the valley bottom and stream courses. Towards higher altitudes (>4800 m) especially on the wind blown rocky slopes *Poa-Elymus-Artemisia* and *Tanacetum tibeticum* communities were prominent. *Eurotia ceratoides* (a perennial shrub) and *Leymus secalinus* (a coarse grass) formed pure stands of their own near hill bases. The density, species richness, and diversity for various communities have been compared in Table 4.2b. It was found that the communities 1-6 had the higher density, diversity and species richness compared to all other communities. Overall cover, density, species richness and diversity followed the gradients of soil moisture and micro-topography rather than altitudinal gradient (Table 4.2b). Most of the livestock camps were characterized by the prominence of an unpalatable nitrophilous herb, *Chenopodium glaucum*, and a coarse grass *Leymus secalinus*.

Table 4.2b: Characteristic features of selected plant communities in Tso Kar basin, Changthang Plateau.

Community type	Cover (%) ±SD	Density (m^{-2}) ±SD	Species Richness	Diversity (H')
Scirpus-Carex	88.5±8.5	468.2±115.4	12.0±3.2	1.301±0.511
Scirpus-Carex-Ranunculus	94.0±6.2	743.7±406.7	12.3±3.3	1.472±0.266
Scirpus-Kobresia-Ranunculus	91.3±11.1	708.2±519.5	15.3±3.9	1.679±0.387
Puccinella-Polygonum-Carex	83.3±20.2	348.1±300.0	4.0±1.0	0.740±0.743
Polygonum –Minuarta-Carex	85.5±11.4	227.1±62.3	8.3±1.5	1.556±0.390
Carex-Polygonum-Elymus	90.0±8.7	235.1±32.9	9.7±3.1	1.622±0.605
Stipa-Alyssum-Oxytropis	36.6±12.5	34.7±36.1	7.3±2.2	1.321±0.357
Carex-Oxytropis-Artemisia	55.9±22.6	99.4±116.4	8.5±3.7	1.232±0.788
Poa-Elymus-Artemisia	61.7±23.6	27.6±29.8	5.3±1.5	1.006±0.177
Leymus	60.0±0.0	55.7±57.8	3.0±0.0	0.143±0.193
Chenopodium	40.0±14.1	77.8±36.1	4.5±0.7	0.341±0.479
Chenopodium – Leymus	46.0±12.9	61.2±45.5	3.8±1.3	0.537±0.217

4.3 Assessment of grazing lands

Despite the cold arid conditions, short growing season and intensive use by the livestock as well as wild herbivores, the study area supports reasonably good vegetation cover. Except livestock campsites and scrub steppe all other landscape units were dominated by graminoids. Forbs and shrubs had low prominence value. The marsh meadows had the highest proportion of graminoids (primarily sedges). Although the marsh meadows around Tso Kar and Starstapuk Tso form only *ca.* 5 % of the study area, these patches support a considerable population of livestock (nearly 5000 sheep and goats, 600 yaks and over 80 horses) during crucial winter months. During summer this area serves as an important breeding ground for the migratory waterfowl including black-necked crane. The

availability of forage in terms of prominence values in various landscape units is given below (Table 4.3; Fig. 4):

Table 4.3: Prominence Values (PV) as an index of forage availability of graminoids, forbs and shrubs in various Landscape Units of Tso Kar Basin.

Landscape / Vegetation Type	Prominence Value		
	Graminoids	**Forbs**	**Shrubs**
Livestock Camp Sites	74.50	**235.90**	29.10
Desert Steppe (Plains)	**237.70**	115.60	73.90
Steppe on the Lower Slopes	**371.40**	68.10	12.80
Higher Slopes and Ridges	**179.70**	109.70	41.80
Scrub Steppe	100.63	38.71	**328.65**
Moist Meadows	**642.20**	100.80	44.70
Marsh Meadows	**850.00**	88.40	0.00

Preponderance of graze resistant grass and sedge (graminoid) communities in the study area can be attributed to a long and evolutionary history of grazing by ungulates. This, however, doesn't preclude the low primary productivity and limited carrying capacity of the pastures. Crude density of livestock in the study area at present is as high as 41.54 km^{-2}. Mass mortality of livestock during severe winters due to shortage of forage and decline in wool production have been major complaints by the herders (Mr. Konchok Stanzin, *pers. communication*). While most of the sandy plains and mountain slopes appear to be stable in terms of vegetation cover, a few areas show the signs of degradation especially the lower slopes close to camping sites from where *Caragana* and *Eurotia* bushes have been systematically removed for the fuel wood. Heavily grazed areas are characterized by the abundance of *Carex melanantha, Leymus secalinus*, and an unpalatable herb *Chenopodium glaucum*. The former species are less preferred during summer and may form bulk forage during winter season. According to the herders Starstapuk area has the adequate vegetation cover to support most of the livestock from

Samad area during winter while lower areas of Kharnak are in poor condition. We didn't notice any exotic or recently invaded species in the study area. This means the palatable species still have chances to regenerate and general cover of vegetation could increase if the area gets slight relief and other land use practices (e.g., ill planned developmental activities) are kept under control. Based on these considerations over all condition of rangelands in the study area may be rated as 'good'.

4.4 Patterns of livestock grazing by *Changpa* herders

The *Changpas* follow a traditional and definite pattern of seasonal movement. The three grazing units in the study area *viz*., Kharnak, Samad and northern parts of Puga valley differ considerably in terms of pasture availability during various seasons. The family groups and Tibetan refugees use the demarcated areas. It was reported that in recent years many more refugee families have immigrated to the eastern part of the study area. The seasonal use of various pastures and movement pattern of the herders in Samad area is given in Fig. 4.

The *Changpas* of Samad area arrive at Pongonagku for new year celebration by mid November. About 8 families designated on rotation for the service of Thugje Gompa reach directly at Rale village for the occasion. The celebration lasts for about 5-6 days. Soon rest of the families from Pongonagku also march towards their camp at Rale (near Thugje). The pastures around Pongonagku and Rale, relieved from summer grazing, sustain all the livestock in the area for about 3 – 4 weeks. By late December *i.e*., onset of severe winter, the herders move to the southern banks of lake Starstapuk. While the local herders (*Changpas*) follow the left bank of Tso Kar which is shorter and more vegetated to reach the winter camps, the refugee herders have to follow the drier and longer route through the right bank. The marsh meadows around Starstapuk, stream courses and the lower hill slopes are said to be best wintering areas. Hence the herders spend two to three months (January – March) around this area in three groups. During heavy snowfall male yaks are taken to higher slopes along the Nuruchan stream to feed among the *Caragana* scrub. By late March or early April all the herders move to the left bank of Polokongkha

stream (southern and warmer slopes) for two to three weeks. Camps may be shifted to Polokongkha earlier in the event of heavy snowfall and severe weather. During late April or early May that marks the beginning of spring (new sprout), the herders again congregate around Rale and Pongonagku when they harvest wool. Thereafter, the herders move to More plains (Chhubjang, Rolechen, Rockchung, and Mangjul areas) for two months i.e., till mid June. Peak summer (late June to August) is spent in southern parts of More Plains (Norchung, Chorchen, and Rena). Male yaks and horses are separated and taken further south to Phirtse area near Pang during peak summer in order to reduce competition and provide adequate grazing areas to cows and calves. Towards the end of August all the herders bring back their livestock for 2-3 days to Rolechen area for salt and water at the western bank of Tso Kar. During September the herders move towards upper Kiamchuthang, Zara Nala and slopes of Tanglang La. The head man (*Gub/Goba*) usually occupies centrally located pasture and keeps liaison between the herders and the government representatives. The rules and traditions are well laid and the position of the *Gub* is rotated annually. Usually lottery system (drawing the name out of all the family heads) is adopted to select a Gub. Throughout the summer and fall the herders keep themselves busy collecting fuel (brush wood and dung) as well as ration for the winter. Depending upon the weather conditions the herders move between lower and higher slopes of Kiamchuthang and Tanglang La during October and early November. Finally, they proceed to Pongonagku for much awaited new year celebration. This system of rotation in the study area, according to herders, has been in practice since several decades and appears to be sustainable. Concerns have been raised only after the influx of refugee herders.

The Samad area appears to have relatively better summer and winter pastures compared to Kharnak and Ankung (northern Korzok). Nevertheless, most of the herders in the study area feel the necessity of additional forage supply and cattle feed during winter. Kharnak and Ankung herders informed us that they have to keep winter stock of additional barley and rice flour as feed for milking yaks. Such a practice is reported throughout the Tibetan region (Camille Richard, *personal communication*). A limited amount of fodder is cultivated in Ankung village (Puga valley). In recent years the AHD has initiated the fodder development programme at Nuruchan. Encouraged by the Block Development

Office, nearly 40 families and a few refugee families of Samad have also started cultivating fodder as winter feed near Nuruchan. Other families don't cultivate fodder owing to shortage of manpower and old age. The herders were appreciative of such an effort. However, long term implications of diverting water channels and intensive use of the area for fodder cultivation need to be understood. Diversion of water from the feeder stream of Starstapuk may change the hydrology, ecosystem functioning and productivity of the marsh meadows down stream.

5.0 DISCUSSION

Changthang plateau has been reported as floristically impoverished compared to other areas of Ladakh by earlier authors (e.g., Kachroo *et al*., 1977, Chaurasia and Singh 1997). An update on the flora based on the present survey reveals that it harbours at least 232 species of vascular plants. This study also underlines the importance of graminoids in the flora of the region. It can be stated that though the Tso Kar basin forms only less than <1% of the geographical area of Ladakh, it harbours nearly 25% of the reported flora from the region. Since the area forms a continuum with the vast Tibetan plateau, very few endemic species are expected from the study area. Species sensitive to heavy trampling, grazing and aridity such as orchids and ferns were completely absent in the present study area. The following species were either absent or extremely rare in the study area (which are otherwise common in other parts of trans-Himalaya): *Ephedra gerardiana, Rosa webbiana, Lonicera spinosa, Salix* spp*., Juniperus spp., Berberis* spp*., Hippophae tibetana, Cicer microphylla* and *Cotoneaster* spp. Selective removal of some of these species for fuel wood or over grazing through centuries and failure of regeneration cannot be ruled out. Palynological studies in the area could reveal some of the interesting facts of phytogeography.

Sixteen plant communities identified in the study area based on TWINSPAN follow the gradients of soil moisture, micro-topographic variation and altitude. General cover, density, species richness and diversity values were more pronounced along the gradients of soil moisture and micro-topography rather than altitude as indicated by very

low correlation coefficients. Compared to the herbaceous alpine meadows of the Greater Himalaya (e.g., Kala et al., 1997, Singh and Rawat 1999), the steppe formations in the study area have higher proportions (both diversity and prominence value) of graminoids. Higher diversity and biomass of grazing ungulates, both wild and domestic, in the trans-Himalaya compared to moist and smaller pockets in the alpine areas suggest that the former ranges have had much older evolutionary history with grazing ungulates that could have resulted in the prominence of graminoids (Bock *et al*., 1995). Koirala *et al*., (2000) have also reported higher prominence of graminoids from the cold-arid pastures of upper Mustang area of Nepal.

Are the rangelands in the study area degraded ? Based on the general vegetation cover, density and diversity (Table 4.2b) as well as high prominence values of graminoids in most of the landscape units (Table 4.3) overall condition of the rangelands in the Tso Kar basin (especially Samad grazing block) could be rated as 'good'. Miller and Schaller (1996) have reported only 10 – 16 % cover of vegetation (rest bare ground) from eastern Chang Tang Reserve, Tibet. Similarly, from the adjacent region of trans-Himalaya i.e., Kibber plateau of Spiti, Mishra (2001) has reported low vegetation cover compared to the present study area and stated that a majority of the rangelands in the Spiti Valley are overstocked and that the human impacts on the vegetation are intensive and widespread. Owing to more intensive agro-pastoral activity, it is likely that pastures on Kibber plateau are more degraded compared to Tso Kar basin. Forage availability in terms of biomass during winter season, and proportions of palatable and unpalatable species in the range would give the true picture of rangeland condition. Future studies in the area need to address these parameters.

According to herders most of the graminoids are highly palatable during summer except *Leymus secalinus* and *Carex melanantha*. Most preferred species by livestock, according to herders, include Pangsa (*Kobresia* spp.), Sahu (*Leontopodium himalayanum*), Jhak (*Elymus longe-aristaus* and *E. nutans*), Havre (*Saussurea ceratocarpa*), Shyot (*Stipa orientalis* and *S. sibirica*), Nyargal (*Oxytropis microphylla*), Semu (*Poa* spp.), and Trolo (*Potentilla bifurca*). But several herbs and shrubs e.g., *Artemisia* spp., *Tanacetum* spp.,

Caragana versicolor, Kochia indica, Axyris amaranthoides, Bieberstenia odora, Hyoscyamus niger, Physochlaina praealta, Scrophularia scabiosaefolia, Ranunculus spp., and *Urtica hyperborea* are not preferred as forage by the livestock during summer. During autumn and winter most of the livestock prefer to feed on *Eurotia ceratoides*, *Artemisia sieversiana, A. gmelini,* and several aromatic herbs, which are otherwise avoided during the growing season. *Caragana versicolor,* a leguminous and low thorny bush, is the main source of fuel wood for the herders in the study area. Systematic removal of this species from the lower slopes followed by soil erosion has resulted in the desert like conditions in such areas and reduced species diversity (Table 4.2 a). *Caragana* being a thorny and less penetrable protects several forbs and grasses from being grazed. It may also facilitate the growth of associated species by increasing N availability in the soil.Yaks feed among the *Caragana* scrub during peak winter partly on the young twigs, fallen leaf litter or associated species. Sheep and goats are also known to suck the fallen leaves of *Caragana* during extreme fodder scarcity and may browse on young sprouts and flowers of *Caragana* during spring (R. Samphael, *pers*. *communication*). It is, therefore, evident that this species plays an important role in sustaining the associated species and buffering the ecosystem from excess of biotic pressure in these rangelands. Interestingly, *Caragana* scrub doesn't figure out as a distinct vegetation type in the Chang Tang Reserve of Tibet although other plant communities are similar (Schaller 1998).

Present stocking densities of livestock (35 – 41 animals km^{-2}) in the study area seems to be at its peak and those of wild ungulates quite low. During a period of four – five weeks we encountered one group of shapu (14 individuals), a group of nyan (8 nos.), ca. 10 –12 groups of kiang (2 – 4 individuals), besides occasional marmots and Tibetan woolly hares. According to the herders the wild animals mostly use the higher slopes to the north of Samad and Polokongkha. The data on indirect evidences collected by us (e.g., spoor, including those of snow leopard and Tibetan wolf) corroborates this. Some of the herders complain that their winter pastures get depleted by kiangs but also report that kiangs undergo frequent mortality during severe winters.

Recently, the Jammu & Kashmir State Wildlife Department has declared Changthang (including the present study area) as wildlife sanctuary. However, no management plan has been prepared for the area. It may be pertinent to note that further increase in the livestock population and intensification of land use in terms of tourism development, construction and settlements may negatively affect the rangelands as well as wildlife populations. Therefore, a careful and participatory planning would be essential for the long term conservation of these rangelands and their constituents - the *Changpas*, their livestock and the wildlife.

6.0 CONCLUSIONS

An updated inventory of Changthang (Ladakh) flora highlights the preponderance of graminoids, and evolutionary history of grazing by wild and domestic ungulates. Continued biotic pressure coupled with harsh climatic conditions in the area has manifested in the dominance of Hemi-cryptophytic and Chamaephytic Life-forms. As many as 16 plant communities have been identified in the study area, which are distributed along the gradients of soil moisture, altitude and micro-topography. Relative proportions of graminoids, forbs and shrubs (in terms of prominence value) across various landscape units have been analyzed. A preliminary account of current herding patterns followed by the *Changpas* within Samad grazing unit has been discussed that needs to be investigated further. Although overall rangeland conditions in the Tso Kar basin seems to be 'good', the conditions may degrade in near future owing to steady increase in the livestock population and shortage of pastures. For the sustainable use of rangelands and long term conservation of the entire ecosystem a careful planning based on participatory approach backed by researched information would be essential. We, therefore, recommend the following strategies and action points for these unique rangelands:

i. Establishment of long term vegetation monitoring plots and initiate experimental studies to understand the effect of fuel wood removal and intensive grazing on the vegetation, and also to document the process of vegetation recovery in the area,

ii. Additional studies in the wintering ranges of livestock and wild ungulates and studies on the palatability, biomass availability and relative forage quality (in terms of nutrients) of the major species in the region,

iii. Evolve a joint management strategy for the conservation of the area involving the major stakeholders in the area *viz*., the *Changpa* herders, management authorities of Changthang Wildlife Sanctuary, Block Development Office, Departments of Animal Husbandry and Tourism.

iv. The marsh meadows in the study area serve as important livestock grazing grounds during autumn – winter and crucial breeding areas for migratory birds during summer. These areas need to be given highest priority and any developmental activities such as changes in the landuse around these meadows, diversion of water channels for the tourist camps and buildings are likely to cause disturbances and threats to these areas. Such activities need to be minimized in the area.

ACKNOWLEDGEMENTS

This study was jointly funded by the International Centre for Integrated Mountain Development (ICIMOD), Kathmandu and CLFRS programme at the Wildlife Institute of India (WII). We are thankful to Ms. Camille Richard, Rangeland Management Specialist at ICIMOD, for taking keen interest in the study and help in arranging the funds. We are grateful to Shri S.K. Mukherjee, Director, WII for the encouragements. Drs. V.B. Mathur, Y.V. Bhatnagar and Shri Qamar Qureshi facilitated the survey and helped us in various ways during the study. Our special thanks are due to Shri P.L. Saklani, Herbarium Technician at WII for his invaluable assistance in conducting this study both in the field and at headquarters. We extend our sincere thanks to Dr. T. Phuntsog from Animal Husbandry Department, Ladakh, all the officials from the Wildlife Department based at Leh, Mr. Rigzin Samphel of Block Development Office at Nyoma, Mr. Konchok Stanzin, Mr. Chain Singh (driver) and field assistants for their help and assistance.

REFERENCES

Anonymous. 1998. Statistical Handbook, Govt. of Jammu & Kashmir, District Leh 1996-97. Directorate of Economics and Statistics. District Statistical Evaluation Agency, LAHDC, Leh.

Anonymous. 2001. Conserving Biodiversity in the Indian Trans-Himalaya: New Initiatives of Field Conservation in Ladakh. First Annual Technical Report, (1999-2000). Wildlife Institute of India, International Snow Leopard Trust and US Fish & Wildlife Service.

Aswal, B. S. and Mehrotra, B. N. 1994. Flora of Lahaul-Spiti (a cold desert in north west Himalaya. Bishen Singh Mahendra Pal Singh, Dehradun, India.761pp.

Bhatnagar, Y.V. 2001. Status Survey of Large Mammals in Eastern Ladakh and Nubra. Pp. 108-135. In Anonymous Report: Conserving Biodiversity in the Indian Trans-Himalaya: New Initiatives of Field Conservation in Ladakh, Wildlife Institute of India, International Snow Leopard Trust and US Fish & Wildlife Service.

Bock, J.H., Jolls, C.L. and Lewis, A.C. 1995. The Effects of Grazing on Alpine Vegetation: A Comparision of the Central Caucasus, Republic of Georgia, with Colorado Rocky Mountains, U.S.A. Arctic and Alpine Research 27 (2):130-136.

Chaudhury, A. 2001. Poverty and Development among the Changpas. Unpubl. Ms. International Centre for Integrated Mountain Development, Kathmandu, Nepal.

Chaurasia, O.P. and Singh, B. 1997. Cold Desert Plants Vol. – III: Changthang Valley. Field Research Laboratory, DRDO, Leh. 84 Pp.

Dinerstein, E. 1979. An Ecological Survey of Royal Karnali-Bardia Wildlife Reserve, Nepal. Part K: Vegetation, modifying factors and successional relationship. Biol. Conserv. 15: 127-150.

Hartmann, H. 1987. Pflanzengesellschanften trockener Standorte aus der subalpine und alpine Stufe im sudlichen und ostlichen Ladakh, Candollea 42 (1) : 277 – 326.

Hill, M.O. 1979. TWINSPAN – A fortan programme for arranging multivariate data in an ordered two way table by classification of the individuals and attributes. Ithaca, Cornell University, New York.

Jina, P.S. 1995. High Pasturelands of Ladakh Himalaya. Indus Publishing Co. New Delhi. 142 pp.

Kachroo, P., Sapru, B.L. & Dhar, U. 1977. Flora of Ladakh: An Ecological and Taxonomic appraisal. Bishen Singh Mahendra Pal Singh, Dehra Dun.

Kala, C.P., Rawat, G.S. & Uniyal, V.K. 1998. Ecology and Conservation of the Valley of Flowers National Park, Garhwal Himalaya. Wildlife Institute of India, Dehra Dun. 99 pp.

Kent, M. and Coker, P. 1992 Vegetation description and analysis. A practical approach, Belhaven Press, London 363 pp.

Koirala, R.A., Shrestha, R. and Wegge, P. 2000. Grasslands in the Damodar Kunda Region of Upper Mustang, Nepal. Pp. 53-67. in Richards, C. et al., Grassland Ecology and Management in Protected Areas of Nepal., International Centre for Integrated Mountain Development.

Maguran, A.E. 1988. Ecological diversity and its measurement. Croom Helm. 179 pp.

Miller, D. J. and Schaller, G. 1996. Rangelands of the Chang Tang Wildlife Reserve in Tibet. Rangelands 18: 91-96.

Mishra, C. 2001. High altitude survival: conflicts between pastoralism and wildlife in the Trans-Himalaya. Wageningen University, The Netherlands. Doctoral Thesis. ISBN 90-5808-542-2.

Misri, B. 1993. Pastures, Pashmina and the Changpas of Changthang. In Pangtey, Y.P.S. and Rawal, R.S. (Eds.). High Altitudes of the Himalaya: Biogeography, Ecology and Conservation. Pp. 255-262. Gyanodaya Prakashan, Naini Tal.

Mueller-Dombois, D. & Ellenberg, H. 1974. Aims and Methods of Vegetation Ecology. John Wiley & Sons, New York, 547 pp.

Murti, S.K. 2001. Flora of Cold Deserts of Western Himalaya. Vol. I (Monocotyledons). Botanical Survey of India. 452 pp.

Polunin, O. and Stainton, A. 1984. Flowers of the Himalaya. Oxford University Press, Delhi.

Raunkaier, C. 1934. The Life Forms of Plants and Statistical Plant Geography. Clarendon Press. Oxford.

Rawat, G.S. 1984. Studies on the high altitude flowering plants of Kumaon Himalaya. Ph. D. Thesis, Kumaun University, Naini Tal.

Rawat, G.S., Adhikari, B.S. & Rana, B.S. 2001. Vegetation surveys in the Indian Trans-Himalaya. Pp. 7 – 14. In Anonymous Report: Conserving Biodiversity in the Indian Trans-Himalaya: New Initiatives of Field Conservation in Ladakh, Wildlife Institute of India, International Snow Leopard Trust and US Fish & Wildlife Service.

Richard, C. 1999. Rangelands and Livestock as a niche opportunity for Ladakh. International Centre for Integrated Mountain Development, Kathmandu, Nepal.

Rodgers, W.A. and Panwar, H.S. 1988. Planning a protected area network for India. Wildlife Institute of India, Dehra Dun. Vol. I & II.

Schaller, G. B. 1998. Wildlife of the Tibetan-Steppe. Chicago: The University of Chicago Press. 373 pp.

Schweinfurth, U. 1957. *Die horizontale und vertikale Verbreitung der Vegetation im Himalaya*, Boner Geographische Abhandlungen Heft 20, 372 pp.

Singh, P. and Jaypal, R. 2001. A Survey of Breeding Birds of Ladakh. In Anonymous Report: Pp. 74-104. Conserving Biodiversity in the Indian Trans-Himalaya: New Initiatives of Field Conservation in Ladakh, Annual Technical Report, Wildlife Institute of India, International Snow Leopard Trust and US Fish & Wildlife Service.

Singh, S.K. and Rawat, G.S. 1999. Flora of Great Himalayan National Park, Himachal Pradesh. Bishen Singh Mahendra Pal Singh, Dehra Dun. 304 pp.

Woods, C.A., Kilpatrick, C.W., Rafique, M., Shah, M. and Khan, W. 1999. Biodiversity and Conservation of Deosai Plateau, Northern Areas, Pakistan. In Mufti, S.A. et al., (eds.). Biodiversity of Pakistan. Pp. 33-59. Pakistan Museum of Natural History, Islamabad & Florida Museum of Natural History, Gainseville.

Appendix-I: Plants collected and recorded from -Tsokar basine, Eastern Ladakh

Abundance (Abun): **SR**=Site Record; **S**= Sparse; **O**= Ocassional; **R**= Rare; **F**= Frequent

Life Forms (LF): **H** = Hemicryptophytes; **G**= Geophytes; **Ch**= Chaemephytes; **T**= Therophytes; **HH** = Hydrophytes; **N**= Nanophanerophytes

Botanical Name	Family	Coll. No.	Abun	LF
*Aconogonum tortuosum (*D.Don) Hara	Polygonaceae	53335	F	Ch
Agrostis sp.	Poaceae	5318	S	H
Allium auriculatum Kunth	Amaryllidaceae	5349	O	G
Allium jacquemontii Kunth	Amaryllidaceae	SR	S	G
Allium victorialis L.	Amaryllidaceae	5537	R	G
Alyssum canescens DC.	Brassicaceae	5396, 5422	F	Ch
Androsace sarmentosa Wall.	Primulaceae	SR	F	Ch
Androsace sp.	Primulaceae	5475	S	Ch
Arabidopsis himalaica Schulz	Brassicaceae	SR	O	T
Arenaria festucoides Benth.	Caryophyllaceae	SR	F	Ch
Arenaria glanduligera Edgew.	Caryophyllaceae	5490	S	Ch
Arenaria serpyllifolia L.	Caryophyllaceae	SR	O	Ch
Arenaria sp.	Caryophyllaceae	5480	F	Ch
Arenaria bryophylla Fernald.	Caryophyllaceae	5348, 5425	O	H
Arnebia guttata Bunge	Boraginaceae	5510	S	H
Artemisia biennis Willd.	Asteraceae	5463	F	H
Artemisia gmelinii Web. ex Stechm.	Asteraceae	5328, 5347	F	Ch
Artemisia macrocephala Jacq. ex Bess	Asteraceae	5304, 5507, 5534	O	Ch
Artemisia salsoloides Willd.	Asteraceae	5395	F	Ch
Artemisia scoparia Wald. & Kit.	Asteraceae	5417, 5558	O	Ch
Artemisia sieversiana Willd.	Asteraceae	5334	F	Ch
Artemisia wallichiana Bess. Var.	Asteraceae	5359	O	Ch
Aster molliusculus (Lindl. ex DC.) Cl. Var. *minor*	Asteraceae	5464	O	Ch
Aster sp.	Asteraceae	5464	R	Ch
Astragalus confertus Benth ex Bunge	Fabaceae	SR	O	Ch
Avena sativa L.	Poaceae	5483	S	T
Axyris amaranthoides L.	Chenopodiaceae	5447	F	H
Bieberstainia odora Steph	Geraniaceae	SR	O	Ch
Brassica napus L.	Brassicaceae	5477	O	T
Bromopsis sp ?	Poaceae	5366	O	H
Calamagrostis holciformis Jaub. & Spach.	Poaceae	5317, 5456	O	H
*Calamagrostis pseudophragmites (*Hall.f.) Koel.	Poaceae	5376	O	G
Calamogrostis sp.	Poaceae	5568	F	H

Caragana versicolor (Wall.) Benth.	Fabaceae	5327	F	Ch
Carex borii Nelmes	Cyperaceae	SR	O	T
Carex diluta Bieb.	Cyperaceae	5403	F	H
Carex gracilenta Bieb. ex Boeck	Cyperaceae	5319	F	H
Carex melanantha Mey	Cyperaceae	5307, 5470	F	H
Carex microglochin Wahlb.	Cyperaceae	SR	F	H
Carex nivalis Boott	Cyperaceae	SR	F	H
Carex orbicularis Boott.	Cyperaceae	SR	S	H
Carex parva Nees	Cyperaceae	SR	O	H
Carex sp.	Cyperaceae	5459, 5474	O	H
Carex stenophylla Wahlb	Cyperaceae	SR	S	H
Carex stenophylla Wahlb.	Cyperaceae	5413	F	H
Catabrosa aquatica (L.) P. Beauv.	Poaceae	5404	O	H
Catabrosella himalaica (Hk.f.) Tzv.	Poaceae	SR	S	H
Chenopodium botrys L.	Chenopodiaceae	5400, 5444, 5524	F	H
Chenopodium glaucum L.	Chenopodiaceae	5325	F	T
Chenopodium sp.	Chenopodiaceae	5447	S	H
Chorispora sabulosa Camb	Brassicaceae	5548	F	H
Christolea crassifolia Camb	Brassicaceae	5530, 5542	F	Ch
Christolea himalayensis (Camb.)Jafri.	Brassicaceae	SR	R	H
Cicer microphyllum Benth.	Fabaceae	5346	S	Ch
Corydalis adiantifolia Hk.f. & T.	Fumariaceae	5501, 5344	S	Ch
Corydalis moorcroftiana Wall. ex Hk.f. & T.	Fumariaceae	SR	S	Ch
Corydalis sp.	Fumariaceae	5344	R	Ch
Delphinium brunonianum Royle	Ranunculaceae	SR	R	Ch
Deschampsia caespitosa (L.) P. Beauv.	Poaceae	5468	S	H
Deschampsia koeleroides Regel	Poaceae	5561	S	H
Draba alpina Hk.f. & T.	Brassicaceae	5556, 5557	O	T
Draba altaica Bunge	Brassicaceae	SR	O	H
Draba oreades Schrenk	Brassicaceae	SR	O	H
Dracocephalum heterophyllum Benth.	Lamiaceae	5358, 5412	F	H
Elaeocharis sp.	Cyperaceae	5407	F	T
Elsholtzia ciliata (Thunb.) Hyland.	Lamiaceae	SR	S	H
Elsholtzia eriostachya Hk.f. *var.*	Lamiaceae	5436, 5471	F	H
Elymus dahuricus Turcz. Ex Griseb.	Poaceae	SR	F	H
Elymus longe-aristatus (Boiss.) Tzve	Poaceae	5316,5409, 5414, 5322	F	H
Elymus nutans Griseb.	Poaceae	5301	F	H
Elymus semicostatus Nees ex Steud.	Poaceae	SR	F	H
Ephedra gerardiana Wall.	Ephedraceae	5552	R	Ch
Eremopoa persica (Trin) Rozhev.	Poaceae	5482	F	H
Eritichium sp.	Boraginaceae	4410	S	T
Eritrichium fruticulosum Klotz.	Boraginaceae	5410, 5541	O	T
Eruca sativa Mill.	Brassicaceae	5419	R	Ch

Euphorbia tibetica Boiss.	Euphorbiaceae	5331, 5430	F	Ch
Euphrasia himalaica Wettst.	Scrophulariaceae	5494	S	T
Eurotia ceratoides Mey	Chenopodiaceae	5303	F	N
Festuca olgae (Regel) Krevot.	Poaceae	5549	O	H
Festuca sp.	Poaceae	5443, 5466	F	H
Festuca valesiaca Schleich. Ex Gaud.	Poaceae	SR	F	H
Gentiana crassuloides Bureau & Franchet	Gentianaceae	5381, 5521, 5447, 5381	O	T
Gentiana sp.	Gentianaceae	5427	S	H
Gentianella moorcroftiana Wall. Ex G	Gentianaceae	5517, 5486	F	T
Halerpestis sarmentosa (Adams.) Komar.	Ranunculaceae	5394	F	H
Hedysarum cachemirianum Benth.	Fabaceae	5554	S	Ch
Hedysarum kumaonense Benth.	Fabaceae	5399	R	Ch
*Heteropappus altaicus (*Willd.) Nov	Asteraceae	5448	S	H
Hippuris vulgaris L.	Hippuridaceae	5374	F	HH
Hordeum vulgare Linn.	Poaceae	SR	S	T
Hyoscyamus niger L.	Solanaceae	SR	S	T
Juncus leucomelas Royle ex D.Don	Juncaceae	5406	O	G
Juncus thomsonii Buchen	Juncaceae	5479	R	G
Kobresia capillifolia (Decne.) Cl.	Cyperaceae	5353	F	H
Kobresia duthiei Cl.	Cyperaceae	SR	F	H
Kobresia nepalensis (Nees) Kuek.	Cyperaceae	SR	O	H
Kobresia pygmaea Cl.	Cyperaceae	5421	F	H
Kobresia royleana (Nees) Boeck.	Cyperaceae	5377	O	H
Kobresia schoenoides Steud.	Cyperaceae	SR	O	H
Kobresia sp.	Cyperaceae	5405, 5558	S	H
Kochia indica Wight	Amaranthaceae	5341	F	H
Kochia stellaris Moq.	Amaranthaceae	5339, 5361	F	H
Lamium rhomboideum Benth.	Lamiaceae	5332	O	H
Lancea tibetica Hk.f. & T.	Scrophulariaceae	5489	O	T
Leontopodium himalayanum DC.	Asteraceae	5350, 5429	O	H
Leontopodum fimbrilligerum Drumm.	Asteraceae	SR	S	H
Lepidium apetalum Willd.	Brassicaceae	5310, 5557	F	T
Lepidium virginicum L.	Brassicaceae	5529	O	H
Lepyrodiclis holosteoides Mey	Caryophyllaceae	5505, 5535	O	H
Leymus secalinus Tzvelev	Poaceae	5314, 5306	F	G
Lomatogonium carinthiacum Br.	Gentianaceae	SR	O	T
Lomatogonium spathulata (Kerner) Fernald	Gentianaceae	5338, 5372	S	T
Lonicera spinosa Walp	Caprifoliaceae	SR	R	N
Malva verticillata L.	Malvaceae	SR	R	H
Microgynoecium tibeticum Hk.f.	Chenopodiaceae	5391	O	H
Microsisymbrium axillare (Hk.f. &T) Sc.	Brassicaceae	5426	S	H
Microula tibetica Benth.	Boraginaceae	5533	R	T
Minuarta sp. ?	Caryophyllaceae	5496, 5992	O	H

Myricaria prostrata Hk.f. & T.	Tamaricaceae	5484	R	N
Nepeta eriostachya Benth.	Lamiaceae	5438, 5439	O	H
Nepeta floccosa Benth.	Lamiaceae	5509	F	H
Nepeta laevigata (D.Don) Hand-Mazz.	Lamiaceae	SR	F	H
Nepeta longibracteata Benth.	Lamiaceae	5536, 5543	S	H
Nepeta podostachya Benth.	Lamiaceae	5528, 5540	O	H
*Orinus thoroldii (*Stapf. ex Hemsl) Bor	Poaceae	5311	S	H
Oxytropis cachemiricana Camb.	Fabaceae	5309, 5462	O	H
Oxytropis humifusa Kar. & Kir.	Fabaceae	SR	R	H
Oxytropis lapponica (Wall.) Gay. var.	Fabaceae	5321, 5371	O	H
Oxytropis microphylla DC.	Fabaceae	5324, 5362	F	H
Oxytropis microphylla DC. Var.	Fabaceae	5362	O	H
Oxytropis sp.	Fabaceae	5408, 5446	R	H
Parnassia laxmanni Pallas ex Schult	Parnassiaceae	5455	R	G
Pedicularis longiflora Rudolph.	Scrophulariaceae	5369	O	H
Pedicularis oederi Vahl.	Scrophulariaceae	5556	R	H
Pedicularis pectinata Wall ex Bth.	Scrophulariaceae	5516, 5405	O	H
Pedicularis sp.	Scrophulariaceae	5465	R	H
Physochlaena praealta (Walp.) Miers.	Solanaceae	5351, 5512	O	H
Plantago gentianoides Sibth & Smith	Plantaginaceae	5539	O	H
Pleurospermum brunonis (DC.) Benth ex Cl	Apiaceae	SR	R	H
Pleurospermum candollii (DC.) Benth ex Cl.	Apiaceae	SR	R	H
Pleurospermum sp.	Apiaceae	5467	S	H
Poa attenuata Trin.	Poaceae	5364	F	H
Poa koelzii Bor	Poaceae	5567	O	H
Poa lahulensis Bor	Poaceae	5343	F	H
Poa nemoralis L.	Poaceae	5563	F	H
Poa pagophylla L.	Poaceae	SR	F	H
Poa pratensis subsp. angustifolia	Poaceae	5569	F	H
Poa sp1. *(tall green)*	Poaceae	5422	S	H
Poa sp2 (dense purple)	Poaceae	5357	O	H
Poa stapfiana Bor	Poaceae	SR	F	H
Poa supina Schr.	Poaceae	5565	F	H
Polygonum delicatulum Meissn.	Polygonaceae	SR	O	T
Polygonum filicaule Wall. ex |Meissn.	Polygonaceae	5489	F	H
Polygonum islandicum Hk.f.	Polygonaceae	5475	R	T
Polygonum sibiricum Lam.	Polygonaceae	5323, 5379,	F	Ch
Potamogeton pectinatus L.	Potamogetonaceae	SR	F	HH
Potamogeton perfoliatus L.	Potamogetonaceae	SR	R	HH
Potentilla anserina L.	Rosaceae	5469	F	H
Potentilla bifurca L.	Rosaceae	5312, 5333, 5423	F	Ch
Potentilla curviseta Hk.f.	Rosaceae	5515	R	Ch
Potentilla multifida L.	Rosaceae	5340	F	Ch

Potentilla nivea L. Var. himalaica	Rosaceae	5440	R	Ch
Potentilla sericea L.	Rosaceae	5326, 5415	O	Ch
Potentilla supina L.	Rosaceae	SR	F	Ch
Primula involucrata Wall. ex Duby	Primulaceae	5457	S	H
Pucciniella distans (Wahlb) Parl.	Poaceae	5458	F	T
Pucciniella himalaica Tzv.	Poaceae	5337, 5385	F	T
Pucciniella sp.	Poaceae	5368, 5392	F	T
Ranunculus brotherusii Edgew.	Ranunculaceae	SR	F	H
Ranunculus hirtellus D.Don	Ranunculaceae	SR	S	H
Ranunculus laetus Wall.	Ranunculaceae	SR	R	H
Ranunculus natans Mey	Ranunculaceae	SR	F	HH
Ranunculus pulchellus var. typicus	Ranunculaceae	5370	O	H
Ranunculus pulchellus Mey	Ranunculaceae	5428,	F	H
Ranunculus sp.	Ranunculaceae	5370	F	H
Ranunculus trichophyllus Chaix	Ranunculaceae	5378	F	H
Ranunculus tricuspis ?	Ranunculaceae	5445	R	H
Rheum speciforme Royle	Polygonaceae	SR	R	G
Rhodiola fastigiata (Hk. f. & T.) Fu	Crassulaceae	5450	F	Ch
Rhodiola heterodonta A. Boriss.	Crassulaceae	5473	R	Ch
Rhodiola sp.	Crassulaceae	5473	F	Ch
Rochelia macrocalyx Bunge	Boraginaceae	5555	S	H
Sagina saginoides (L.) Karsten	Caryophyllaceae	5545	O	H
Salix hastata L.	Salicaceae	5538	R	N
Saussurea ceratocarpa Decne var.	Asteraceae	5554	O	H
Saussurea gnaphalodes Sch.-Bp.	Asteraceae	5329	O	H
Saussurea leontodontoides (DC.) Sch	Asteraceae	5441	O	H
Saussurea piptathera Edgew.	Asteraceae	SR	R	H
Saussurea taraxacifolia Wall.	Asteraceae	5354	O	H
Saxifraga hirculus L.	Saxifragaceae	5431	R	H
Saxifraga sibirica L.	Saxifragaceae	5435	O	H
Scirpus cariciformis Vest.	Cyperaceae	SR	O	H
Scirpus planifolius Grimm.	Cyperaceae	5478	F	H
Scirpus planifolius Grimm.	Cyperaceae	5308, 5380, 5402	F	H
Scirpus pumilus Vahl.	Cyperaceae	5365, 5388	F	H
Scirpus setaceous L.	Cyperaceae	5416	F	H
Scirpus sp.	Cyperaceae	5432, 5454, 5387, 5393	O	H
Scrophularia scabiosaefolia Benth.	Scrophulariaceae	5336, 5451	F	H
Sibbaldia parviflora Willd.	Rosaceae	SR	F	Ch
Sibbaldia sp.	Rosaceae	5313	O	Ch
Silene edgeworthii Bock.	Caryophyllaceae	SR	F	Ch
Silene moorcroftiana Wall. ex Benth	Caryophyllaceae	SR	S	Ch
Silene stewartii (Edgew.) Maj.	Caryophyllaceae	5437, 5461, 5511	O	Ch
Silene tenuis ?	Caryophyllaceae	5499	S	Ch

Sisymbrium brassiciforme Mey	Brassicaceae	SR	R	T
Sisymbrium sp.	Brassicaceae	5426	O	T
Stachys tibetica Vatke	Lamiaceae	5504	O	Ch
Stipa jacquemontii Jaub. & Spach.	Poaceae	5355	F	H
Stipa orientalis Trin	Poaceae	5302, 5566	O	H
Stipa sibirica auct. non (L.) Lamk.	Poaceae	5305, 5355	F	H
Sueda microsperma (Mey.) Fenz.	Chenopodiaceae	5390, 5452	R	H
Tanacetum falconeri Hk.f.	Asteraceae	SR	F	Ch
Tanacetum gracile Hk.f. & T.	Asteraceae	5434	O	Ch
Tanacetum tibeticum Hk.f. & T.	Asteraceae	SR	F	Ch
Tanacetum tomentosum DC.	Asteraceae	5330	O	Ch
Taraxacum officinale Wigg.	Asteraceae	5342, 5384	F	H
Taraxacum wattii Hk.f.	Asteraceae	5523, 5492	F	H
Thalictrum alpinum L.	Ranunculaceae	5433	O	H
Thylacospermum caespitosum (Camb.) Schi	Caryophyllaceae	SR	O	Ch
Triglochin maritimum L.	Juncaginaceae	5382	F	G
Triglochin palustris L.	Juncaginaceae	5375	F	G
Trisetum clarkei (Hk.f.) Stew.	Poaceae	5560	O	H
Trisetum spicatum Richt.	Poaceae	5481	F	H
Urtica hyperborea Jacq. ex Wedd.	Urticaceae	5420	F	Ch
Veronica biloba L.	Scrophulariaceae	5557	R	T
Vicatia coniifolia DC.	Apiaceae	5500, 5467	F	H
Viola kunawarensis Royle	Violaceae	5363	O	H
Waldhamia glabra (Decne)Regel	Asteraceae	SR	S	H
Waldhamia tomentosa (Decne)Regel	Asteraceae	SR	R	H
Youngia gracilepis (Hk.f.) Bab. & Steb	Asteraceae	5538	F	H
Youngia tenuifolia Bab. & Steb.	Asteraceae	5222,5224, 5525	F	H
Zannichellia palustris L.	Zannicheliaceae	5386	R	HH