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Depletion of Oak (*Quercus* spp.) Forests in the Western Himalaya: Grazing, Fuelwood and Fodder Collection

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1. Introduction

The Himalaya, youngest mountain range of the world covers about 18% of total geographical area of India. Forests constitute (50% of India's forest cover) an important natural resource base in the Himalaya, most important being the temperate broad leaf forests, which are largely dominated by different species of oak (*Quercus* species). In India Rodgers & Panwar (1988) divided the Indian Himalaya into six provinces *viz.,* Ladakh mountain, Tibetan plateau, North-West Himalaya, Western Himalaya, Central Himalaya and the Eastern Himalaya. The Western Himalaya comprises of the eastern part of Himachal Pradesh and the state of Uttarakhand between the rivers Satluj and Sharada. Oaks (*Quercus* spp.) are the dominant, climax tree species of the moist temperate forests of the Indian Himalayan region (Troup, 1921) where about 35 species of *Quercus* are extensively distributed between 1000-3500 m elevations. Five species of evergreen oak namely *Quercus glauca* (phaliyant/harinj), *Q. leucotrichophora* (banj), *Q. lanuginosa* (rianj), *Q. floribunda* (tilonj/moru) and *Q. semecarpifolia* (brown/kharsu) grow naturally in the western Himalaya.

In the Western Himalaya, oak species assume considerable conservation significance as they are providers of numerous ecosystem services (conservation of soil, water, native flora and fauna) and serve as lifeline for the local communities. Predominantly three oak species (*Quercus leucotrichophora, Q. floribunda and Q. semecarpifolia*) are intricately associated not only with agro-ecosystems but also with the life support system of the inhabitants of the hills in this area. The oak forests are source of fuelwood, fodder and can be correlated with natural springs and wildlife (Singh, 1981).

The Himalaya is the home of many unique and diverse human groups, living in the river valleys and mountain slopes which differ from each other in terms of language, culture, tradition, religion and patterns of resource use. They have been subsisting on the Himalayan natural resources for millennia. In recent few decades, with better access to global market and demand of socio-economic development, local people's dependence on natural resources has increased immensely. Steady increase in human population, tourism, over exploitation, widespread logging, overgrazing, removal of leaf and wood litter from the forests floor has been responsible for the forest degradation in the region (Gorrie, 1937; Chaturvedi, 1985). Other than excessive exploitation by the local communities, replacement of oak by pine (Singh et al., 1984) has become a common and ever increasing phenomenon in the Western Himalayan region. These forests have been burnt from time to time by the local inhabitants in order to encourage growth of grasses and to increase the preponderance of the fire-resistant commercial species (*e.g.,* Chir pine), at the expense of oak species. All the gentle and accessible meadows in the temperate, alpine and sub-alpine regions have undergone extensive habitat degradation, with over 70% of the natural vegetation reported to have been lost (Singh, 1991). Ives and Messerli (1989) called this explanation "overly simplistic" and have named it the "Theory of Himalayan Environmental Degradation".

In this chapter we are mainly concerned with three major forms of activities that have affected the western Himalayan oak, grazing, fuelwood and fodder collection. All these three activities are mainly linked to subsistence living of the local population of the hills. We provide local data on these parameters from Kedarnath Wildlife sanctuary, Western Himalaya.

2. Material and methods

2.1 Study area

The study was conducted in the southern fringe of Kedarnath Wildlife Sanctuary, Chamoli-Rudraprayag district in Western Himalaya. The area is characterized by undulating topography, wide variation in the altitude, rain fall, temperature and soil conditions. The area is an important wintering range of several high altitude animals and is used by a large number of local agro-pastoral and migratory community (gujjars) besides tourists and pilgrims during summer. The intensive study area (~975 km^2) covers a wide altitudinal range from 1500-3680 m asl with the varying mean annual temperature range (-4 to 34^0C). About 182 villages are distributed around Kedarnath WS, of which about 50 are close to the wildlife area. The main pressure on the protected area (PA) is in the summer season involving grazers like sheep, goats and buffaloes along with the load of pilgrimage and collection of fuelwood and fodder. About twenty villages situated close to the sanctuary were selected for the present study. Livestock rearing and tourism are the main landuse practices across different altitudinal zones in the region.

2.2 Data collection and analysis

A field survey was carried out from 2006 to 2010, to study the status of plant diversity along the altitudinal and human use gradient across various oak forests. Based on extensive reconnaissance survey and dominance, three types of forests, *Q. leucotrichophora* (1200-2200 m asl), *Q. floribunda* (2201-2700 m asl) and *Q. semecarpifolia* (2701-3300 m asl) were selected for the vegetation study. There were around 16 camping sites present in the study area from where data was collected. These camps are regularly visited by the pastoral communities every year, therefore an attempt was made to understand the impact of grazing and camping on the forest cover. Geometrically corrected Landsat data for the year 1976 (MSS), 1990 (TM) and 1999 (ETM+) were used to focus on the grazing pressure on the forested area over the period. All the three forests had been categorised into different disturbance categories, (i.e. Undisturbed (UD), Moderately disturbed (MD), and Highly disturbed (HD), with the help of the disturbance index (Kanzaki and Kyoji 1986). Canopy cover and grazing by livestock/year is among the most important parameters in the measurement of the disturbance, and were measured by a densitometer (GRS densitometer) and total livestock count respectively. Basal area (area occupied by the base of a tree) is a good indicator of the size and volume or weight of a tree. Girth of cut stumps was measured at ground level and basal area for cut stumps was calculated. Cut stump index was calculated on the basis of the ratio of basal area of cut stumps to the total stand basal area including felled ones.

Stratified random transects with 10 plots at every 200 m interval depending upon the accessibility, were laid in all three types of forests along the altitudinal and anthropogenic pressure gradients. 10 m radius (314 m^2 area) plot for tree species with concentrated plot of 5 m radius (78.5 m^2 area) for shrubs and regenerating individuals within the larger plot was laid. For the ground layer *i.e.,* grasses and herbs 1m × 1m quadrats were laid one each in East, West, North and South directions. In each stipulated plot, name of the species, number, circumference at breast height (CBH, 1.37m) and canopy cover were measured for trees and only number of individuals were recorded for the shrub species. Plants, >30 cm cbh and >3 m straight bole were considered as trees, regenerating individuals of tree species between 10-30 cm cbh were considered as sapling and <10 cm cbh to one or two leaf stage individuals were considered as seedlings. Woody species which had cbh < 20 cm, height < 3 m and those had several branching from base of the stem were considered as shrubs. Transects were laid along pathways and streams in forests in spatially distributed pattern, so as to minimize the autocorrelation in the vegetation. Anthropogenic pressure was assessed in terms of canopy cover (%), cut stumps analysis, livestock availability/year and fuelwood collection. Since fuelwood/fodder collection and livestock grazing are the major cause of disturbance in these forests, total livestock unit available per year and total fuelwood/fodder collection of different forest stands had been used to quantify the intensity of disturbance.

Field data was analyzed both in regress (scientific purposes) and simple (convenience of local people and management authority) methods, where it was quantitatively analysed for frequency, density and basal area following the standard ecological methods. The Importance Value Index (IVI) for tree species was determined as the sum of relative frequency, relative density, and relative basal area. Species richness, the number of species per unit area, Shannon diversity index, and evenness index were also calculated. Chi-square test was performed to test whether the densities of trees in the different categories of forests are (<4 km, > 4 km and sanctuary area) significantly different.

For the estimation of fuelwood and fodder collection, informal interviews were taken in each village. Interviews revealed on an average, two people per day par household were involved in fuelwood and fodder collection. The total number of households in each village were multiplied by two to give an approximation of the total population responsible (TPR) for fuelwood and fodder collection in each village. The identification of major fuelwood and fodder species was mainly based on interviews, informal discussions and personal observations of the authors. The quantity of fuelwood and fodder collection was estimated over a period of 24 hours using a weighted survey method. Traditionally, the woodlot was weighed and left in the kitchen to be burnt and the actual fuelwood consumption was measured following 24 hours. Similarly, the fodder lot was weighed before keeping for the stall feeding and measured on a daily basis.

3. Results and discussion

3.1 Grazing in the oak forested area

Five distinct pastoral practices: (a) nomadic, (b) semi-nomadic, (c) nuclear transhumance, (d) trans-migratory and (e) sedentary have been reported in the area (Rawat, 2007). Few families from every village practice a kind of semi-pastoralism, with animal husbandry (sheep/goats) in higher elevations (2500-4500 m) as their predominant occupation although, over the period of time, several communities have changed their life style from nomadic to semi-nomadic wherein only few members of the family move along with their herds to high altitude areas. Other than that there are nomads, such as "Gujjars" who lead a pastoral life style, traversing almost the entire elevation range that supports oak forests (1200-3300 m asl.) in the western Himalaya to graze their animals (buffaloes, cows and mules).

Livestock mainly feed on small regenerating plants and in this process they gradually eliminate the understory vegetation of the forest. People, who carry livestock with them, meet their needs for fuelwood and timber for making huts and poles for fencing from the surrounding forests. As a result of regular lopping and logging, the canopy density continues to decrease, as younger plants are not available to occupy the open canopies.

3.2 Vegetation structure and regeneration status along grazing gradient

The forests within the 3-4 km distance from villages were frequently used by local communities throughout the year for grazing, fuelwood, and fodder collection. The forests situated away from the villages (>4 km) were occasionally used by the people when they go to higher elevations (sub-alpine and alpine) for grazing in summer and come down before winter. Sanctuary and nearby forests in cool temperate and sub-alpine zones are frequently grazed by livestock of migratory community (gujjar) as well as local people for 6 to 8 months. The forests away from the village (>4 km) significantly showed higher tree density (463 trees ha^{-1}) and regenerating individuals (seedlings 2490 individuals ha^{-1} and saplings 481 individuals ha^{-1}) in comparison with village forests and forests near sanctuary. Chi square test was performed to test whether the densities of trees in the different categories of forests are significant, the null hypothesis was rejected showing marked differences in densities of trees in the different categories of forest at 5% of difference ($\dot{\alpha}$=0.05). Shrub density in village forests was higher than away from village and nearer to the sanctuary forests. This is because excessive grazing supports high shrub cover of unpalatable species (Singh and Singh, 1992). High invasive species cover, low canopy and herbaceous cover in village forests indicates the high collection (lopping/logging) of available species (*Q. leucotrichophora, Daphniphyllum himalayense, Alnus nepalensis* etc.) for fuelwood, fodder and livestock grazing (Table 1).

Among the dominant tree species, *Q. leucotrichophora* (115 trees ha^{-1}) had maximum density in village forests, *Q. floribunda* (76 trees ha^{-1}) had highest density in distant forests (forests away from village) and *Q. semecarpifolia* (178 trees ha^{-1}) had maximum density in forests near the sanctuary (Table 2). *Sarcococca saligna* and *Daphne papyracea* were only shrubs which were frequently found in understory of all the three different forests.

Parameters	< 4 kms from village	>4 km from village	Near Sanctuary area
	n= 40	n=40	n=40
*Tree density $ha^{-1} \pm$ SE	408 ± 4.1	463 ± 2.9	386 ± 9.9
*Shrub density $ha^{-1} \pm$ SE	5420 ± 63.8	4885 ± 129.3	3936 ± 114.6
*Herb density $ha^{-1} \pm$ SE	67375 ± 300	89875 ± 340.4	561188 ± 2052.5
*Seedling density $ha^{-1} \pm$ SE	917 ± 11.9	2490 ± 28.6	475 ± 17.2
*Sapling density $ha^{-1} \pm$ SE	455 ± 4.9	481 ± 6.4	217 ± 4.9
% canopy cover (trees)	29.63	54.63	34.25
% Ground cover	4.15	11.63	45.38
% Herb species cover	42.5[a]	15.5[b]	35[c]
Diversity (H′)	3.30	3.1	2.93
Richness (R)	100	86	92

*significant at ά=0.05 level, [a]*Eupatorium adenophorum* (invasive species), [b]*Strobilanthes atropurpureus*, [c]*Trachydium roylei*

Table 1. Comparison of vegetation at different distance from villages.

Parameters	< 4 kms from village (Village Forests)	>4 km from village (Distant Forests)	Forests near Sanctuary
	n= 40	n=40	n=40
Tree species			
Q.leucotrichophora	115	10	-
Q. floribunda	-	76	4
Q. semecarpifolia	-	14	178
R. arboreum	72	42	171
Lyonia ovalifolia	57	55	2
Daphniphyllum himalayense	32	3	-
Alnus nepalensis	35	8	-
Pyrus pashia	31	-	-
Shrub species			
Sinarundinaria falcata	1828	229	-
Chimnobambusa jaunasarensis	-	2634	-
Thamnocalamus falconeri	-	-	643
T. spathiflora	-	392	-
Sarcococca saligna	471	1172	2236
Daphne papyracea	16	153	38
Berberis lycium	382	-	-
Randia tetrasperma	672	-	-

Table 2. Density ha^{-1} of important trees and shrubs across the disturbance gradient

The GIS analysis of the study sites shows that the area of grazing land was initially 492.95 ha (1976) and it gradually increased to 601.496 ha (1990), 723.621 ha (1999) and 792.428 ha (2005). This clearly indicates that there has been a steady increase in the area of grazing land at the cost of forest cover around camping sites i.e., ca 108.54 ha during 1976–1990 (14 years), 122.49 ha during 1990–1999 (9 years) and 68.78 ha during 1999–2005 (6 years) (Thakur et al. 2011) (Fig.1).

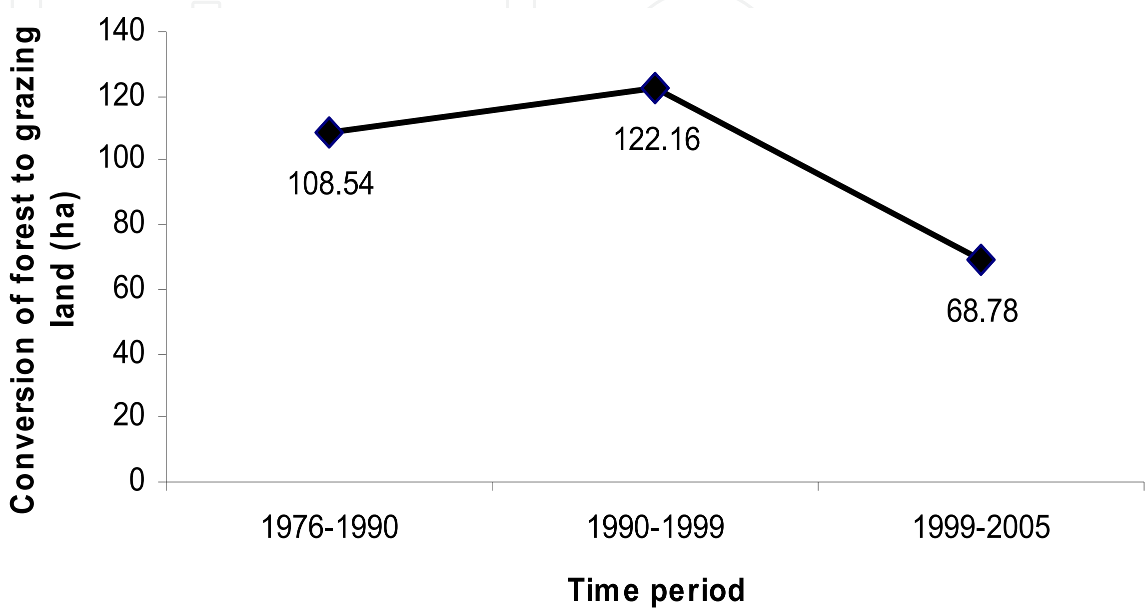

Fig. 1. Conversion of forest to grazing land across various time periods

3.3 Fuelwood consumption by villagers and temporary shops

Fuelwood is an important component of household economies in the Himalaya. In the western Himalaya, about 77.4% of the total human population is rural. Due to low connectivity with the urban areas of the country, the alternative sources of energy resources are not easily accessible hence making the population totally dependent on wood resources (Table 3) of the area. The information on fuelwood resources of the Himalaya is almost scattered. The issue as such has been addressed invariably but there has been no attempt to correlate the fuelwood consumption by villagers and migratory nomads (Gujjars). A total of 865 species of vascular plants (angiosperms, gymnosperms and pteridophytes) belonging to 479 genera and 131 families, were recorded from the region (Singh, 2008). According to growth habits these species were distributed across 501 herbs, 110 shrubs, 74 trees, 43 climbers, 70 graminoides and 61 ferns. Among all, 88 woody species (54 trees and 34 shrubs) are commonly used for fuelwood by the local people (Singh et al. 2010). The diversity of fuelwood use was depended on the species quality, accessibility and availability and also the human population of the adjoining villages (Singh and Singh, 1992).

The density of preferred woody species (for fuelwood and fodder) was highest in the distant forests (463 ± 2.9 ind/ha) followed by village forests (408± 4.1 ind/ha) and least in near sanctuary forests (386 ± 9.9 ind/ha). Seasonal variation of resources extracted from the forests was very much evident from the study. In permanent villages, fuelwood was either cut directly from the forests or dead wood of any kind was collected. Fuelwood consumption at permanent village did not vary across different seasons. The average fuelwood consumption was found to be 20-22 kg/day/household (Table 4a, 4b), where 40-60 species were used by the local communities. Whereas at temporary huts or shops, the fuelwood consumption was restricted between April to October, but due to high tourist season and low temperature at higher altitude, use of fuelwood was quite high compared to permanent residents of villages.

Zone	Important fuelwood species	Important fodder species
Warm temperate (1500-2200m)	*Caesalpinia decapetata, Daphniphyllum himalayense, Alnus nepalensis, Lyonia ovalifolia, Quercus leucotrichophora*	*Grewia optiva, Celtis australis, Ficus roxburghii, Ficus nemoralis, Ficus claveta, Quercus leucotrichophora, Quercus glauca, Sinarundinaria falcata, Chrysopogon gryllus*
Cool temperate (2200-2700m)	*Quercus semecarpifolia, Quercus floribunda, Lyonia ovalifolia, Rhododendron arboreum, Abies pindrow*	*Quercus floribunda, Quercus semecarpifolia,Thamnocalamus spathiflora,Thamnocalamus falconeri,Chimnobambussa jaunsarensis, Chrysopogon gryllus*
Sub-alpine (2700-3300m)	*Quercus semecarpifolia, Rhododendron campanulatum, Rhododendron arboreum*	*Quercus semecarpifolia, Thamnocalamus falconeri*

Table 3. Consumption of major fuelwood and fodder species at different altitudinal zone.

Village	# fuelwood colleting family	# population responsible for collection	# fuelwood collection (kg/day/h.hold[a])	# fuelwood collection (Q.[b]/year)
Siroli	62	124	20-22	2232-2482
Mandal	79	158	20-22	2844-3163
Khalla	53	106	20-22	1908-2122
Koteshwar	46	92	20-22	1656-1841
Bandwara	41	82	20-22	1476-1641
Bairangana	33	66	20-22	1188-1321

a= household, b= Quintal (1 quintal=100 Kilograms)

Table 4a. Fuelwood collection by villagers in the warm temperate region (Singh et al. 2010).

Village	# fuelwood colleting family	# population responsible for collection	# fuelwood collection (kg/day/h.hold[a])	# fuelwood collection (Q.[b]/year)
Dadon	13	26	23-25	538-585
Nail	75	150	23-25	3105-3375
Nauli	40	80	23-25	1656-1800
Kalsir	60	120	23-25	2484-2700

a= household, b= Quintal (1 quintal=100 Kilograms)

Table 4b. Fuelwood collection by villagers in the cool temperate region (Singh et al. 2010).

Fourteen temporary dhabas (hotels) are established every year in the cool temperate region at Chopta (2900m) for 6-8 month during tourist season. Out of 14 dhabas, 12 dhabas consumed fuelwood on an average of 0.9 Q/day/dhaba and 2 dhabas consumed average of 3 Q/day/dhaba of fuelwood. This consumption of fuelwood continued up to 6 months (May to October), during the remaining two months (April and November) 2 dhabas consumed 1.2 Q/day/dhaba fuelwood. The requirement of fuelwood is fulfilled mostly from their respective village forests and partially from the distant forests (Table 5) by only 10-20 species.

In the sub-alpine and alpine region near the famous Hindu shrine "Tungnath" 10 dhabas used fuelwood from nearby forests for six months. Each dhaba owner consumed on average 30 kg/day fuelwood. *Rhododendron campanulatum, Q. semecarpifolia* and *R. arboreum* trees were the main source of fuelwood. The fuelwood consumption by dhaba owners is significantly higher ($p<00.2$) than the fuelwood consumed by a village in the region.

Areas	**# Dhabas**	**# fuelwood collection kg/day/dhaba**	**# fuelwood collection Q./year**	**# fuelwood species collected**
Cool temperate region	14	90-120	3096.4	20
Sub-alpine region	10	30	540	11

Table 5. Fuelwood collection by dhaba owners in the cool temperate region.

Fodder collection: Over 146 species at different altitudinal zone were used as fodder, among them grasses had the highest contribution (58 species). At permanent villages, most of the livestock remain at home. These were strictly stall-fed throughout the year. Few cattle go into the nearby barren fields or forests for approximately one month every year for grazing. Fodder demands were basically fulfilled through leaf fodder, agricultural by-products and grass fodder (green and dried). There was a seasonal variation in the type of fodder collected. Leaf fodder available in the villages constitutes the major fodder for cattle throughout the year except during the rainy season when green grasses and legumes were used. The leaf fodder (*Q. leucotrichophora* and *S. falcata*) lopped from nearby forests was used from October to May. Agricultural by-products which constituted the staple fodder in winter was collected from May to August. In the permanent village, each family had 3-5 stall fed livestock with fodder requirement of 25-30 kg/day/livestock. Mandal village had maximum fodder requirement per year followed by Siroli and Bandwara according to their village size (Table 6).

Out of 146 species reported as fodder from the study area, 13 species of leaf-fodder were largely used / harvested in the villages. The preferred fodder species in different seasons in the permanent villages are different (Figure 2). From December to May, broadleaf species such as *Grewia optiva, Ficus roxburghii, Q. leucotrichophora* and *Sinarundinaria falcata* constitute major fodder species. In June-September few broad leaf species *(Celtis australis* and *Ficus nemoralis)*, agricultural by-products and grasses fulfil the major requirements of fodder. From October to December, large amount of grasses are collected from the nearby protected grassy slopes and used as a good quality fodder.

Villages	Livestock population	# Availability of fodder in villages (Q/Y)	# Fodder req./year (Q/Y)	# Fodder dependency on forests (Q/Y)
Siroli	146	12204-15224	23268- 27922	11064-12682
Mandal	118	15157-18953	27648- 33178	12491-14225
Khalla	106	9128-11388	16333- 19600	7205-8212
Koteshwar	123	8462-10549	13961- 16753	5499-6204
Bandwara	152	8199-10206	18250- 21900	10051-11694
Bairagana	91	6852-8552	13596- 16315	6744-7766

Table 6. Availability and requirement of fodder (Quintal) per year in the villages.

Few grass species *i.e., Chrysopogon gryllus* (Khor) and *Pennisetum purpureum* (Napier) are cultivated by the villagers in their respective barren fields. Each village has its appointed portion of hillside as its hay preserve. The grass is cut in October- November, dried for sometime and brought home or if trees are very near, hey is hung up on tree branches in wisps to dry. Nowadays, due to increase in population, decrease in forest area and introduction of high bred cattle, people from the valley are facing shortage of fodder at times. It is not an acute problem in the region but improvement of forest blanks near villages and pasture land by using good quality seeds of grasses and trees can help in overcoming problem of fodder scarcity in the area.

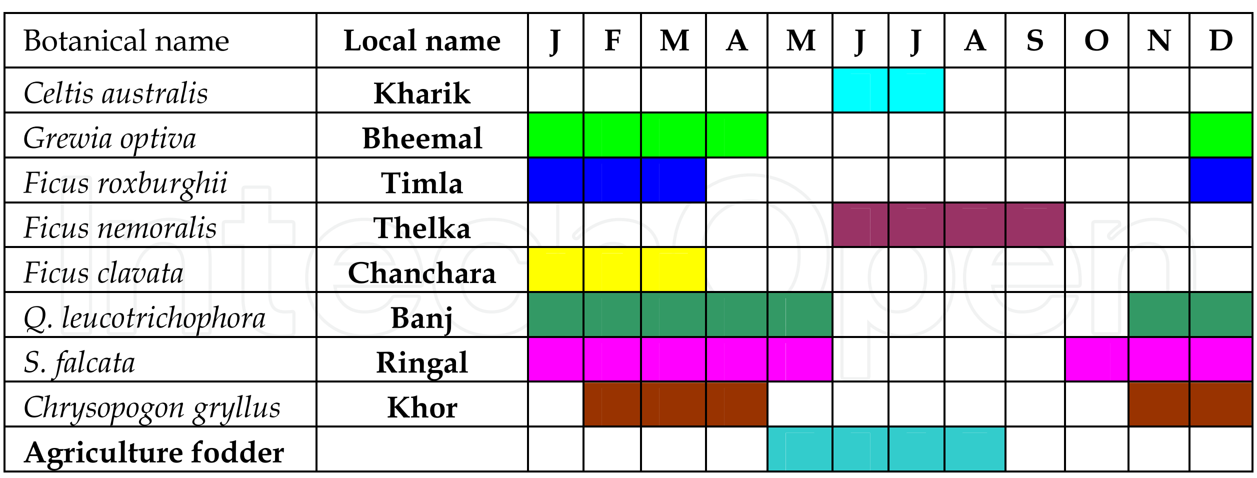

Fig. 2. Timing for collection of major fodder species across different months.

3.4 Impact of fuelwood and fodder collection on the village and sanctuary forests

The woody species such as *Q. leucotrichophora, R. arboreum, P. pashia, L. ovalifolia* and *A. nepalensis* fulfil the requirements of fodder and fuelwood in the villages whereas *Q. floribunda, Q. semecarpifolia, R. arboreum* and *R. campanulatum* were used as fuelwood near sanctuary areas. Density of trees, shrubs and saplings were found to be significantly higher in less disturbed village forests as well as sanctuary forests. Whereas, the seedling density was found to be higher in highly disturbed forests with low canopy cover. The ground cover was higher in highly disturbed forests in both the regions, where most of the ground was covered by weedy species. The percentage of lopped trees in village forests (53%) was higher than the sanctuary forests (37%). The village forests species were lopped for fodder as well as fuelwood but in near sanctuary forests, species were mainly lopped for fuelwood requirements (Table 7).

Parameters	Village forests (1700m)		Sanctuary forests (2900m)	
	High collection	Less collection	High collection	Less collection
Tree density/ha	365 ± 8.54	537 ± 8.78	221 ± 12.09	465 ± 32.48
Shrub density/ha	4796 ± 67.52	5195 ± 180.53	3455 ± 130.98	4117 ± 102.01
Species diversity	2.98	2.67	1.89	2.19
Seedling density/ha	2810 ± 86.11	1341± 25.26	696 ± 40.55	263
Sapling density/ha	526 ± 14.41	645 ± 13.87	212 ± 12.99	441 ± 19.16
No. of lopped tree/ha	195	42	83	2
Canopy cover (%)	21.67	47.67	25	41.66
Ground cover (%)	8.8	4.67	64.66	27

Table 7. Comparison of various parameters in village forests and sanctuary forests

4. Impact of grazing

In some pastures, grazing is essential to maintain species diversity (Naithani *et al.* 1992, Negi *et al.* 1993, Saberwal 1996) mainly in the Himalayan alpine region, but some other studies (Ram *et al.* 1989, Sundariyal and Joshi 1990, Singh 1991, Rawat and Uniyal 1993 and Kala 1998) revealed that intermediate level of grazing maintains species diversity. Besides, livestock grazing abiotic factors like snowfall, soil, altitudes and aspects also influence the structure and composition of these pastures (Kala *et al.* 1995).

Presently, it is estimated that more than 15,000 sheep and goats, ~ 2000 buffalos and about ~8000 mules are known to graze in temperate and alpine region of entire Kedarnath WS (Singh 2008). In the present investigation about 900 sheep and goats and ~1100 buffaloes/cows graze temperate to alpine region of the study area. The investigation shows that grazing areas (migratory summer camp = 19) were scattered in almost all altitudes, slopes and aspects. High species density and low diversity in highly grazed areas also indicated the dominance of few grazing indicator species (*Trachydium roylei*). The less disturbed areas were mainly dominated by *Danthonia cachymeriana* and the other herbaceous species had low density and high species richness. Highly grazed areas have shown low above ground biomass (Nautiyal *et al.* 2001), and high density of the species *i.e., Trachydium roylei, Oxygraphis polypetala, Anemone rivularis, Taraxacum officinale and Carex* spp. Camping sites were found to be dominated with opportunistic herbs e.g., *Rumex nepalensis, Polygonum amplexicaule, P. polystachyum* and *Impatiens sulcata* (Singh 1999).

In the present study, it was observed that dependency of villagers for their basic needs in the nearby forests may be sustainable but the use of sub-alpine and alpine forests for livestock grazing and tourism are the major causes of forest degradation. Reserved Forests near villages that possessed small village forests were often badly degraded, while those located at some distance away from villages are in better condition with lower level of disturbance. Maithani (1994) reported a village forest in Gopeshwar (Chamoli) district which has been managed for decades and is "the best protected forest in the area". Such village forests which are closely monitored by the Village Panchayats might have a better regeneration status than the village forests that were observed during our study. Oak regeneration appears to be benefited by moderate levels of disturbance which resulted in the partial opening of the canopy. This is also supported by Rao and Singh (1989), Thadani and Ashton (1995) in the Central Himalayan oak forests *(Quercus leucotrichophora)* and Quintana-Ascencio et al. (1992) in Mexican highlands (*Quercus crispipilis*). All the studies concluded that these species are unable to regenerate under deep shade, and require open patches relatively free from browsing and trampling by ungulates.

5. Conservation and management approach

Forest resources and agricultural products are the main resources of livelihood for the local people in the study area but these resources seem to be degrading day-by-day. Conservation of such areas cannot be achieved without the involvement of local communities who are directly dependent on these resources for their daily needs. For the long term conservation of forests and other natural resources local people and forest department can help in following ways:

1. Traditional management of grassy slopes: Certain village pastures are closed for grazing during rainy season (July-September) when flowering and fruiting of these species take place. These pastures are opened for fodder collection after peak grazing season when seeds are dispersed for new generation. This practice does not only meet the fodder requirement of local people but also helps in the regeneration of grassy slopes. These tussock forming native grasses *e.g.,* Khor, Napier should be promoted at large scale by the local people and plantation of these species in barren and open pastures need to be undertaken. These species are not only used as fodder but also used for thatching roofs of temporary huts.
2. Protection and sustainable utilization of important fodder tree species (*Ficus roxburghii, Ficus claveta, Ficus nemoralis, Celtis australis* and *Grewia optiva*) in the fringes of agriculture and barren fields help in the conservation of neighbouring village forests and should be promoted. Plantation of these species should be encouraged at large scale by the Forest Department and NGOs. The seedlings and saplings of these species should be distributed to local people at subsidized rates.
3. Fuelwood consumption by 'Dhaba' owners at Chopta (14 numbers) and Tungnath (10 numbers) for six months is higher than the annual consumption of fuelwood by an

average village in the Mandal valley. Therefore, for the proper management of fuelwood at these shops, the Forest Department can provide the fallen and dead trees to these Dhaba owners at low cost. These fallen logs are easily available in Ragsi and Trisula Reserve Forests. Alternative option could be to provide gas stoves and cylinders to these Dhaba owners at subsidized rates so as to decrease their dependency on the forest resources for fuelwood.

Conservation of these valuable species would not be possible without the active participation of the local people. By improving their living standards and by giving benefits of conservation to them, long term conservation goals can be achieved.

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This book is dedicated to global perspectives on sustainable forest management. It focuses on a need to move away from purely protective management of forests to innovative approaches for multiple use and management of forest resources. The book is divided into two sections; the first section, with thirteen chapters deals with the forest management aspects while the second section, with five chapters is dedicated to forest utilization. This book will fill the existing gaps in the knowledge about emerging perspectives on sustainable forest management. It will be an interesting and helpful resource to managers, specialists and students in the field of forestry and natural resources management.