Kangchendzonga Biosphere Reserve, Sikkim: Vegetation dynamics and livestock-rangeland linkages along a tourist trekking corridor

H. Birkumar Singh*, R.C. Sundriyal and E. Sharma*****
* Regional Research Laboratory, Manipur Substation, Lamphelpat- 795 004, Imphal, Manipur, India
**G.B. Pant Institute of Himalayan Environment and Development, North East Unit,
Vivek Vihar, Itanagar- 791113, Arunachal Pradesh, India.
***G.B. Pant Institute of Himalayan Environment and Development, Sikkim Unit,
P.O. Tadong- 737102, Gangtok, Sikkim, India.

Abstract

This paper reports vegetation dynamics and livestock-rangeland linkages along a trekking corridor of the Kangchengzonga Biosphere Reserve (KBR) in the Sikkim Himalaya. The people of the region are primarily engaged in subsistence agriculture and animal husbandry. In recent years, however, farmers are opting for off-farm activities, tourism being the most desirable one. Animals are reared for meeting diverse needs and most of them are free grazed in various rangelands in KBR area, which though, is within the carrying capacity level, over-grazing is not be over ruled at places. For stall fed animals, fodder is collected from 43 tree species from forests and 10 agroforestry species. The alpine meadows show high species diversity with nutritious species and are used as summer grazing grounds. The herbage diversity and productivity is highly influenced by grazing with 30-70% reduction in biomass in freely- grazed areas. As the animal number is increasing for domestic and tourism (as pack animals) purposes, it expected that more animals would graze in these grasslands in near future. Therefore, management of KBR needs to address the grazing issue and suitable policies need to be framed involving local people along with large scale cultivation of fodder species in farmers fields, practicing deferred grazing and educating people for adverse effect of grazing in the area.

Introduction

Biosphere Reserves are protected areas of respective terrestrial, coastal and marine environments that have been internationally recognized for their value in conservation and in providing the scientific knowledge, skill, and human values to support sustainable development (Anonymous 1999). At the international level the Biosphere Reserve Programs was launched under the auspices of the Man and Biosphere Programme in 1971, and the first Biosphere Reserve came into being in 1976. Since then a wide network has steadily been built up with nearly 300 Biosphere Reserves in more than 75 countries all over the world. The Indian National Man and Biosphere Committee, set up by the Central Government, created a Core Group of Experts in 1979 for submitting recommendations for potential areas to be constituted into Biosphere Reserves. The principles for declaring the area under network are: *in-situ* conservation of biodiversity (genetic resources, species, ecosystem) of natural and semi-natural ecosystems and landscapes; contribution to foster sustainable economic development of the human population living within and around the Biosphere Reserves and provide facilities for long-term ecological studies; environmental education and training; and research and monitoring related to local, national and global issues of conservation and sustainable development (Anonymous 1999). Despite of the fact that formation of Biosphere Reserve advocates for strengthening of R&D activities, large number of reserves still lack details on their vegetation, wildlife, and the linkages between flora, fauna and human-livestock needs being met from it.

Seasonal animal migration between alpine meadows and lower temperate forest pasture is a common strategy for securing sufficient forage for grazing animals in the Himalayan region (Sundriyal 1995). Kangchengzonga area, who has recently gained the status of 11th Biosphere Reserve in the country (Lepcha 1999), falls in the eastern Himalayan region in Sikkim State (India) and it provides an important pasturage to local and transhumance herders who graze their animals in diverse rangelands from mid to high elevation areas since time immemorial. The Kangchengzonga Biosphere Reserve (KBR) is also used as a popular tourist destination by nature lovers for past many decades. Trekking groups and mountaineers use a large number of pack animals, which although a source of revenue generating for locals, have significant impact

Correspondence: Dr. R.C. Sundriyal, Tel./ Fax: 0360-2211773: E-mail: sundriyalrc@yahoo.com

on vegetation and trail due to grazing and trampling on the alpine and sub-alpine areas. In the recent times the KBR has been the focus of attention due to its rich vegetation, diverse habitats and socio-cultural setup of communities, and increase of tourist flow to visit the Reserve. This paper describes general features of the KBR along with its vegetation diversity, livestock rangeland linkages and its impact on biomass-productivity of different pastures. It also highlights the need and strategy for resource management in near future.

Study area

Sikkim, a tiny Himalayan State in the northeastern India with 7096 km^2 area falls in the Eastern Himalayan range and lies between 27°4′46″ to 28°7′48″ N latitude and 88°55′25″ to 88°58′ E longitude, extending approximately 114 km from north to south and 64 km from east to west, with parallel ranges of mountains like a staircase from north to south. The rich natural and cultural heritage of Sikkim makes this small Himalayan State an attractive destination for international and domestic tourists (Rai & Sundriyal 1997). The KBR falls between 27°25′ to 27°55′ N latitude and 88°3′ to 88°38′ E longitude in the West and North Districts of Sikkim. It exhibits a picturesque view of snow clad mountains, lakes, alpine vegetation, thick forests in temperate to subalpine zones and, rich wildlife, and considered the most popular tourist destination in Sikkim (Fig. 1). Many village settlements with varied ethnic groups such as Lepchas, Bhutias, Limboos and Nepalese are in the buffer zone of the Reserve that surrounds the core zone (Kangchengzonga National Park) while only a small settlement of 10 families of Tibetan origin settles inside the core zone at a place called Tshoka. The 45km long Yuksam-Dzongri-Goecha La trekking corridor inside the KBR is one of the most important tourist destinations in Sikkim, which is also identified as a priority area for tourism development by the State Government. The Reserve supports a large number of animals from surrounding settlements as well as animals of nomadic graziers. Animals graze throughout the year at low-elevation pastures, and most of them migrate to alpine areas during summer-rainy season. At places the trail sites, camping grounds and surrounding of cattle sheds in high altitudes show signs of overgrazing of landscapes. Continuous increase in grazing animal population over the years may deteriorate these pastures further, thus deserve immediate attention.

The alpine zone consists of three main grazing pastures, namely Dzongri, Thangsing-Samiti and Chawrigang-Basecamp, covering an area of 1360 ha. The sub-alpine zone pasture, which is closer to timberline, has an approximate area of about 200 ha which separates the temperate zone with alpine area through a distinct timberline. This zone extends from Tshoka, which is the last human settlement area up to Deorali (Fig. 1). The area between Tshoka and Yuksam falls in temperate zone (cool and warm) dominated by thick forest cover. The cool temperate has an area of about 200 ha under pasture, while the warm temperate has nearly 800 ha area suited for grazing. Total pasture area is 2560 ha which forms the present study sites. About 625% of the pasture area is conducive for grazing and therefore could be considered effective rangeland area.

Methodology

Primary data on number of heads of livestock, their types and grazing locations were recorded through field observation in grazing areas and thereafter verified by household survey during 1996-1999. Formal and informal interviews were conducted with Graziers in the field, and data were collected on income generated from pack animals and other animal products. The animal mobility for grazing and duration of grazing at different locations were recorded. Animals showed preference for some plant species, which was observed for each animal species. To understand the impact of grazing on vegetation a total of 16 plots (each of 100 m^2 area) were fenced (exclosure) at four different locations along the 1500-3800 m elevations along Yuksam-Dzongri trail, and data were collected on plant diversity and biomass productivity in grazed as well as protected plots. The locations of the four ecological zones for establishments of the exclosure were at the warm temperate site (1700m), cool temperate site (2100m), sub-alpine near timberline (3700m), and alpine pasture (3900m). Biomass and productivity measurement was done using 'core monolith sampling' method (quadrat size 50x50x30cm) (n=10 at each site) at monthly intervals for two years as suggested by Sundriyal and Joshi (1990). Records were made on biomass of each individual species, separated to live shoot, dead shoot, litter and below ground plant parts. Furthermore, species were also grouped into palatable and unpalatable biomass category. More details of the methodology used are available in Singh (2000). Carrying capacity, which expresses the grazing limit of different pastures, was estimated following Sundriyal (1989). Each animal group was fed by given quantity of fodder and thus total fodder need was derived for different

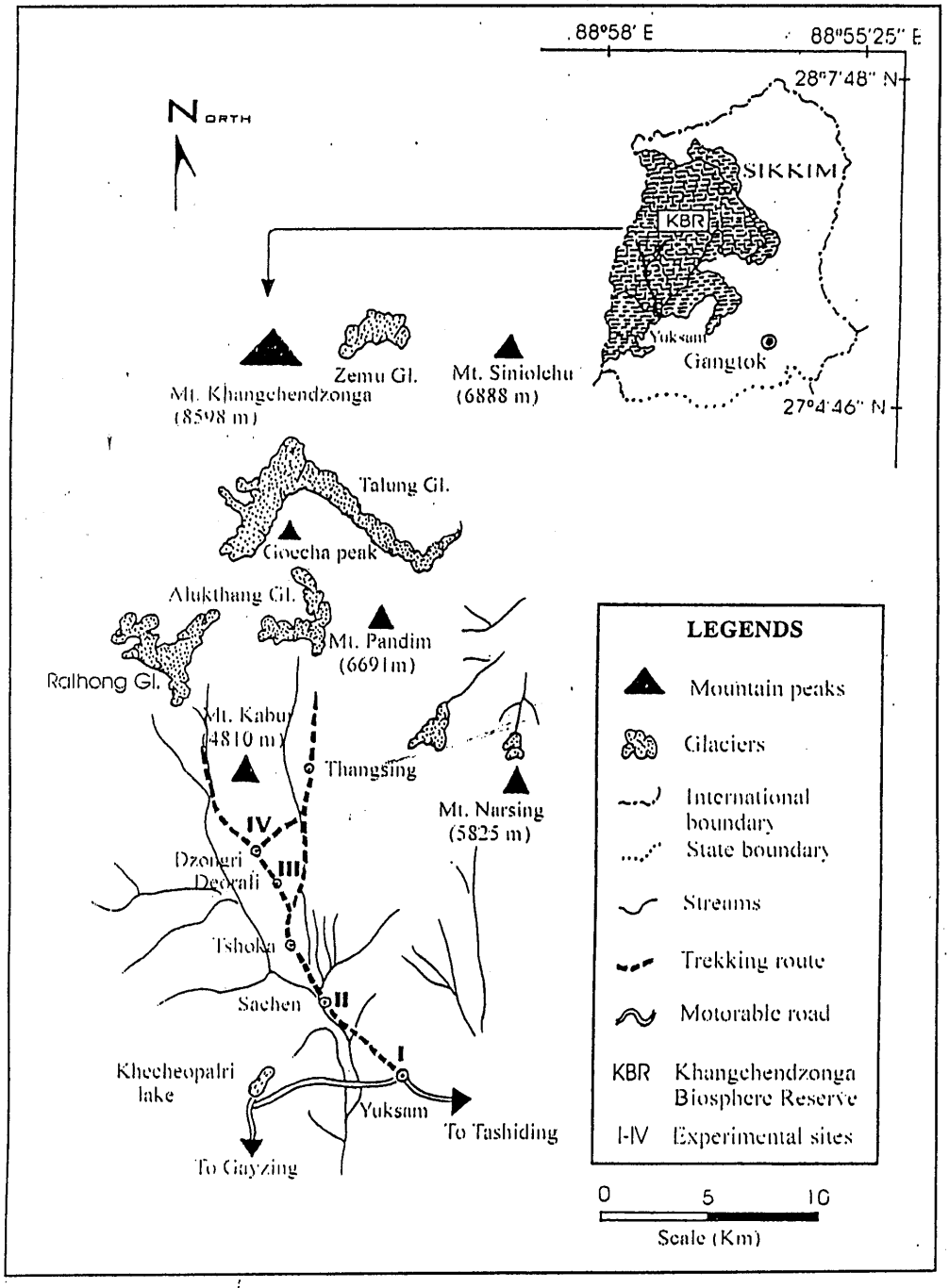

Fig. : Location map showing livestock grazing exclosure sites along the Yuksam-Dazongri trail in Khangchendzonga Biosphere Reserve

livestock species (i.e., cow, horse, ox, sheep, goat). Each animal was converted to cow unit in term of its fodder requirement and the carrying capacity of the pastures are presented on cow unit basis.

Results

Diagrammatic presentation of the KBR and the Trail is given in Fig.1. Daily records on the climatic data were done for the study area at three major zones, i.e. temperate site (at Yuksam, 1700 m), sub-alpine site (Tshoka, 3000 m) and alpine site (Dzongri, 3900 m). Records were taken on minimum and maximum temperatures and rainfall (Fig. 2). At temperate site a maximum temperature of 24°C was recorded in the month of August and minimum of 3.8°C in January. Sub-alpine zone had a maximum temperature of 16.1°C (September) and minimum of -3°C (January). Alpine zone had prolonged winters and was under snow cover for at least five months (November-March), the snow starts melting in April and thereafter vegetation grows. The maximum and minimum temperatures were recorded as 13°C (August-September) and -8°C (January), respectively. Temperate site received an average annual rainfall of 3760 mm, of which 1/3 was recorded in just one month (August). The sub-alpine site received a total rainfall of 3648 mm, while alpine site recorded a total annual rainfall of 2319 mm. The main precipitation during the months between December to March was in the form of snow at the alpine zone.

Protected area network in Sikkim

In India altogether 12 Biosphere Reserves have been declared between 1986-2000, and KBR is the second last declared so far. All Biosphere Reserve covers 45299.1 km^2 areas, of which 27% falls in the Himalayan region (Table 1). KBR comprised 5.78% area of all Biosphere Reserve network in the country. A few more areas have been identified to be covered under this network (Table 1). The Sikkim State is fairly well represented for area under Protected Area Network (PAN) with nearly 41% of its total area under PAN having 1 Biosphere Reserve /National Park and 5 Sanctuaries. KBR represents nearly 91% of the total protected area of the State.

General features of KBR

The Kangchengzonga area was given the status of National Park on the 27th August 1977 with a total area of 846 km^2. Due to its biological, ecological and landscape significance, the area of this Park was further extended to 1784 km^2 in 1996. This National Park was given the status of Biosphere Reserve (Gazette notification No. J-22016/76/91-BR, dated 7th February, 2000) very recently with addition of some more areas (total area of 2655.26 km^2) (Lepcha 1999). The KBR has two core zones with a total area of 1819.34 km^2 and four buffer zones covering an area of 835.92 km^2, having an elevation range that varies from 1220-8550 m above mean sea level. As such the Biosphere Reserve has many glaciers, most prominent and largest amongst them is Zemu Glacier. The lofty Mt. Kangchengzonga (Kanchanjunga) forms the highest peak with 8598 m elevation and is the third highest mountain peak in the world. The Mt. Kangchengzonga literally means 'Abode of the Gods' and consists of five 'treasure houses' indicating the other five adjacent peaks, which are the guardian deity of Sikkim. These adjoining peaks are Mt. Narsing (5825 m), Mt. Pandim (6691 m), Mt. Simvo (6811 m), Mt. Kabur (7338 m) and Mt. Siniolchu (6888 m). The scenic, aesthetic, religious and natural beauty, which is provided by the unique topography and landscapes along with the forest and pasture wilderness almost in pristine set up and wild flowers of varied forms and colours in the Reserve, forms the main attraction, which draws nature lovers and trekkers from all over the world.

The floristic wealth of KBR is rich and diverse though much details of the vegetation are not known. The Biosphere Reserve has 1398 km^2 (53%) area under mixed, conifer and oak-rhododendron forests, though 313 km^2 (22%) of it is in degraded state (Fig. 3). A total of 482 km^2 (18%) is under alpine zone while 638 km^2 (24%) comparised of snow cover, glaciers and lakes. Nearly 113 km^2 (4%) is under scrub and forest blanks. There are large variety of faunal species in the Biosphere Reserve (Lephca 1994). The KBR also provides patronage to many threatened and rare plant species, such as *Aconitum* sp., *Meconopsis* sp., *Taxus baccata*, *Swertia* sp., *Rhododendron* sp., *Juniperus* sp., *Heracleum wallichii*, *Panax* sp., *Nardostachys grandiflora* and many orchid species. There is a further need to study more details of the vegetation and its dynamics. With increase in tourism activities, number of pack animals and livestock-products, there is every possibility that the KBR may receive high biotic pressure in near future, therefore it is an urgent need to start researches that provide useful information on livestock-pasture relationship so that necessary corrective measures could be taken up for Biosphere Reserve management.

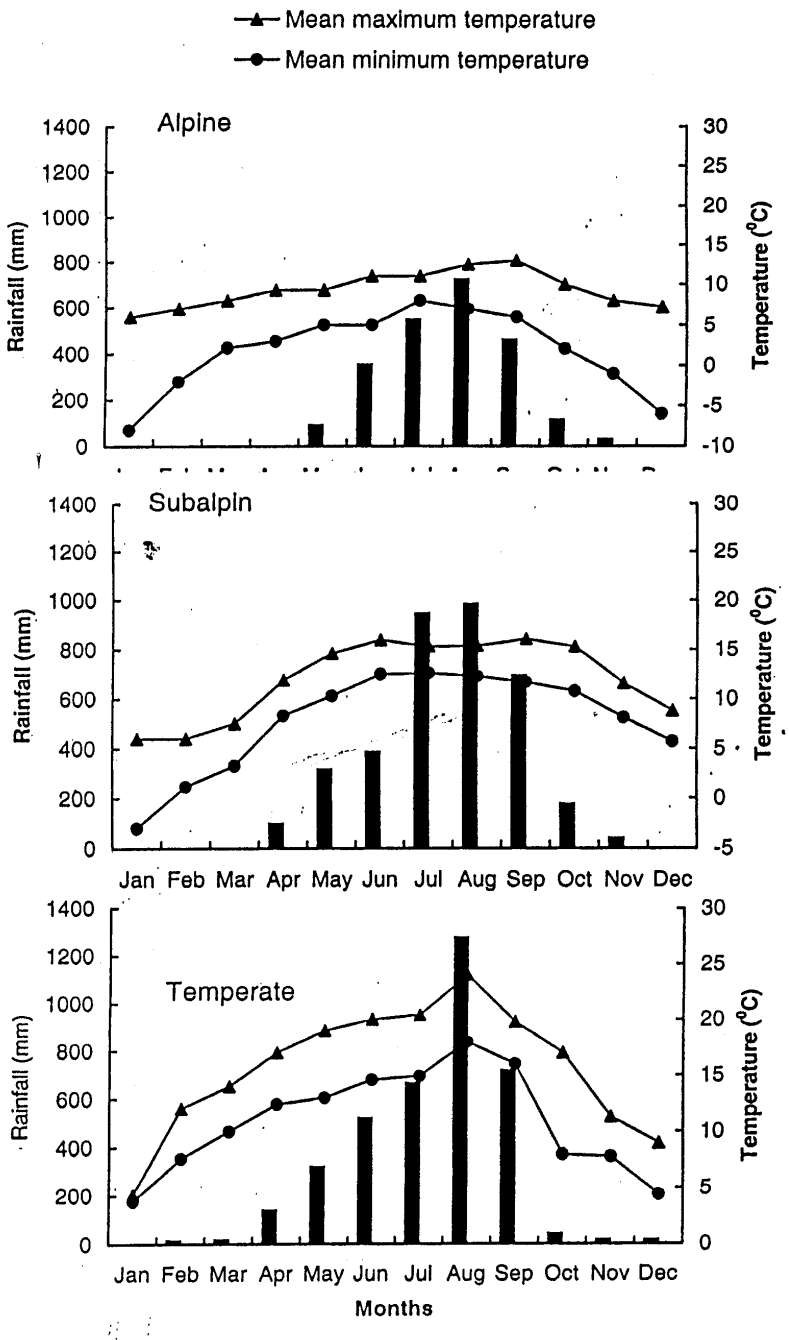

Fig. 2. Weather data for the different zones in the Kangchendzonga Biosphere Reserve

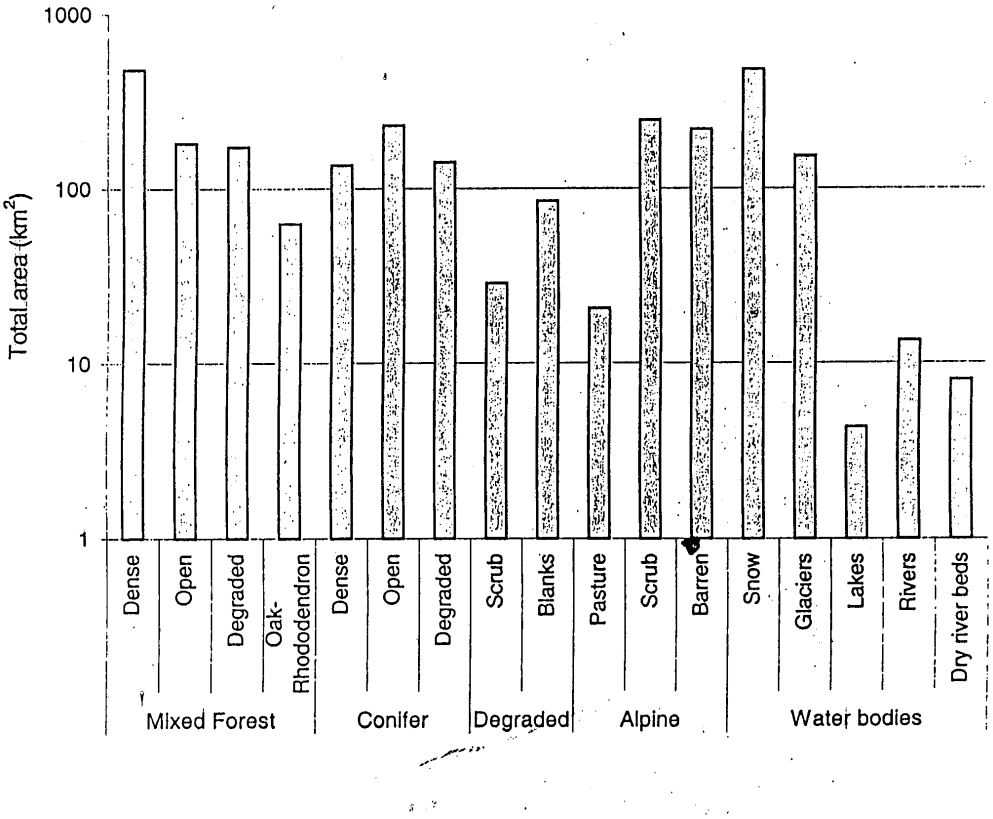

Fig. 3. Major vegetation and water bodies types and their area in Kangchendzonga Biosphere Reserve (broad categories are given on x-axis along with sub-categories)

Yuksam-Dzongri trekking corridor

The KBR has been a major trekking destination and the Yuksam-Dzongri-Goechha La trail with its exhilarating climb through dense forests and past impressive mountain views is the major focus for nature lovers. The forests and alpine meadows are among the most biologically diverse communities with as many as 36 species of Rhododendrons, 400 species of orchids and many other flowering plants. This trekking corridor receives about 2000 national and international tourists every year. The trail head starts from Yuksam that was Sikkim's first capital with some places of wide attraction, such as archeological ruins of the old palace at Norbu Gang and 'Dubde Monastery' that is the oldest monastry in the State. Yuksam settlement comprises of ethnics such as Lepchas, Bhutias, Nepalese, Limboos, while Tshoka that fall inside the KBR is inhabited by Tibetan refugees. Subsistence agriculture is the main livelihood. However, in recent years, the increased tourism activities have drawn the attention of local people and they have diversified their activities to tourism durlng trekking season that has two peaks in March to May and September to November. Local communities involve in tourism by providing services, such as porters, trek cooks, guides, pack-animal owners, lodge operators and vegetable growers. Besides, the area also provides important pasturage for local and transhumance herders who graze their yaks, dzos, cows, horses and sheep on many pastures (rangelands) along with entrepreneurs owning pack animals for trekking groups and mountaineers. A large number of dzos and horses are engaged as pack animals during tourist seasons. A large number of sheep, cows, and yaks use alpine pasture during April to October for forage. The reserve is frequently visited by local communities for fuel, food and fodder collection, and the demand has increased tremendously during recent times (Rai & Sundriyal 1997). A huge quantity of firewood is used by trekkers, which is a major concern.

Continuous grazing, collection of fodder, fuel wood and trampling of vegetation by animals and visitors at places have left visible signs of deterioration. This may seriously affect the vegetation, soil and habitat of certain areas in near future. Therefore, the management strategies for KBR needs to address issues of grazing and its possible impact on the vegetation and plant communities with reference to its structure, biomass productivity and nutrient cycling as influenced by grazing along with an assessment of existing stocking rate and carrying capacity of various pastures in KBR. The most important aspect is to modify the existing policies so that the KBR could be managed with the help of local stakeholders by providing them better means of income and livelihoods so that the goal of the conservation could be achieved in a sound and sustained way.

To study the details of the vegetation dynamics and animal impact on it, four sites identified along the Yuksam-Dzongri Trail, varying in elevation, species composition and climatic conditions (Fig. 1). The sites were at Yuksam (warm-temperate), Sachen (cool temperate), Deorali (sub-alpine) and alpine (Dzongri) (Table 3). The ground vegetation plant communities of the four study sites were designated as *Pilea-Eupatorium-Silaginella* community (warm-temperate); *Elatostema-Pilea-Rumex* community (cool-temperate); *Poa-Potentilla-Geranium* community (subalpine) and *Bistorta-Poa-Potentilla* community (alpine). An area of 20x20 m (four 10x10 m) size was fenced at each site to avoid impact of grazing. Both, fenced and open grazed areas were having similar vegetation structure and composition at initial stages.

The soils of all sites were acidic, which increases with depth of soil (Table 4). Soil moisture content was higher in upper (0-15 cm) depth at all the study sites. Different sites showed nearly more or less similar levels of nitrogen, phosphorus, and carbon content and all of them decrease with soil depth. Soil porosity increased with altitude ranging from 39.2 - 54.3% in upper (0-15 cm) and 43.8 - 60.0% in lower (15-30 cm) soil depths (Table 4). Generally, the soil of alpine site had higher clay and sand proportion than the soil of other sites. Subalpine site at Deorali had maximum silt percentage. Gravel per cent was higher in lower temperate site at Yuksam (Table 4). Clay proportion was more in higher elevation which ranged from 4.2 - 10.9% in (0-15 cm) and 5.7 - 14.0% in (15-30 cm) soil depth. Silt content also showed the similar trend like clay.

Vegetation dynamics

Four distinct vegetation zones have been identified, viz. warm-temperate, cool temperate, subalpine and alpine based on the climatic zones along the Yuksam-Dzongri trail (Fig. 1). The warm temperate starts from Yuksam (1600m) upwards to 2000 m and this zone supports to fulfil the local resident's demands for fuel, fodder and timber. The area also receives heavy grazing pressure. The forest cover is thin mainly due to timber and fuelwood extraction. The major tree species were *Castanopsis* spp., *Toona ciliata*, *Evodia fraxinifolia*, *Macaranga pustulata*, while *Rubus ellipticus*, *Edgworthia gardneri*, *Melastoma normale* formed the middle layer. *Eupatorium cannabinum*, *Cyanotis vaga*, *Hydrocotyle javanica*, *Pilea umbrosa*, *Pilea scripta*, *Persicaria capitata*, and *Brachiaria* sp. were prominent ground vegetation. The cool-temperate site (2000-3000 m) comprised of *Magnolia campbellii*, *Rhododendron arboreum*, *Quercus lamellosa*, and *Acer campbellii*, while *Aconogonum molle*, and *Arundinaria maling*, *Zanthoxylum acanthopodium* formed the secondary layer. The dominant ground vegetation were *Tupistra nutans*, *Viola* sp., *Selaginella* sp., *Elatostema sessile*, *Urtica dioica*, *Girardinia palmata* and *Laportea terminalis*.

The maximum canopy coverage in the sub-alpine zone has been formed by *Abies densa* and secondary middle layer by *Rhododendron barbatum*, *Rhododendron hodgsonii*, *Viburnum cordifolium*, *Arundinaria maling* and *Rosa sereciea*. Primulas, *Selinum tenuifolium*, *Fragaria* sp., *Prunella vulgaris*, with high density of *Abies densa* seedlings and saplings formed the ground vegetation.

Alpine areas were devoid of trees, and rhododendrons, Junipers and *Rosa sereciea* formed the major vegetation. High density of *Juniperus recurva* in the form of depressed circular patches were common in gentle slopes whereas bushes of rhododendrons were found in steep slope. The ground vegetation was dominated by *Poa* spp., *Potentilla peduncularis*, *Potentilla microphylla*, *Potentilla coriandrifolia*, *Aletris pauciflora*, *Bistorta affinis*, *Pedicularis* spp. and Primulas. As the elevation goes higher to 4000 m and above, botanically curious plants like woolly *Swertia multicaulis*, *Eriophyton wallichii* and pyramid-shaped *Rheum nobile* are all seen and these plants are adapted to very harsh climate.

Floristic composition

Lists of plants encountered along with their flowering period, life forms and growth forms have been prepared according to the Bentham and Hooker's sequence of classification for temperate, subalpine and alpine zones (Appendix 1). In the temperate zone, a total of 182 species were recorded, of which 148 were

dicots (81.3%), 32 monocots (17.6%) and only 2 species of gymnosperms (1.1%). These species belonged to 66 families (57 dicots, 7 monocots and 2 gymnosperms) and under 133 genera (109 dicot, 22 monocot and 2 gymnosperm). At subalpine zone, a total of 73 species were recorded, of which 60 species belonged to dicots (82.2%), 11 species monocots (15.1%) and remaining 2 species were gymnosperms (2.7%). These species belonged to 32 families (27 dicots, 4 monocots and 1 gymnosperms) and under 48 genera (38 dicots, 8 monocots and 2 gymnosperms).

In alpine zone a total of 120 species were recorded, of which 105 were dicots (87.5%), 13 monocots (10.8%) and only 2 species of gymnosperms (1.7%). These plants belonged to 34 families (26 dicots, 7 monocots and only one gymnosperm). The families like Ericaceae (12 spp.), Primulaceae (10 spp.), Polygonaceae (8 spp.), Ranunculaceae and Scrophulariaceae (7 spp., each) were represented most.

The growth forms study revealed that at temperate zone 36.3% species were trees, 20.9% shrubs/undershrubs, 15.4% tall forbs, 6.7% cushion and spreading forbs, 6% each for climbers and epiphytes, 5.5% short forbs, 2.7% graminoid, and least being the creepers (0.5%). At the subalpine zone, climber, creeper and epiphytes were absent. Tall forbs (27.4%) dominated at the subalpine zone, which was followed by shrub/undershrub (20.5%), cushion and spreading forbs (16.4%), short forb (15.1%) and the graminoid (6.9%) was the least. At the alpine zone, tree stratum were absent and was dominated by short forb (31%), followed by cushion and spreading forb (28%), tall forb (25%), shrubs (10%) and the graminoid (6%) the least.

Woody plants dominate in the temperate and subalpine zones, and lower percent of herbaceous vegetation might be due to grazing pressure and collection of non-timber forest products. As the elevation increased, woody species decreased in number and herbaceous increased their dominance. Much higher elevation comprised of cushion and spreading forbs. This change is an adaptive mechanism to severe climate in the higher elevation.

Livestock – rangeland linkages

In Sikkim State the major primary sector is agriculture with more than 80% population engaged in it, however it is subsistence type. Cultivation of cash crops like large cardamom, ginger, mandarin orange and potato along with animal husbandry have became the major economic activity in farms. Animal husbandry has good scope for further development because the region has a high potential for fodder production. The main vegetable crops are cabbage, beans, mustard, peas, potato, etc. All these vegetables are grown in their private lands and are mainly for their own consumption. Small quantities of surplus are sold to the market. The crop residues are fed to animals and supplement a good proportion of forage demand. The villagers maintain a good number of fodder trees in the agricultural lands that provides fodder during the lean period. The livestock is integral part of each household and an important source of income to all families (Fig. 4). During 1992, the State had a livestock population of 200035 cattle, 114707 goats, 16268 sheep, 44477 pigs, 5349 yaks/dzos, 2932 buffaloes and 1789 horses, totaling to 385557/animals (Paljor 1998). Oxen are generally used to plough the land. Livestock dung forms major traditional manure and many villagers maintain more animals numbers especially to get the manure for their agricultural lands. The average number of 54 animals per km^2 has been recorded for the State. The Livestock population increased by about 66% from 1987 to 1992 that shows the importance of this sector in the State. The livestock types and population of Yuksam-Dzongri trekking corridor reveals that at Yuksam 274 families reared a total number of 1448 livestock with an average 5.28 animals $household^{-1}$, while in Tshoka village 75 livestock was recorded showing 7.5 animals $household^{-1}$. The total livestock of Yuksam block increased from 1324 to 1523 during 1996 to 1998 showing a net growth of 15%.

Sikkim has four major grazing routes, of which two falls in the KBR. All the routes lead to alpine pastures during summer months, where animals graze on lush-green vegetation for 4-5 months. The major portions of the grazing land is under alpine pasture followed by 'khasmal' land (forests areas designated to meet villagers needs) and 'gaucharan' (grazing land). The graziers take their animals to alpine and sub-alpine pastures during the warm period generally from April to October and bring them back to the lower valleys during winter months. At lower altitudes stall feeding as well as free grazing are equally practiced, though certain animals (Yak, Dzo, Sheep) are generally maintained as free grazed. Only a few milking animals and calves are kept at home and stall fed. At Tshoka village all the animals were free grazed. Nearly 40 cows, 160 yaks, 120 dzos, 13 horses and 508 sheep (total livestock 841) were recorded free grazed in Dzongri and its surrounding alpine pastures during summer months. Yaks graze throughout the year at high altitudes because of their inability to adapt at lower elevations.

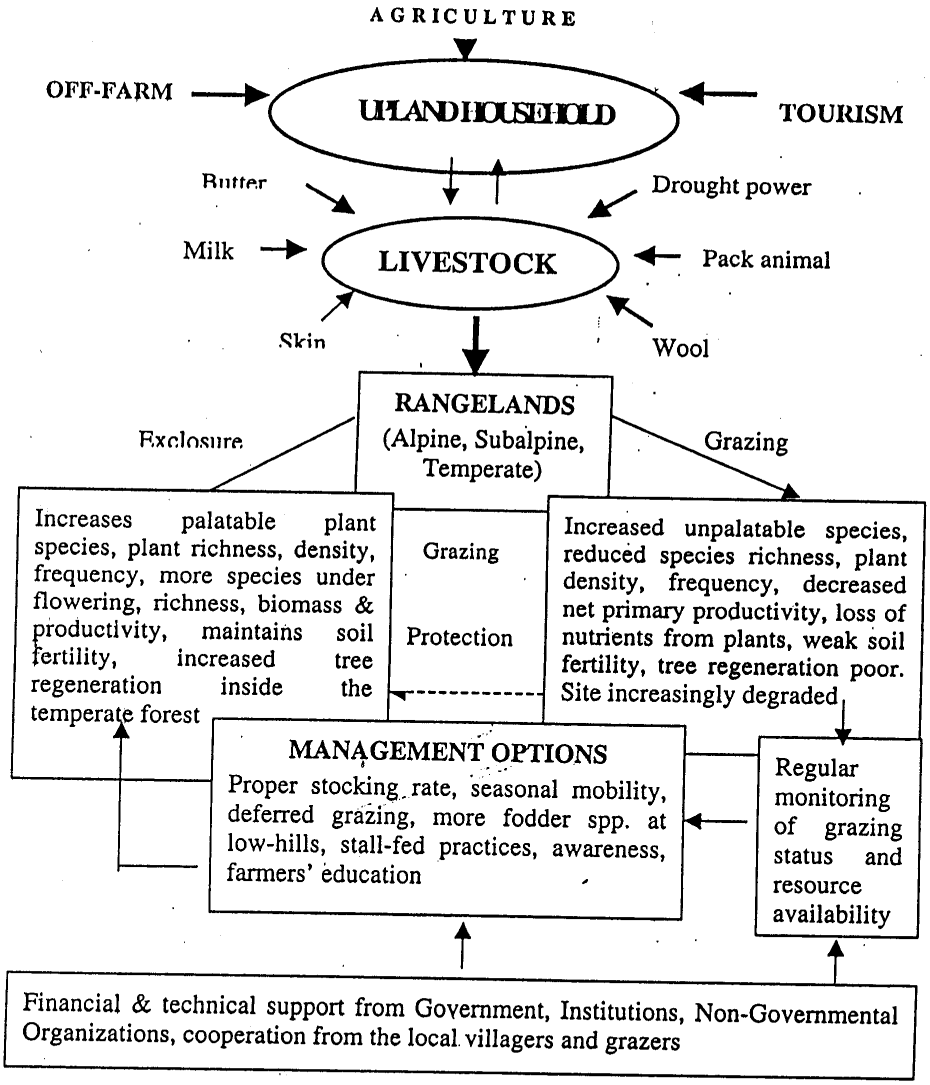

Fig. 4. Linkages between livestock grazing and rangeland and its management options in the Kangchendzonga Biosphere Reserve

Tourism and livestock

The 26-km Yuksam-Dzongri corridor inside the KBR is one of the most important trekking routes in Sikkim. Every year about 2000 domestic and foreign tourists trek here. A tourist group of more than 3 persons generally hires pack animals. If the group is smaller i.e., < 3 persons then the local porters manage, which are available at the trail head at Yuksam @ of Rs. 80/- per day. Trekking cooks are hired @ Rs. 100/- per day. The cost of one pack animal ranged between Rs. 110-120/- per day that can carry about 40-60 kg load. Himalayan Mountaineering Institute (HMI), Darjeeling, West Bengal, conducts training programs every year (5 basic and 3 advance courses) at the base camp. These groups have trek along the same route. Nearly 100-120 trainees in each basic course, and 80-100 trainees in each advance course participate in HMI

training. In every course they used around 40 pack animals for fairly long time. The area also provides pasturage for local and transhumance herders along with entrepreneurs owning pack animals for trekking groups and mountaineers. The Forest Department started collection of fees for pack animals entering the Reserve since September 1998 (Notification No.124/KNP/WL/F/01). The entry fee has been fixed as Rs. 5/- per animal per day. However, it was observed that generally more number of pack animals freely graze in the area than the number of animals for which fees has been collected for entry.

The cattle are considered as a sign of wealth and a person with nearly 20 cattle is considered a rich man in Lepcha community. In north Sikkim around 72% households receive income from livestock rearing (Paljor 1998). They also provide a good percentage of organic manure to the soil. There are three main items of revenue source from livestock in KBR area, viz., pack animals, dairy products and wool products. Raw wool is sold @ Rs. 70-80/- per kg, yak and sheep milk @ Rs. 10/- and Rs. 15/- per liter respectively, butter (cheese) @ Rs. 160/- per kg, and dried cheese (chhurpi) @ Rs. 120/- per kg. A total revenue of Rs. 11,37,600/- and Rs. 10,29,300/- generated in 1997 and 1998, respectively; out of which 61% was from pack animals, 32% from dairy products, 7% from wool products and a very small portion (0.42%) from skin products. Besides, the Forest Department also collected a sum of Rs. 19,800/- as revenue during 1998 as entry fees for pack animals operating in the Yuksam-Dzongri trail. About 68% of the fees came from Himalayan Mountaineering Institute's training program and remaining 32% came from pack animals hired by trekkers. Reduction of about 10% in income from livestock in 1998 compared to 1997 was mainly because of fewer tourist's arrival resulting from road disruption due to landslides.

Fodder resources

For stall-fed animals, 83% of total fodder demand is collected from forests, which is mostly met from 43 species. The remaining 17% demand is met from agroforestry species (10 species, mainly of *Ficus* group), which are maintained by the villagers as forage bank in their farms for scarcity period (December to February). An average household in Yuksam produced about 793 kg fodder annually. The farmers are aware of good fodder and only selective species are collected for this purpose (Table 5). Crude fibre content of fodder species ranged from 8.55 - 30.43%; cellulose 4.59 to 37.32%; hemi cellulose 6.00 - 35.85%; lignin 6.56 - 35.89%; nitrogen 1.04 - 4.97%; phosphorus 1.038 - 0.377% and crude protein ranged between 6.25 - 31.06%.

Rangeland productivity

Aboveground biomass shown strong positive relationship with rainfall. The aboveground biomass also increases with elevation ($P<0.0001$) (Table 6). Aboveground biomass contribution by different growth forms was most dominated by shrub/undershrub (33.2%) at Yuksam, tall forbs (41.2%) at Sachen, graminoids at both Deorali (41.2%) and Dzongri (37.5%). Foraging characteristics study of livetock showed that bite rate ranged from 41.2 - 59.5 bite min^{-1} apparent bite size from 52.0 - 105.6 mg $bite^{-1}$, foraging hours from 7.75 - 11.9 hours day^{-1}, and forage intake rate ranged from 1.17 - 4.03 kg day^{-1}. The palatable species had higher biomass contribution at cool-temperature and sub-alpine areas than the alpine and temperate sites, which is probably because of low grazing pressure at former two-sites. Protection of species from grazing increased pastures aboveground biomass by 50% at all sites ($P<0.0001$). Exclosure of pastures also increased biomass of palatable species from 58% - 83% at Yuksam, 80% - 93% at Sachen, 79% - 90% at Deorali and from 23% - 78% at Dzongri. The result indicated that protection of vegetation has high impact on species composition and biomass. However, protection of grasslands from grazing did not show any significant change in belowground root biomass in all the study sites. Pasture protection from grazing has increased the productivity of pastures by 64% at Yuksam, 76% at Deorali, 20% at Sachen, and 114% at Dzongri. Details of animal behaviour and stocking rates are already available (Singh *et al.* 2003). The stocking rate at peak growing grazing period was recorded 0.57 - 1.81 CEU (Cow equivalent unit) ha^{-1} at Dzongri and Yuksam, respectively. Annual stocking rate were estimated as 1.54 CEU ha^{-1} at Yuksam, 0.33 CEU ha^{-1} at Sachen, 0.29 CEU ha^{-1} at Deorali and 0.30 CEU ha^{-1} at Dzongri. The carrying capacities of pastures at different elevation zones were estimated. Yuksam pasture had a carrying capacity of 1.34 CEU ha^{-1} $year^{-1}$, Sachen with 1.18 CEU $ha^{-1}year^{-1}$, Deorali with 0.96 CEU ha^{-1} $year^{-1}$ and Dzongri with 0.86 CEU ha^{-1} year. These results indicate that the present level of grazing is well within the carrying capacity of the pastures. Linkages between a household, livestock and rangeland (grazing land) are shown in Fig 4. It is clear from the figure that animals are required as drought power (mainly ox) and for milk, butter and other purposes. Free grazing of the grassland if continuously adopted, may lead to deterioration of the pasture condition. On the contrary,

exclosure (or control grazing) may upgrade the grassland status. Therefore, the best management option is to control stock rate, frequent mobility, controlled grazing and production of better forage species in the traditional systems (Fig. 4). This will reduce pressure on natural stands.

Discussion

The present study deals with structural and functional aspects of vegetation, livestock-rangeland linkages, and livestock grazing impact on pastures along the Yuksam-Dzongri trekking corridor in the KBR of the Sikkim Himalaya. The study area covers four major ecological zones (warm temperate, cool temperate, subalpine and alpine) that extend between 1600 m - 4200 m altitude in the buffer zone. This trekking corridor is a representative of different climatic zones, vegetation types and landscapes. Over 2000 tourists (national and international) trek in this corridor every year along with many porters, cooks, naturalistic guides and pack animals. The Himalayan Mountaineering Institute (Darjeeling, West Bengal) conducts training programs for about one thousand trainees every year that are also supported with a large number of dzos and horses as pack animals. In the villages nearby KBR area, livestock form an integral part of sustenance especially linked with tourism. Substantial income is generated from livestock, 60% of which comes from tourism sector only, therefore, more and more people are attracted towards this. There is every possibility that in near future animal number may go up to earn maximum revenue. Therefore, the rangeland management and fodder development must also consider future demands.

Animal migration to alpine meadows (Dzongri) during the summer months is a common strategy adopted by locals for getting sufficient forage as is also reported from other parts of the Himalaya (Ram *et al.* 1989, Farooquee 1996). There are five types of animals viz., cattle, dzo, yak, horse and sheep that graze in alpine pastures while goats graze inside the lower forest throughout the year. Yaks never come down to lower elevations for their climatic non-tolerance. During snowfall yaks concentrate near the timberline and browse rhododendrons and other bushes. From Yuksam village hundreds of cows, dzos, goats, sheep and horses graze surrounding areas. And livestock grazing pattern and seasonal mobility from one area to other depends on the availability of fodder resources.

The studied rangelands show a dominance of woody species at lower elevations, while herbaceous species dominate the higher ridges with cushion and spreading plants. Such change in plant habits could be attributed to adapt harsh climatic conditions in alpine areas. Grazing reduces palatable species from the stands. Also, the species richness and diversity increases with protection of rangelands from grazing (Sundriyal & Joshi 1990). Grazing also had an impact on tree species regeneration, and seedlings/saplings of top-canopy species decreased. The productivity of pastures is comparable with the other Himalayan rangelands (see Sundriyal 1995). Exclosure increased biomass by more than 50% at different sites. It also improved recovery of palatable species in the stand. The carrying capacity of present rangelands could be compared with those of the better-managed grasslands in the Garhwal Himalaya (Gupta 1986). The grazing pressure at present is nearly within the carrying capacity limit of the various pastures. However, a few areas are observing overgrazing, which should be avoided. Adopting deferred grazing practice for reducing pressure in certain over grazed areas could prove beneficial to maintain biomass-productivity. Grazing at lower elevations near Yuksam area need to be reduced. Fodder collection and other resource extraction like fuelwood, timber and non-timber forest products (wild edibles) also add to deteriorate the rangeland conditions, therefore, need to be tackled simultaneously. Strengthening fodder at each household level, for which farmers are also willing, could help to improve the rangelands condition. Also, establishment of permanent enclosures at representative sites for regular monitoring and impact assessment of livestock grazing will definitely help in long-term sustainable management of rangelands in the KBR. Farmers are needed to be educated on the number of grazing animals and their causative affect on pasture. Suitable trainings need to be given to animal owners to educate them about the bad affect of continuous grazing and trampling of vegetation. It is important to mention here that a similar training programme was given to yakmen about the impact of free grazing on pastures, and that has made the yakmen aware about the health of the pastures (Anonymous 1997).

During recent years, there has been an increasing trend to look for off-farm income, particularly for Government services. Tourism services have become very remunerative in recent years (Rai & Sundriyal 1996). This sector is receiving due attention from the Government side (Sharma 1997). Tourism offers scope for involving people at different levels i.e., as porters, naturalist guides, pack animal owners, lodge operators, trek cooks, etc. Recently Sikkim Biodiversity and Ecotourism Project was launched, that focused on human resource development through training, and also enhancement of infrastructure and tourism services, conservation of natural resources and channelizing the revenue generation (Anonymous 1997). The project

had good impact on the area and communities. The result/outcome of the project should be harvested for the broader interest of the KBR area. If properly managed the KBR area can be developed as a model destination for nature walkers, and it can also provide sustained incentive to local communities through various means. For a long term planned development of the area the biodiversity need to be protected at any cost. Implementing suitable strategies for local community development in harmony with the biodiversity conservation could be the key of sustainable development of the area and the region.

Acknowledgement

Authors thank the Director, G.B. Pant Institute of Himalayan Environment and Development, Kosi-Katarmal, Almora, for providing facilities and the Mountain Institute for support. The project received funding from Biodiversity Conservation Network, USAID.

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Table 1. Present status of conservation (Biosphere Reserves) areas in India

Status	Name of the biosphere reserves	State (s)/UT	Date of notification	Area (km^2)
Declared	Niligiri	Karnataka, Kerala and Tamil Nadu	01/08/1986	5520.0
	Nanda Devi	Uttaranchal	18/01/1988	6,470.03
	Nokrek	Meghalaya	01/09/1988	820.0
	Great Nicobar	Andaman & Nicobar	06/01/1989	885.0
	Gulf of Mannar	Tamil Nadu	18/02/1989	10500.0
	Manas	Assam	14/03/1989	2837.0
	Sunderbans	West Bengal	29/03/1989	9630.0
	Similipal	Orissa	21/06/1994	4374.0
	Dibru-Saikhowa	Assam	28/07/1997	765.0
	Dehang-Debang	Arunachal Pradesh	02/09/1998	5111.5
	Kangchendzonga	Sikkim	07/02/2000	2619.9
	Pachmarhi	Madhya Pradesh	03/03/1999	5111.5
Proposed	Namdapha	Arunachal Pradesh	-	-
	Thar desert	Rajasthan	-	-
	Little Rann of Kutch	Gujrat	-	-
	Kaziranga	Assam	-	-
	Andaman	Nicobar	-	-
	Abujmarh	Madhya Pradesh	-	-
	Amarkantak	Madhya Pradesh	-	-
	Cold Desert	Jamu & Kashmir and Himachal Pradesh	-	-
	Seshachalam	Andhra Pradesh	-	-
	Chintapalli	Andhra Pradesh	-	-
	Lakshdweep Islands	Lakshdweep	-	-

Table 2. Protected areas in Sikkim

Biosphere Reserve/ Sanctuary	Name of the Biosphere Reserve/National Park/Sanctuary	District (s)	Elevation (m)	Area (km^2)
Biosphere Reserves	Kangchengzonga	North & West	1600-8598	2619.92
National Park	Kangchengzonga National Park	North & West	-	1,784.0
Sanctuaries	Shingba Rhododendron	North	3300	43.00
	Kyongnosla Alpine	East	3292-4110	31.00
	Fambong Lho Wildlife	East	1524-2750	51.76
	Barsey Rhododendron	West	1700-4500	104.00
	Maenam Wildlife	South	-	35.34
Total	-	-	-	4,669.02

Table 3. Study area location at different ecological zones and their characteristics along the Yuksam-Dzongri trail of Kangchengzonga Biosphere Reserve

Ecological zones	Pasture name	Altitudinal range (m)	Slope range (terrain)	Grazing area of the pasture (ha)	Plant community	Dominant ground vegetation
Temperate(warm)	Yuksam	1700-2000	Steep slope (40-60°)	700	*Eupatorium Pilea-Selaginella*	*Pilea scripta, Pilea umbrosa, Silaginella* sp., *Eupatorium cannabinum, Hydrocotyle javanica, Astilbe revularis, Cyanotis vaga*, etc.
Temperate (cool)	Sachen	2000-3000	Medium slope (20-50°)	160	*Pilea-Rumex-Elatostema*	*Elatostema sessile, Rumex nepalensis, Silaginella* sp., *Brachiaria* sp., *Plantago erosa, Pilea umbrosa*, Ferns, etc.
Subalpine	Deorali	3000-3800	Gentle slope (10-30°C)	140	*Poa-Potentilla-Geranium*	*Poa* spp., *Potentilla peduncularis, Anemone tetrasepala, Geranium nakaoanum, Aletris pauciflora*, etc.
Alpine	Dzongri	3800-4000	Gentle slope (10-30°C)	250	*Poa-Bistorta-Potentilla*	*Poa* spp., *Bistorta affinis, Potentilla peduncularis, P. microphylla, Potentilla coriandrifolia, Gentiana* spp., etc.
	Thangsing-Samiti	3800-4200	Gentle slope (10-30°C)	200		
	Chawrigang -Basecamp	3900-4200	Gentle slope (10-30°C)	150		
Total				1600		

Table 4. Soil characteristics at four elevation sites along the Yuksam-Dzongri trail (during 1998)

Study site	Soil depth (cm)	Moisture content (%)	Bulk density (g cm^{-3})	Soil pH	Soil texture (%)			
					Clay	Silt	Sand	Gravel
Yuksam	0-15	23.9±1.2	1.18±0.11	5.17±0.06	5.3±0.3	6.1±0.1	37.6±1.3	51.0±0.8
	15-30	21.6±0.8	1.23±0.06	5.06±0.13	6.7±0.6	5.1±0.1	36.1±1.7	52.1±1.5
Sachen	0-15	23.8±0.9	1.17±0.16	5.29±0.08	4.9±0.2	7.1±0.2	49.0±0.4	39.0±0.7
	15-30	18.9±1.8	1.20±0.13	5.26±0.03	5.9±0.7	4.5±0.1	48.0±0.8	41.6±0.8
Deorali	0-15	26.2±1.6	1.13±0.09	4.53±0.14	4.2±0.1	10.9±0.3	39.0±0.6	40.0±1.7
	15-30	24.1±1.2	1.21±0.09	4.94±0.04	5.7±1.2	11.3±0.7	41.4±1.7	41.6±1.9
Dzongri	0-15	29.0±1.3	1.08±0.11	5.41±0.11	10.9±0.8	11.5±1.1	52.0±1.6	25.6±0.8
	15-30	24.9±0.9	1.18±0.11	4.93±0.11	14.0±1.3	8.4±0.8	62.0±2.2	15.6±0.3

Table 5. Common fodder species collected from forest and agriculture lands at Yuksam village and in alpine (Dzongri) and subalpine (Deorali) pastures

Species	Vernacular name	Habit	Ranking	Availability
Forest				
Acer campbellii.	'Kapasey'	Tree	††	Aug.-Nov.
Acer laevigatum	'Kapasey'	Tree	††	Aug.-Nov.
Acer oblongum	'Putley'	Tree	††	Aug.-Nov.
Aconogonum molle	'Thotney'	Shrub	††	Jun-Sep.
Artocarpus lakoocha	'Badar'	Tree	†††	Jul.-Oct.
Arundinaria maling	'Malingo'	Shrub	†††	Round
Diploknema butyracea	'Chewri'	Tree	††	Jun-Aug.
Betula cylindrostachys	'Saur'	Tree	††	May-Oct.
Brachiaria sp.	'Bonsoghans'	Herb	†††	Apr.-Nov.
Brassaiopsis mitis	'Chuletro'	Shrub	†††	Round
Castanopsis tribuloides	'Katus'	Tree	†	Jun-Aug.
Commelina benghalensis	-	Herb	††	May-Sep.
Cyperus sp.	-	Herb	†††	Round
Diplazium umbrosum	'Ningro'	Herb	††	Round
Pteris sp.	'Unyo'	Shrub	††	May-Dec.
Erythrina indica	'Falado'	Tree	†††	Apr.-Oct.
Ficus clavata	'Lute-khanew'	Tree	†††	Apr.-Sep.
Ficus cunia	'Khanew'	Tree	†††	Apr.-Nov.
Ficus foveolata	'Dudilhara'	Climber	†††	Mar.-Dec.
Ficus hirta	'Khasrey''	Shrub	††	May-Nov.
Ficus nemoralis	'Dudhilo'	Tree	†††	Round

Ficus roxburghii	'Nebhara'	Tree	†††	Round
Gamblia ciliata	'Khursimal'	Shrub	†	May-Sep.
Garuga pinnata	'Dabdabe'	Tree	††	May-Sep.
Glochidion acuminatum	'Latikat'	Tree	†††	May-Oct.
Heynea trijuga	'Ankha-tarua'	Tree	††	Apr.-Oct.
Litsaea polyantha	'Kutmero'	Tree	†††	May-Sep.
Macaranga pustulata	'Malata'	Tree	††	Apr.-Nov.
Machilus edulis	'Kawla'	Tree	†††	May-Dec.
Maesa chisia	'Bilaune'	Shrub	†	May-Sep.
Morus laevigata	'Kimbu'	Tree	††	May-Sep.
Mussaenda frondosa	'Dhobi'	Shrub	††	Jun-Sep.
Pentapanax racemosa	'Chindey'	Climber	††	Mar-Dec.
Prunus cerasoides	'Payun'	Tree	††	May-Oct.
Quercus lamellosa	'Bajrant'	Tree	†	Jul-Sep.
Rhaphidophora divursiva	'Kanchirna'	Climber	†	Round
Saurauia napaulensis	'Gagoon'	Tree	†††	Round
Schefflera impressa	'Balu-chinde'	Tree	†††	May-Oct.
Thysanolaena maxima	'Amliso'	Shrub	†††	Round
Turpinia nepalensis	'Thali'	Tree	††	May-Sep.
Vaccinium serratum	-	Epiphyte	†	Apr-Dec.
Vitex heterophylla	'Panchpate'	Shrub	†	Jun-Sep.
Zanthoxylum alatum	'Timboor'	Shrub	††	May-Oct.
Agroforestry				
Alnus nepalensis	'Uttis'	Tree	†	Round
Arundinaria maling	'Malingo'	Shrub	†††	Round
Bambusa sp.	'Bans'	Tree	†††	Round
Brassaiopsis mitis	'Chuletro'	Shrub	†††	Round
Ficus cunia	'Khanew'	Shrub	†††	Round
Ficus nemoralis	'Dudhilo'	Shrub	†††	Round
Ficus roxburghii	'Nebhara'	Tree	†††	Round
Prunus cerasoides	'Payun'	Tree	††	May-Oct.
Saurauia napaulensis	'Gagoon'	Shrub	†††	Round
Thysanolaena maxima	'Amliso'	Shrub	†††	Round
Alpine/Subalpine:				
Aletris pauciflora	-	Graminoid	†††	May-Sep
Anemone tetrasepala	-	Forb	†	May-Aug
Bistorta affinis	-	Cushion	†	Apr-Oct
Corydalis juncea	-	Forb	†††	Jun-Aug
Gentiana phyllocalyx	-	Spreading	††	May-Aug
Geranium nakaoanum	-	Cushion	††	Jun-Aug
Hemiphragma heterophyllum	-	Spreading	†	Apr-Oct.
Juncus thomsonii	-	Graminoid	†††	May-Sep.
Pedicularis hoffmeisteri	-	Forb	††	Jun-Aug

Phaeonychium parryoides	-	Cushion	†††	Jun-Aug
Poa sp. I	'Booki'	Graminoid	†††	Apr-Oct
Poa sp. II	'Booki'	Graminoid	†††	Apr-Oct
Poa sp. III	'Booki'	Graminoid	†††	Apr-Oct.
Potentilla coriandrifolia	-	Cushion	††	Jun-Sep.
Potentilla microphylla	-	Cushion	†	May-Sep.
Potentilla peduncularis	-	Forb	†	Apr.-Oct.
Primula primulina	-	Forb	††	Jun-Aug.

*Preference ranking as cited by the villagers and also by personal observations (††† = most preferred, †† = medium preferred, and † = least preferred).

Table 6. Monthly variation in aboveground shoot biomass (g m^{-2}) of herbaceous plants during growing season of 1998 and 1999 in grazed and exclosure plots at four elevation study sites along the Yuksam-Dzongri trail

Study sites (Ecological zones)	Months	1998		1999	
		Gr	Ex	Gr	Ex
Yuksam (Warm temperate)	January	104	118	113	156
	April	209	236	226	252
	June	296	423	282	462
	August	310	567	337	641
	October	204	319	216	338
Sachen (Cool temperate)	January	94	125	101	132
	April	188	251	203	264
	June	306	440	328	443
	August	490	616	488	693
	October	242	297	209	286
Deorali (Sub alpine)	April	134	157	126	149
	June	297	387	278	389
	August	350	535	352	587
	October	197	253	184	281
Dzongri (Alpine)	April	129	145	134	157
	June	206	381	265	420
	August	243	510	310	539
	October	147	197	161	225

Abbreviation used: Gr = Grazed, Ex = Exclosure. ***ANOVA*:** Year $F_{1,704}$=1.75, NS; Site $F_{3,704}$=9.4, P<0.0001; Month $F_{3,704}$=102, P<0.0001; Treatment $F_{1,704}$=103, P<0.0001; Year × Month $F_{3,704}$=0.60, NS; Year × Site $F_{3,704}$=0.19, NS; Year × Treatment $F_{1,704}$=0.44, NS; Month × Site $F_{9,704}$=1.47, NS; Month × Treatment $F_{3,704}$=12, P<0.0001; Site × Treatment $F_{3,704}$=0.65, NS; Year × Month × Site $F_{9,704}$=0.15, NS; Year × Month × Treatment $F_{3,704}$=0.11, NS; Year × Site × Treatment $F_{3,704}$=0.152, NS; Month × Site × Treatment $F_{9,704}$=0.44, NS; Year × Month × Site × Treatment $F_{9,704}$=1.00, NS; $LSD_{(0.05)}$=40.86.

Appendix 1. List of important species, their flowering period, life forms and growth-forms in temperate zone along the Yuksam-Dzongri trail in Kangchengzonga Biosphere Reserve

Families/Species	Flowering period	Life-forms *	Habit **
Temperate Zone:			
Ranunculaceae	Apr-May	Ph	Cl
Clematis montana Buch.-Ham. ex DC.	Mar-May	Ph	Tr
Magnoliaceae	Sep-Oct	Ph	Tr
Magnolia campbellii Hook. f. Thoms.	Jul-Aug	Ph	Tr
Michelia cathcartii Hook. f. & Thoms.	Mar-Apr	Ph	Tr
M. champaca Linn.	Aug-Sep	Ph	Tr
M. excelsa Wall.	May-Jun	Ph	Cl
M. lanuginosa Wall.			
Menispermaceae	Apr-Jun	Ph	Us
Stephania rotunda Lour.	Oct-Apr	Ph	Sh
Berberidaceae	May-Jul	Th	Sf
Berberis wallichiana DC.			
Mahonia napaulensis DC.			
Brassicaceae	Mar-May	Ch	Sf
Nasturtium indicum Linn.			
Violaceae	Apr-May	Ph	Sh
Viola canescens Wall.			
Flacourtiaceae	Apr-Sep	Ph	Sh
Casearia glomerata Roxb.			
Hypericaceae	Jun-Sep	Ch	Sp
Hypericum japonicum Thunb. ex Murray	Jun-Aug	Ch	Sf
Caryophyllaceae	Sep-Nov	Ph	Tr
Drymaria cordata Linn.			
Stellaria medica (Linn.) Cyrill.			
Theaceae	Mar-May	Ph	Sh
Eurya acuminata DC.			
Saurauiaceae	May-Jun	Ph	Tr
Saurauia napaulensis DC.			
Elaeocarpaceae	May-Aug	Th	Tf
Elaeocarpus sikkimensis Mast.			
Balsaminaceae	Apr-Jun	Ph	Tr
Impatiens sp.	Jun-Sep	Ph	Sh
Rutaceae	Jun-Sep	Ph	Sh
Evodia fraxinifolia Benth.			
Zanthoxylum acanthopodium DC.	May-Jun	Ph	Tr
Z.alatum Roxb.			
Burseraceae	Apr-Aug	Ph	Tr
Garuga pinnata Roxb.	Feb-May	Ph	Tr
Meliaceae	Mar-May	Ph	Tr
Amoora wallichii King.			
Toona ciliata Roxb.	May-Jun	Ph	Cl
Heynea trijuga Roxb.			
Vitaceae	May-Jun	Ph	Tr
Cissus repanda Vahl.			

Staphyleaceae			
Turpinia nepalensis Wall.	Apr-May	Ph	Tr
Aceraceae	May-Aug	Ph	Tr
Acer campbellii Hook. f. & Thoms.	May-Jun	Ph	Tr
A.cappadocicum Gled.	May-Jul	Ph	Tr
A.laevigatum Wall.	May-Jul	Ph	Tr
A.oblongum Wall. ex DC.	Feb-Apr	Ph	Tr
A.pectinatum Wall. ex. Pax.	Jul-Aug	Ph	Tr
A.villosum Wallich.	Aug-Sep	Ph	Tr
Anacardiaceae			
Rhus insignis Hook. f.	Jun-Aug	Ph	Tr
R.semialata Murr.			
Fabaceae	Mar-Apr	Ph	Tr
Albizzia procera Benth.	Apr-Jun	Ch	Sf
Rosaceae	Jul-Aug	Ph	Sh
Eriolobus indica Schn.	Oct-Nov	Ph	Tr
Fragaria nubicola Lindl. ex Lacaita	Jun-Feb	Ph	Sh
Neillia rubiflora D. Don	Jun-Feb	Ph	Sh
Prunus cerasoides D. Don	Jun-Feb	Ph	Sh
Rubus ellipticus Sm.			
R. nepalensis (Hook. f.) Kuntze	Jul-Sep	Ph	Sh
R. paniculatus Sm.	Apr-May	Ph	Tr
Saxifragaceae			
Astilbe revularis Buch.-Ham. ex D. Don	Jun-Aug	Ph	Tr
Ribes graciale Wall.			
Hamamelidaceae	Mar-Jun	Ph	Us
Bucklandia populnea R. Br.	Jul-Nov	Ph	Sh
Melastomataceae	Jul-Oct	Ph	Sh
Melastoma normale D. Don	Aug-Oct	Ph	Sh
Osbeckia nepaleansis Hook.			
O. stellata Buch.-Ham. ex D. Don	Jun-Aug	Ph	Cl
Oxyspora paniculata (D. Don) DC.			
Cucurbitaceae	Jul-Aug	Th	Sf
Citrullus colocynthis Schrad.			
Begoniaceae	Jul-Aug	Th	Tf
Begonia sp.	Jun-Aug	He	Sp
Apiaceae	Jun-Aug	He	Sp
Heracleum nepalense D. Don			
Centella asiatica (Linn.) Urb.	Jun-Jul	Ph	Tr
Hydrocotyle javanica (Linn.) Urb.	Jun-Jul	Ph	Sh
Araliaceae	May-Jun	Ph	Tr
Acanthopanax cissifolius Harms.	May-Jul	Ph	Sh
Brassaiopsis mitis C.B. Clarke			
Gamblia ciliata C.B. Clarke	May-Jun	Ph	Tr
Pentapanax leschenaultii Seem.			
Cornaceae	Aug-Sep	Ph	Cl
Nyssa javanica Wangerin	Apr-Jun	Ph	Sh
Caprifoliaceae	Apr-May	Ph	Sh
Lonicera glabrata Wall.	Apr-Jun	Ph	Sh
Viburnum colebrookianum Wall.			
V. cordifolium Wall. ex DC.	Jul-Aug	Ch	Sf
V. erubescens Wall. ex DC.	Mar-Apr	Ph	Sh
Rubiaceae			

Galium verum Linn.	Jun-Nov	Ph	Cl
Mussaenda roxburghii Linn.	Mar-May	Ch	Sf
Rubia manjith Roxb ex. Fleming	May-Feb	Ph	Sh
Rubus calycinus Wallich ex D. Don	Apr-Jun	Th	Sf
R.ellipticus Smith	Jul-Aug	Th	Tf
R.niveus Thunb.	Aug-Sep	Th	Tf
Asteraceae	Jun-Oct	Th	Tf
Adenostema viscosum Frost.	Jul-Oct	Ch	Tf
Ageratum conyzoides Linn.	Oct-Mar	Ch	Tf
Anaphalis sp.	Oct-Mar	Ch	Tf
Artemisia vulgaris Linn.	Mar-Oct	Ch	Tf
Eupatorium cannabinum Linn.	Apr-Oct	Ch	Tf
E. odoratum Linn.			
Gynura cushimboa (D. Don) S. Moore	Feb-Jun	Ph	Sh
G. nepalensis DC.	May-Jul	Ph	Ep
Vacciniaceae	Mar-Apr	Ph	Ep
Agapetes serpens (Wight) Sleumer			
Vaccinium retusum Hook. f.	Jun-Sep	Ph	Tr
V. serratum Wight	Feb-May	Ph	Tr
Ericaceae	Jun-Jul	Ph	Ep
Andromeda elliptica Sieb. & Zucc.			
Rhododendron arboreum Linn.	Aug-Sep	Th	Cu
R.vaccinioides Hook. f.			
Plantaginaceae	Mar-May	Ph	Sh
Plantago erosa Wall.			
Myrsinaceae	Aug-Sep	Ph	Tr
Maesa chisia Buch.-Ham. ex D. Don			
Symplocaceae	Jul-Aug	Ph	Tf
Symplocos theifolia Don			
Asclepiadaceae	Jul-Aug	Ph	Us
Asclepias curassavica Linn.			
Loganiaceae	Jul-Sep	Ch	Sp
Buddleja asiatica Lour.	Apr-May	Ch	Sp
Scrophulariaceae	May-Jun	Ch	Sf
Drymaria cordata Linn.	Jul-Aug	Ch	Sp
Hemiphragma heterophyllum Wall.			
Mazus dentatus Wall. ex Benth.	May-Jun	Ph	Ep
Wulfenia amherstiana Benth.	Jul-Aug	Th	Sf
Gesneriaceae			
Aeschynanthus sikkimensis Stapf.	Jul-Aug	Th	Us
Chirita bifolia D. Don	Jun-Jul	Th	Tf
Amaranthaceae			
Achyranthes aspera Linn.	Apr-May	Ph	Tr
Amaranthus sp.	Jul-Oct	Ph	Tr
Verbenaceae			
Callicarpa arborea Roxb.	May-Jun	Ch	Sp
C. macrophylla Vahl.	Oct-Mar	Ph	Sh
Lamiaceae			
Ajuga lobata D. Don	May-Oct	Ph	Sh
Leucosceptrum canum Sm.	Apr-Nov	Ch	Sp
Polygonaceae	Jun-Jul	Th	Sf
Aconogonum molle D. Don			
Persicaria capitata Gross.			

Polygonum sp.	May-Jun	Ph	Cl
Piperaceae	May-Jun	Ph	Cl
Piper boehmeriaefolia (Miq.) DC.	Apr-May	Ph	Cr
P. longum Linn.			
Aristolochiaceae	May-Jun	Ph	Tr
Aristolochia griffithii Duchartre	May-Jun	Ph	Tr
Lauraceae	Jul-Aug	Ph	Tr
Beilschmiedia roxburghiana Nees	Jul-Aug	Ph	Tr
B. sikkimensis King	Sep-Nov	Ph	Tr
Cinnamomum cecidodaphne Meissn	Apr-May	Ph	Tr
C. impressinervium Meissn	Nov-Mar	Ph	Tr
C. obtusifolium Nees	Mar-Apr	Ph	Tr
C. tamala (Buch.-Ham.) Nees & Eberm	Mar-Apr	Ph	Tr
Litsaea citrata Blume	Apr-Jun	Ph	Tr
L. polyantha Juss	Mar-Apr	Ph	Tr
M. edulis King			
Machilus gammieana King	Aug-Sep	Ph	Us
M. odoratissima (Nees) Kosterm	Oct-May	Ph	Sh
Thymeliaceae			
Daphne involucrata Wall.	Jul-Aug	Ph	Ep
Edgeworthia gardneri (Wall.) Meissner			
Loranthaceae	Apr-May	Ph	Tr
Viscum articulatum Linn.	Apr-Jun	Ph	Tr
Euphorbiaceae	Oct-Nov	Ph	Tr
Aporosa dioica Muell.			
Glochidion acuminatum Muell.	Apr-Jun	Ph	Sh
Macaranga pustulata King	Apr-Jun	Ch	Tf
Urticaceae	Jun-Aug	Ph	Us
Debregeasia salicifolia (D. Don) Rendle	Jun-Aug	Ph	Us
Elatostema sessile Wedd.	May-Aug	Ch	Tf
Girardinia dicursifolia (Link) Friis.	Aug-Sep	Ch	Tf
Laportia terminalis Wight	Jun-Aug	Ph	Us
Lecanthus peduncularis (Royle) Wedd.			
Pilea scripta (Buch.-Ham. ex D.Don) Wedd.	Jun-Sep	Ph	Sh
Urtica dioica Linn.	Jun-Aug	Ph	Ep
Moraceae	Jul-Aug	Ph	Tr
Ficus cunia Buch.-Ham. ex Roxb.	Jul-Aug	Ph	Tr
F.foveolata Wall.	Apr-Jun	Ph	Tr
F. infectorius Linn.	Apr-May	Ph	Tr
F. nemoralis Wall.			
F. roxburghii Wall. ex Miq.	Apr-Aug	Ph	Tr
Morus laevigata Wall.	Mar-May	Ph	Tr
Juglandaceae			
Engelhardtia spicata Leschen ex Blume	Oct-Dec	Ph	Tr
Juglans regia Linn.	Mar-Apr	Ph	Tr
Betulaceae			
Alnus nepalensis D. Don	Apr-May	Ph	Tr
Betula alnoides Ham.	Oct-Nov	Ph	Tr
Fagaceae	Aug-Sep	Ph	Tr
Castanopsis hystrix Miq.	Jul-Aug	Ph	Sh
C. indica (Roxb.) Miq.	Apr-May	Ph	Tr
C. tribuloides (Sm.) A. DC.	Apr-Jun	Ph	Tr
Lithocarpus pachyphylla (Kurz) Rehder			

Quercus lamellosa Sm.	Aug-Sep	Ph	Tr
Q. lanata Sm.			
Taxodiaceae			
Cryptomeria japonica D. Don	Aug-Sep	Ph	Tr
Cupressaceae			
Juniperus sp.	Jun-Jul	Ph	Ep
Orchidaceae	May-Jun	Ch	Tf
Bulbophyllum affine Lindl.	Mar-Apr	Ph	Tr
Calanthe brevicornu Lindl.	Apr-May	Ph	Ep
Coelogyne cristata Lindl.	Apr-May	Ph	Ep
C. flaccida Lindl.	Jun-Aug	Ph	Ep
C. ochracea Lindl.	May-Jun	Ph	Ep
Habenaria pectinata D. Don	Jul-Aug	Th	Tf
Dendrobium fimbriatum Hook.	Oct-Nov	Ph	Tr
Malaxis muscifera (Lindl.) Kuntze			
Pleione praecox (Sm.) D. Don	Jul-Aug	Ch	Tf
Zingiberaceae	Jun-Aug	Ch	Tf
Hedychium aurantiacum Roscoe	Jun-Aug	Ch	Tf
H. ellipticum Sm.			
Roscoea purpurea Sm.	May-Jun	Ge	Tf
Liliaceae	Sep-Oct	Ph	Cl
Paris polyphylla Sm.	May-Jun	Ph	Us
Smilax aspera Linn.	Apr-Jun	Th	Gr
S. ferox Wall. ex Kunth			
Tupistra nutans Hook. f.	Jul-Aug	Ch	Gr
Commelinaceae	Jul-Aug	Ch	Gr
Commelina benghalensis Linn.	Jul-Sep	Ch	Gr
C. paludosa Blume			
Cyanotis vaga (Lour.) Schultes & Schultes f.	May-Jun	Ch	Tf
Araceae	May-Jun	Ch	Tf
Arisaema costatum Martius ex Schott	May-Jun	Ch	Tf
A. erubescens (Wall.) Schott	May-Jun	Ch	Tf
A. griffithii Schott	Jul-Aug	Ch	Tf
A. intermedium Blume	May-Jun	Ch	Tf
A. jacquemontii Blume	Aug-Sep	Ge	Tf
A. speciosum Martius ex Schott	Jun-Aug	Ge	Tf
Colocasia esculenta (Linn.) Schott	-	Ph	Cl
Gonatanthus pumilus Engler & Krause	Nov-Dec	Ph	Cl
Pothos scandens Linn.			
Rhaphidophora dicursiva (Roxb.) Schott	Jul-Sep	Ge	Gr
Cyperaceae			
Cyperus sp.	Sporodic	Ph	Tr
Poaceae	Jul-Aug	Th	Tf
Arundinaria maling Gamble			
Brachiaria sp.			
Sub-alpine zone:			
Ranunculaceae			
Anemone tetrasepala Royle	Jun-Aug	He	Tf
Ranunculus diffusa DC.	Jun-Aug	Th	Tf
Thalictrum foliosum DC.	Jul-Aug	Ch	Tf
T. Virgatum Hook. f. & Thoms.	Jun-Aug	Ch	Tf
Papaveraceae			
Corydalis juncea Wall.	Jun-Jul	Ch	Tf

Meconopsis paniculata Prain.	Jun-Aug	Ch	Tf
Brassicaceae			
Lignariella hobsonii (Pearson) Baehni	Jun-Jul	Th	Sp
Pegaeophyton scapiflorum Marquand & Shaw	Jun-Jul	Ge	Cu
Berberidaceae			
Berberis wallichiana DC.	Apr-May	Ph	Us
Theaceae			
Eurya acuminata DC.	Sep-Nov	Ph	Tr
Balsaminaceae			
Impatiens stenantha Hook. f.	Jul-Sep	Ch	Tf
I. sulcata Wall.	Jul-Aug	Ch	Tf
I.urticifolia Wall.	Jun-Aug	Ch	Tf
Aceraceae			
Acer campbellii Hook. f. & Thoms.	Jun-Aug	Ph	Tr
A..Sterculiaceum Wall.	Mar-Jun	Ph	Tr
Geraniaceae			
Geranium nakaoanum Hara	Jun-Aug	Ch	Sp
Fabaceae			
Parochetus communis Buch.-Ham.ex D. Don	May-Oct	Ch	Sf
Rosaceae			
Fragaria daltoniana Gay.	Apr-Jun	Ch	Sp
F.nubicola Lindl. ex Lacaita	Apr-Jun	Ch	Sp
Potentilla coriandrifolia D. Don	Jun-Aug	He	Sf
P. microphylla D. Don	Jun-Jul	He	Sf
P. peduncularis D. Don	Jun-Aug	Ch	Tf
P. plurijuga Hand.-Mazz.	Jun-Aug	Th	Sf
Rosa sericea Lindl.	May-Aug	Ph	Sh
Sorbus foliolosa (Wall.) Spach.	Jun-Jul	Ph	Sh
S. microphylla Wenzing	Jun-Jul	Ph	Sh
Parnassiaceae			
Parnassia nubicola Wall. ex Royle	Jul-Aug	Th	Sf
Onagraceae			
Epilobium latifolium Linn.	Jul-Aug	Th	Tf
E. wallichianum Hausskn.	Jul-Sep	Th	Tf
Apiaceae			
Heracleum wallichii DC.	Jul-Sep	Th	Tf
Selinum tenuifolium Wall. ex C.B. Clarke	Jul-Sep	Ch	Tf
Araliaceae			
Schefflera impressa (C.B. Clarke) Harms.	Aug-Sep	Ph	Sh
Caprifoliacea			
Viburnum erubescens Wall. ex DC.	Apr-May	Ph	Sh
V. nervosum D. Don	Apr-May	Ph	Sh
Vacciniaceae			
Gaultheria pyroloides Miq.	Jun-Jul	Ph	Sp
G. tricophylla Royle	Jun-Aug	Ph	Sp
Vaccinium nummularia C.B. Clarke	Apr-Jun	Ph	Sp
Campanulaceae			
Cyananthus lobatus Wall. ex Benth.	Jul-Sep	Ch	Sf
Ericaceae			
Rhododendron barbatum Wall. Ex G. Don	Apr-May	Ph	Tr
R. cinnabarinum Hook. f.	May-Jun	Ph	Sh
R. dalhousiae Hook. f.	Apr-May	Ph	Sh
R. falconeri Hook. f.	Apr-May	Ph	Sh

R. fulgens Hook. f.	Jun-Jul	Ph	Sh
R. hodgsonii Hook. f.	Apr-May	Ph	Tr
R. lepidotum Wall. ex G. Don	Jun-Aug	Ph	Tr
R. thomsonii Hook. f.	May-Jun	Ph	Sh
R. wightii Hook. f.	Apr-May	Ph	Sh
Primulaceae			
***Primula calderana* Balf. f. Cooper**	**May-Jul**	**Ch**	**Tf**
P. irregularis Craib.	May-Aug	Ch	Cu
P.sikkimensis Hook. f.	May-Jul	Ch	Tf
Gentianaceae			
Giantiana phyllocalyx C.B. Clarke	Jul-Aug	Ch	Sp
G. algida Pallas	Jul-Aug	Ch	Sp
Scrophulariaceae			
Pedicularis hoffineisteri Klotzsch	Jul-Aug	Ch	Sf
Lamiaceae			
Phlomis rotata Hook. f.	Jun-Aug	Ch	Sf
Prunella vulgaris Linn.	Jun-Sep	Th	Sf
Symplocaceae			
Symplocos theifolia Don	Aug-Sep	Ph	Tr
Thymellaceae			
Daphne bholua Buch.-Ham. ex D. Don	Oct-Mar	Ph	Sh
Euphorbiaceae			
Euphorbia stracheyi Boiss.	Jun-Jul	Th	Sf
Betulaceae			
Betula cylindrostachys Wall.	Dec-Jan	Ph	Tr
Salicaceae			
Salix sikkimensis Anderson	Apr-May	Ph	Tr
Pinaceae			
Abies densa Griffith ex R. Parker	Apr-May	Ph	Tr
Tsuga dumosa (D. Don) Eichler	Jul-Sep	Ph	Tr
Orchidaceae			
Galearis spathulata (Lindl.) P.F. Hunt	Jul-Sep	Ge	Sf
Liliaceae			
Aletris pauciflora (Klotzsch) Hand. Mazz.	Jun-Aug	Th	Gr
Polygonatum multiflorum (Linn.) All.	May-Jun	Th	Tf
Smilacina oleraceae (Baker) Hook.f.	May-Jul	Ge	Tf
S. purpurea Wall.	May-Jul	Ge	Tf
Streptopus simplex D. Don	May-Jul	Ge	Tf
Juncaceae			
Juncus thomsonii Buchenau	Jun-Sep	He	Gr
Poaceae			
Arundinaria maling Gamble	Sporodic	Ph	Sh
Poa sp. I	Jun-Jul	He	Gr
Poa sp. II	Jun-Jul	He	Gr
Poa sp. III	Jun-Jul	He	Gr
Alpine zone:			
Ranunculaceae			
Aconitum ferox Wall. ex Seringe	Aug-Sep	Ch	Tf
Aconitum hookeri Stapf.	Aug-Sep	Ch	Sf
Anemone tetrasepala Royle	Jun-Aug	He	Tf
Caltha palustris Linn.	May-Jun	Ch	Sp
Delphinium drepanocentrum (Brechl) Munz	Jul-sep	He	Tf
D. graciale Hook. f. & Thoms.	Jul-Sep	He	Sf

D. viscosum Hook. f. & Thoms.	Aug-Sep	He	Tf
Oxygraphis polypetala (Royle) Hook. f. & Thoms.	Apr-Jun	Ch	Sf
Thalictrum alpinum Linn.	May-Aug	Ch	Tf
Papaveraceae			
Corydalis cashmeriana Royle	May-Aug	Th	Sf
C. juncea Wall.	Jun-Jul	Ch	Sf
C. meifolia Wall.	Jun-Aug	Ch	Sf
Meconopsis dhwojii G. Taylor	Jun-Jul	Ch	Sf
M. grandis Prain	Jul-Aug	Ch	Tf
M. horridula Hook. f. & Thoms.	Jul-Aug	Ch	Sf
M. paniculata Prain	Jun-Aug	Ch	Tf
Brassicaceae			
Lignariella hobsonii (Pearson) Baehni	Jun-Jul	Th	Sp
Caryophyllaceae			
Silene nigrescens (Edgew.) Majumdar	Jul-Sep	Ch	Sf
S. setisperma Majumdar	Jul-Sep	Ch	Sf
Geraniaceae			
Geranium nakaoanum Hara	Jun-Aug	Ch	Sp
G. wallichianum D. Don ex Sweet	Jun-Aug	Th	Tf
Balsaminaceae			
Impatiens glandulifera Royle	Jul-Sep	Ch	Sf
I. stenantha Hook. f.	Jul-Aug	Ch	Sf
I. urticifolia Wall.	Jun-Aug	Ch	Sf
Fabaceae			
Parochetus communis Buch.-Ham. ex D. Don	May-Nov	Th	Sp
Rosaceae			
Geum sikkimensis Prain	Jun-Aug	He	Sp
Potentilla coriandrifolia D. Don	Jun-Aug	He	Sp
P. microphylla D. Don	Jun-Jul	He	Sf
P. peduncularis D. Don	Jun-Aug	He	Tf
P. plurijuga Hand.-Mazz	Jun-Jul	He	Sf
Rosa sericea Lin.	May-Aug	Ph	Us
Spiraea arcuata Hook. f.	Jun-Jul	Ph	Sh
Saxifragaceae			
Arenaria densissima Wall. ex Edgew. & Hook. f.	Apr-Jun	Ch	Cu
Bergenia ciliata (Haw.) Sternb.	Mar-Jul	Ch	Cu
Saxifraga brunonis Wall. ex Seringe	Jun-Sep	Ch	Sp
S. engleriana Harry-Sm.	Jun-Jul	Ch	Cu
S. pulvinaria Harry-Sm.	Jun-Aug	Ch	Cu
S. Stenophylla Royle	Jun-Aug	Ch	Sf
Parnassiaceae			
Parnassia nubicola Wall. ex Royle	Jul-Aug	Th	Sf
Crassulaceae			
Rhodiola himalensis (D. Don) S.H. Fu	Jun-Aug	Ch	Sf
Onagraceae			
Epilobium latifolium Linn.	Jul-Aug	Th	Tf
Apiaceae			
Cortia depressa (D. Don) Norman	Jun-Aug	Ch	Sf
Selinum tenuifolium Wall. ex C.B. Clarke	Jul-Aug	Ch	Tf
Dipsacaceae			
Morina nepalensis D. Don	Jun-Aug	Ch	Sf
M.polyphylla Wall. ex DC.	Jun-Aug	Ch	Tf

Asteraceae			
Anaphalis triplinervis (Sims.) C.B. Clarke	Jul-Sep	Th	Sf
Cremanthodium oblongatum C.B. Clarke	Jun-Aug	Th	Sf
C. reniforme (DC.) Benth	Jun-Aug	Th	Tf
Jurinea dolomiaea Boiss.	Jul-Sep	Ch	Sf
Leontopodium jacotianum Beauv.	Jul-Sep	Ch	Sf
Saussurea costus (Falc.) Lipsch	Jul-sep	Ch	Sf
S. nepalensis Sprengel	Jul-Sep	Ch	Cu
S. obvallata (DC.) Edgew.	Jul-Sep	Ch	Tf
Soroseris hookerana (C.B. Clarke) Stebbins	Jul-Aug	Ch	Sf
Campanulaceae			
Codonopsis thalictrifolia Wall.	Jul-Aug	Th	Sf
Cyananthus incanus Hook. f. & Thoms.	Jul-Sep	Ch	Sp
C. lobatus Wall. ex Benth.	Jul-Sep	Ch	Sf
Ericaceae			
Cassiope fastigiata (Wall.) D. Don	Jun-Aug	Ch	Sf
Gaultheria pyroloides Hook. f. & Thoms. ex Miq.	Jun-Jul	Ch	Sp
G. trichophylla Royle	May-Jul	Ch	Sp
Rhododendron aeruginosum Hook. f.	Jun-Jul	Ph	Us
R. anthopogon D. Don	Jun-Jul	Ph	Us
R.fulgens Hook. f.	Jun-Jul	Ph	Sh
R. lepidotum Wall. ex G. Don	Jun-Aug	Ph	Us
R. lowndesii Davidian	Jun-Aug	Ph	Us
R. nivale Hook. f.	Jun-Jul	Ph	Us
R. setosum D. Don	Jun-Jul	Ph	Us
R. sikkimensis Pradhan & Lachungpa	May-Jun	Ph	Sh
R. thomsonii Hook. f.	May-Jul	Ph	Sh
Pyrolaceae			
Pyrola sikkimensis Krisa	Jul-Aug	Ge	Cu
Primulaceae			
Androsace lehmannii Wall.	Jul-Aug	Ch	Cu
Primula antrodenta W. W. Sm.	May-Jul	Ch	Sf
P. calderana Balf. f. & Cooper	Jun-Jul	Ch	Tf
P. capitata Hook.	Jul-Aug	Ch	Tf
P. glabra Klatt.	Jun-Sep	Ch	Sf
P. glomerata Pax.	Aug-Nov	Ch	Tf
P. irregularis Craib.	Apr-May	Ch	Cu
P. macrophylla D. Don	Jun-Aug	Ch	Tf
P. primulina (Sprengel) Hara	Jun-Aug	Ch	Sf
P. sikkimensis Hook. f.	May-Jul	Ch	Tf
Gentianaceae			
Gentiana algida Pallas	Sep-Oct	Ch	Sf
Gentiana ornata (G. Don) Griseb.	Sep-Oct	Ch	Sp
G. phyllocalyx C.B. Clarke	Jun-Aug	Ch	Sp
G. tubiflora (G. Don) Griseb.	Jul-Sep	Ch	Cu
Megacodon stylophorus (C.B.Clarke)Harry-Sm.	Jun-Jul	Ch	Tf
Swertia multicaulis D. Don	Jun-Sep	Ch	Cu
Boraginaceae			
Trigonotis rotundifolia Benth. ex C.B. Clarke	Jun-Aug	Th	Cu
Scrophulariaceae			
Hemiphragma heterophyllum Wall.	Mar-May	Ch	Sp
Lagotis kunawurensis (Royle ex Benth.) Rupr.	Jun-Aug	Ch	Sf
Pedicularis hoffmeisteri Klotzsch	Jul-Aug	Ch	Sf

P. megalantha D. Don	Jun-Sep	Ch	Tf
P. roylei Maxim.	Jun-Aug	Ch	Sf
P.scullyana Prain ex Maxim.	Jul-Aug	Ch	Sf
Picrorhiza kurrooa Royle ex Benth.	Jun-Aug	Ch	Cu
Lamiaceae			
Eriophyton wallichii Benth.	Jul-Sep	Th	Cu
Phlomis rotata Benth. ex Hook. f.	Jun-Aug	Ch	Sf
Polygonaceae			
Bistorta affinis (D. Don) Greene	Jun-Sep	He	Sp
B. emodi (Meissner) Hara	Jul-Sep	He	Tf
B. macrophylla (D. Don) Sojak.	Jun-Aug	He	Tf
B. vaccinifolia Greene	Aug-Sep	He	Sp
Oxyria digyna (Linn.) Hill.	May-Jul	Ch	Tf
Persicaria polystachya Gross	Jul-Sep	Ph	Tf
Rheum australe D. Don	Jun-Jul	Ge	Tf
R.nobile Hook. f. & Thoms.	Jun-Jul	Ge	Tf
Euphorbiaceae			
Euphorbia stracheyi Boiss.	May-Aug	Th	Sp
Curressaceae			
Juniperus indica Bertol.	Jun-Jul	Ph	Sf
J. recurva Buch.-Ham. ex D. Don	Jun-Jul	Ph	Us
Orchidaceae	Jul-Sep	Ge	Sf
Galearis spathulata (Lindl.) P .F. Hunt	Jun-Jul	Ge	Sf
Orchis latifolia Linn.			
Zingiberaceae	Jun-Aug	Ge	Sf
Roscoea alpina Royle			
Liliaceae	Jun-Aug	He	Gr
Aletris pauciflora (Klotzsch) Hand.-Mazz.	Aug-Sep	He	Gr
Allium wallichii Kunth.	Jul-Aug	Th	Sf
Lloydia flavonutans Hara			
Juncaceae	Jun-Sep	He	Gr
Juncus thomsonii Buchenau			
Araceae	May-Jun	Ge	Tf
Arisaema griffithii Schott.	Jun-Aug	Ge	Tf
A. jacquemontii Blume			
Cyperaceae	Aug-Sep	He	Gr
Carex sp.			
Poaceae	Jul-Sep	He	Gr
Poa sp. I.	Jul-Sep	He	Gr
Poa sp. II	Jul-Sep	He	Gr
Poa sp. III			

Abbreviation used: Ph = Phanerophyte; Ch = Chamaephyte; He = Hemi-geophyte; Ge = Geophyte, Th = Therophyte), **(Tr = Tree; Sf = Short forb; Tf = Tall forb; Cu = Cushion forb; Sp = Spreading forb, Sh = Shrub; Us = Under-shrub; Gr = Graminoid; CI = Climber; Ep = Epiphyte; and Cr = Creeper.