FREEP-GHNP 02/05

Floral Diversity and Vegetation Structure in Great Himalayan National Park, Western Himalaya

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August, 1999

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ACKNOWLEDGEMENTS

We are grateful to Shri S.K. Mukherjee, Director, Wildlife Institute of India (WII) for constant guidance and encouragements. We sincerely thank Shri B.M.S. Rathore, Principal Investigator (PI) of the Forestry Research Education and Extension Project (FREEP) for Great Himalayan National Park (GHNP) at WII and Shri Sanjeeva Pandey (formerly PI of the project, and present Director of GHNP) for providing necessary facilities, support, encouragement and valuable suggestions throughout the course of this study. We are also thankful to various investigators and team members of FREEP-GHNP viz., Drs. P. K. Mathur, S. Sathyakumar, V.B. Mathur, V.P. Uniyal, K. Ramesh, Vinod T.R., Suneet Naithani, Pradeep Chaudhary, Badrish Mehra, and Milind Saxena for cooperation, sharing valuable information and helping us in various ways.

We record our sincere thanks to the following personnel of Himachal Pradesh Forest Department for their kind help and cooperation during the field work at GHNP: Shri P.C. Pande (PCCF), Shri C.D. Katoch and Shri Jogindar Singh (former and present CWLW respectively), Shri Nagesh Kumar Guleria (former Director of GHNP), Shri P. Chowdhary (Dy. Director GHNP), Shri P.L. Chauhan, Shri Anil Thakur, Shri Anil Joshi, Shri H.S. Thakur, Shri S.K. Gularia, and Shri O.P. Gularia. Our grateful thanks are also due to all the frontline staff of GHNP for helping us in the field and also arranging logistics for the field work. We were benefited much from our interaction with various consultants who worked in the project viz, Dr. H.S. Pabla, Shri A.S. Negi, Shri Vinay Tandon, Dr. Sarnam Singh, Dr. Amita Baviskar, Prof. S. Nagia, Dr. Virinder Sharma, Dr. A.J. Gaston, Dr. P. Garson, Dr. R. Tucker, Ms. Maureen DeCoursey, Ms. Camille Richrads, Dr. D.K. Upreti, and Dr. J.M. Julka.

Shri Sunil Thakur (Project Assistant, FREEP-KMTR) helped us in the administrative matters; Dr. K. Sankar, Shri Rakesh Singh, Shri Ajay Sharma, and Shri. Vinod Thakur in soil analysis; Shri M.M. Babu, Shri P.L. Saklani and Shri Shyamlal of WII Herbarium helping in preparation of Herbarium; Shri Rajesh Thapa, Shri V, Sukumar, Shri Lekh Nath, Dr. Manoj Agarwal, Shri Panna Lal, and others from the computer section of WII in various computer applications and analysis. We are thankful to all of them. Thanks are also due to Shri M.S. Rana and other members of Library staff for their cooperation.

Last but not the least, we would like to thank all people from the ecodevelopment zone of GHNP for their support, cooperation and sharing local information. We gratefully acknowledge the hard work and co-operation by the field assistants in GHNP, especially Shri Pradeep Kumar, Shri Niranjan Singh, Shri Chet Ram, Shri Brij Lal, Shri Himmat Singh and Shri Ranjith.

WII, Dehra Dun
Dated

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1.0 GENERAL INTRODUCTION

1.1 BACKGROUND

The Himalaya, a young and complex chain of mountains, is well known for its floral and faunal diversity, aesthetic, geo-hydrological and cultural values. Frequent orographic changes, large-scale surface removals due to geological instability and cyclic climatic changes have greatly influenced the floral and faunal communities in these mountains. According to the palaeo-climatologists, the Miocene orogeny led to drastic changes in the vegetation and the contemporary flora has been almost entirely replaced by the modern flora (Vishnu-Mittre 1972, Singh and Singh 1987, 1992). Extending for about 2500 km from east to west, the Himalayan arc covers more than ten degree of latitudes *i.e.* 27-38° north and exhibits an interesting pattern of rainfall from west to east (increasing gradient) and south to north (decreasing gradient). Variation in the rainfall, mean annual temperature and altitude are considered key factors governing vegetation types in this region. The richness of the species in the Himalayan region is generally attributed to variation in climate and habitat types (Rau 1975, Polunin and Stainton 1984). The temporal and spatial variation in the physical conditions have also resulted in interesting patterns of phytogeography characterized by the high degree of endemism and localised distribution of certain species (Mani 1978, Singh and Singh 1987).

Environmental degradation and loss of biodiversity as a result of excessive anthropogenic pressures, particularly in the fragile Himalaya have caused much concern among the conservationists in the recent years. Several policy documents and action plans have been developed (*e.g.,* Anonymous 1992, Ramakrishnan *et al*. 1996, Dhar 1997). However, in the absence of site specific inventory and documentation of existing biological diversity and assessment of anthropogenic pressures the management agencies such as State Forest Departments, are unable to take any action towards long term conservation. It has well been accepted that establishment of biogeography based protected area (PA) network is the best way to ensure biodiversity conservation in the country (Rodgers and Panwar 1992). But in the Himalayan region, it is often difficult to achieve adequate representation of altitudinal and eco-climatic zones within the PAs. Moreover, most of the PAs are surrounded by large human settlements with considerable biomass dependence on the PAs. If well managed, PAs not only in the conservation of the life support system and ecological processes but also ensure the long term survival of regionally or some times globally important species of flora and fauna. PAs also provide tremendous opportunities to carryout scientific studies and long term monitoring of the flora and fauna including those listed under various threat categories by the International Union for Conservation of Nature and natural resources (IUCN).

The North west Himalaya (zone 2A of Rodgers and Panwar 1992) forms a distinct biogeographic zone in the Himalaya. It lies west of Sutlej river in the Himachal Pradesh and encompasses an area of ca. 69401 km^2. Presently there are 4 National Parks and 27 wildlife Sanctuaries in this zone. Although, a large number of floral and faunal surveys have been conducted in this zone *e.g.* (floral surveys by Collett

EXECUTIVE SUMMARY

1. The vascular flora and vegetation, along with the factors affecting them, were studies in Great Himalayan National Park (GHNP 31^0 38' 28" N to 31^0 51' 58" N lat. and 77^0 20' 11" E to 77^0 45' 52" E long.), located in the Beas catchment of Kullu district, Himachal Pradesh during 1995-1998. The present investigation gives first hand information on the floristic structure, community composition, anthropogenic pressure and status of various rare, endemic and valuable plant taxa of GHNP. The study area covers a wide altitudinal range *i.e.* 1344 to 6205 m asl. The major vegetion types include 72.28 km^2 of broad leaved forest, 35.97 km^2 of coniferous and 131.72 km^2 of mixed conifer forest. The temperature ranges from -10°C to 35 °C. The mean annual precipitation is 1155.7 mm at Niharni and 1158.26 mm at Sainj, the highest being in the month of July. The soil is mostly acidic with pH ranging from 4.16 to 8.22.

2. Systematic surveys of vascular plant species (Angiosperms, Gymnosperms and Ferns) were conducted in different habitats and seasons. Circular plots and quadrats were used to study the community composition in various vegetation types based on stratified random sampling. Circular plot of 12.65 m radius for trees, 5.65 m radius for shrubs were laid. Quadrats of 1 m^2 were sampled for herbs and grasses. A total of 673 plots were laid for trees and shrubs and 2900 plots for herbs in the Tirthan and Sainj valleys keeping in view the area and extent of anthropogenic pressures.

3. Importance Value Index (IVI) of trees were described calculated to describe community structure of trees. Population structure of important tree species were studied based on girth class distribution and abundance of saplings and seedlings. Shannon-Wienner species diversity index (H') was used to calculate the species diversity and Menhinick index for the species richness. Two Way Indicator species Analysis (TWINSPAN) a computer package, was used for community classification and Canonical Correspondence Analysis (CCA) to study the relationship between environmental variables with the vegetation.

4. Impact of anthropogenic pressures were assessed by comparing vegetation structure and composition in various areas of known pressure. Ethnobotanical surveys were conducted within the ecodevelopment zone by direct observation as well as by interviewing the local healers (*Vaidys*) and elderly knowledgeable persons. Information on bamboo, fuel and fodder availability and consumption by the local people within the Park was collected by estimating biomass.

5. A total of 832 species belonging to 128 families and 427 genera of higher plants were recorded Within the Park. According to growth habits these species are distributed over 69 trees, 113 shrubs, 28 climbers, 493 herbs, 96 graminoids (grasses and sedges) and 27 ferns and represent nearly 26% flora of Himachal Pradesh. *Nardostachys grandiflora* was recorded for the first time from Himachal Pradesh. Distribution of rare and valueable taxa have been plotted in the maps.

6. The vegetation of GHNP is divisible into following physiognomic types: Temperate broadleaf forest, Temperate conifer forest, Temperate Oak-conifer forest, Temperate Secondary scrub, Temperate grassy slopes, Subalpine fir-spruce, birch-rhododendron, alpine scrub, alpine meadows (grassy and herbaceous). These types have been described and mapped. Community classification of TWINSPAN revealed a large number (33) of herbaceous communities in the alpine zone (>3,600 m). The temperate zone of Tirthan and Sainj had 23 and 22 communities respectively. Chracterstic feature, diversity and environmental correlates of various communities have been given.

7. IVI and population structure of woody vegetation have been compared in various forest types. *Quercus floribunda* (IVI=150), *Abies pindrow* (IVI=76.18), *Quercus semecarpifolia* (IVI=107.83) and *Rhododendron campanulatum* (IVI=101.22) were the dominant species of temperate, temperate north facing slopes, upper temperate and subalpine zones. The density was highest (214.88 ha^{-1}) in lower temperate (1500-2200 m) region of Sainj valley. Shrub density was highest in lower temperate zone (2966.67 ha^{-1}). A noteworthy feature of shrub layer, was prevalence of bamboo species in most of the broad leaved forest. *Sinarundinaria falcata* in the temperate zone (below 2000 m) and *Thamnocalamus spathiflorus* at higher altitudes (2500-3300 m). The other frequent genera of the shrub layer were *Berberis*, *Desmodium*, *Juniperus*, *Indigofera*, *Rhododendron* and *Viburnum*. The dominant species of alpine zone were *Rhododendron anthopogon*, *Juniperus communis* and *Salix* spp. The overall densities of seedlings and saplings were low for *Quercus leucotrichophora*, *Quercus semecarpifolia*, and *Cedrus deodara* suggesting a low rate of regeneration. *Taxus wallichiana* a commercially harvested medicinal plant, also showed similar trend.

8. Major anthropogenic pressures in the Park are include livestock grazing and collection of medicinal herbs, mushrooms, fuelwood and fodder. Herb and mushroom collection forms one of the major sources of income for the people living in the ecodevelopment area and nearly 85% families earn upto 65% of their cash from these products. At present more than 60 species are commercially exploited by more than 2500 local people. This practice has lead to a marked reduction in species availability in the wild. Areas of different pressure regimes have been compared in terms of vegetation structure and species abundance. Some of the flowering species *e.g. Iris kumaonensis*, *Anemone rivularis*, *Primula denticulata*, *Taraxacum officinale*, *Plantago erosa*, *Inula grandiflora*, *Rumex nepalensis*, *Polygonum polystachyum*, *Polygonum amplexicaule* and *Urtica dioica* showed a tendency to increase under heavy grazing in the six pastures studied and other species *e.g. Anemone tetracepala*, *Geum elatum*, *Geranium wallichianum*, *Potentilla atrosanguinea* and *Dactylorhiza hatagirea* had low abundance in heavily grazed area.

9. Based on the broad findings of this study various conservation strategies have been suggested for the Park. These include i) Providing alternative means of income generation to the families those are solely dependent on the medicinal plant. ii) regulation of collection from the key conservation areas and monitoring of rare and threatened plants for *in-situ* conservation. iii) Formation of medicinal plant societies in the ecodevelopment zone for value addition activities such as packaging, mar-

keting and other small scale enterprises along with awareness and capacity building of both collectors and traders. iv) Research and development efforts to see whether these herbs and mushrooms can be propogated in the nature or through tissue culture. v) Plantation of fuelwood and fodder species in the ecodevelopment area. vi) Proper management and monitoring of species such as *Juniperus*, *Rhododendron*, *Quercus* and *Betula utilis* near camping sites to ensure their growth and development.

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1921, Nair 1977, Chowdhery and Wadhwa 1984, Singh 1992, Aswal and Mehlotra 1994; and wildlife surveys by Gaston *et al*. 1981, 1993) but none of the PAs in the zone has detailed management plan based on the scientific studies on various components.

Flora and vegetation form integral part of wildlife habitat in any area. Therefore systematic floral inventory and analysis of vegetation communities become pre requisitic for the better ecological understanding and for management plan for any PA. A large number of questions pertaining to phytosociology and impact of various anthropogenic activities on the flora and vegetation can be addressed in a controlled environment, particularly when the experimental studies are not feasible. keeping this in view an ecological study study was initiated in the Great Himalayan National Park (GHNP) with the following objectives.

1.2 AIMS AND OBJECTIVES OF THE STUDY

1. To carry out systematic study of the vascular flora of the Great Himalayan National Park.
2. To study the plant community composition and structure along the gradients of human use and altitude.
3. To collect the baseline information on the vegetation parameters of the study area for subsequent environmental monitoring.
4. To collect ecological information on the rare, endemic and endangered plant species for evolving long term conservation plan.

The study forms one component of a multi-disciplinary project “An Ecological Study and Assessment of Biodiversity and Biotic Pressures in the Great Himalayan National Park : An Ecodevelopment Approach” aided by the world Bank through Forestry Research Education and Extension Programe (FREEP). The information generated through this study on the community composition, species diversity and impact of anthropogenic activities on these parameters would be useful in predicting the future changes in the ecological conditions within the Park and ecodevelopment planning in the surrounnding villages. It is also expected that the information contained in this report would serve as a baseline data for subsequent monitoring of vegetation and habitat parameters in GHNP.

1.3 REVIEW OF LITERATURE

The flora and vegetation of north western Himalaya have been studied by several plant taxonomists, naturalists and ecologists. A brief review of the existing literature on the subject is given below.

1.3.1 Floristics

Botanically north western Himalaya has been explored since 19th century. Collett (1921) described 1236 species in *Flora Simlensis* from Simla and neighbouring estates and gave a bibliography which

included almost all the published works pertaining to the area till 1921. The pioneer plant collectors from this region were Royle (1833-1840), Brandis (1879) and Parker (1918). Burkill (1908) gave an account of the spring flora of Simla Hills. Jain and Bhardawaj (1949) made collections from Parvati valley of GHNP and deposited the specimens at the Herbarium of Forest Research Institute, Dehra Dun. Nair and Pant (1966) and Maheshwari (1972) reported few new records from the area. Bir (1963, 1968) and Khullar (1994, 1999) dealt with Pteridophytes of the area. A number of publications (*e.g.,* Hooker 1906, Duthie 1906, Kashyap 1925, Blatter 1927-29, Collett 1921, Stainton 1977, Rau 1974, 1975, Kachroo *et al*. 1993) dealt with the floristic and phyto-geographical aspects of the Western Himalaya. Among more recent works on the flora of western Himalaya including Himachal Pradesh, covering high altitude areas include Nair (1977), Sharma and Kachroo (1981), Dhar and Kachroo (1983), Polunin and Stainton (1984), Chowdhery and Wadhwa (1984), Rawat and Srivastava (1986), Deva and Naithani (1986), Singh (1992), Aswal (1993) and Aswal and Mehrotra (1994). Despite a large number of floral surveys upper Beas catchments of Tirhtna and Sainj rivers which forms the present study area had not been surveyed till the begining of this study.

1.3.2 Vegetation studies

A perusal of literature on the ecology of the Himalayan vegetation reveals that most of the phyto-sociological and other quantitative studies have been conducted in Kumaun and Garhwal Himalaya (*e.g.* Gupta 1972, Singh and Singh 1987, 1992). The most significant works include classification of forest formations (Champion and Seth 1968, Schweinfurth 1968). Gorrie (1933) discussed the ecology of Cedrus deodara in the Sutlej valley. Mohan and Puri (1955) described the succession of the forest communities of Bashar Himalaya. Recent studies include the biomass productivity of various communities (Chaturvedi and Singh 1983, Ram *et al.* 1989, Rana *et al*. 1989, Tewari and Singh 1984, Negi *et al*. 1993, Adhikari 1992, Adhikari *et al*. 1995), regeneration of major tree species (Singh 1983, Singh and Singh 1987, 1992), seasonality and productivity of alpine vegetation (Ralhan *et al*. 1984, Upreti *et al.* 1985, Ram and Singh 1988) in Kumaun Himalaya. In the present study, an attempt has been made to quantify the species composition and structure of various communities in GHNP as very little information exists on this aspect in north western Himalaya. **In the Himalayan region, early description of vegetation were made by Troup (1921), Champion (1923), Kenoyer (1921), Gorrie (1933), Osmaston (1923 and 1927), Schweinfurth (1957; 1968), Puri (1960) and Gupta and Singh (1962). Champion and Seth (1968) described major forest communities. More recently, quantitative studies on the vegetation of western and central Himlaya have been conducted by Saxena *et al.* (1978), Saxena (1979), Pandey (1979), Negi (1979), Ralhan *et al*. (1982), Saxena and Singh (1982), Tewari (1982), Tewari and Singh (1985), Upreti *et al.* (1985), Singh and Singh (1984 a, b and c), Singh, *et al*. (1985) and Kalakoti *et al*. (1986). Singh and Singh (1987a), Bergali *et al.* (1987), Rikhari *et al.* (1989), Tewari *et al.* (1989), Reddy (1989), Lodhiyal (1990), Rawal (1991), Adhikari (1992; 1995) conducted ecological studies in the Kumaun region which lies in the eastern part of Western Himalaya. Therefore, this study was undertaken with a view to find out the pattern of community structure and composition in ecologically distinct and hitherto least studied region of north western Himalaya.

1.3.3 Ethonbotany

Analysis of the flora of Himachal Pradesh shows that there are approximately 3200 species of flowering plants (Chowdhery and Wadhwa 1984). Out of these about 1200 species are reported to be of medicinally value (Chopra *et al.* 1956, 1969). From the ethnobotanical point of view some earlier works done in Himachal Pradesh include Uniyal and Chauhan (1973), on medicinal plants of Lahaul-Spiti forest division and Koelz (1979) on the ethnobotany of Lahaul. More recent work on ethnobotany are Sharma (1976), Uniyal *et al.* (1983), Aswal and Mehrotra (1985), Chauhan and Chauhan (1988), Kapur (1993), Singh (1993), Gaur and Singh (1995), Singh (1996), Brijlal *et al.* (1996) and Singh and Rawat (1998a, 1998b).

1.3.4 Livestock Grazing

Intensive grazing by sheep and goats has been a major causef forest degradation and soil erosion in the temperate areas (Tucker 1986). The studies that deal with the livestock grazing in the western Himalayan region are Phillimore (1981, 1984, 1989), Tucker (1986), Ram *et al*. (1989), Sundariyal and Joshi (1990), Rawat and Uniyal (1993), Negi *et al*. (1993), Sundriyal (1995), Saberwal (1996), Mishra (1997), Kala (1998). A study on the pattern of livestock grazing and its impact on the biodiversity of GHNP is underway, as part of the FREEP (GHNP) project (Mehra and Mathur 1998).

1.3.5 Other studies in GHNP

The wildlife surveys in the area were conducted during 1980's by the Himachal Pradesh Forest Department (HPFP) and Himachal Pradesh Wildlife Project (HWP). Based on the findings of HWP, Gaston *et al*. (1981) suggested the creation of Great Himalayan National Park. During second phase of HWP (1983) more areas were surveyed for wildlife with proposed GHNP and suggestion were made for management. A management plan of GHNP has been operational since 1987 (Sharma 1987). A reappraisal was undertaken by HWP in 1993 and concluded that some improvement has been achieved in the status of certain wildlife species (Gaston and Garson1993). An inventory of birds of GHNP was made by Gaston *et al*. (1993). Indian Institute of Administration has prepared an inductive plan based on their field visits (Mehta *et al*. 1993). The Wildlife Institute of India (WII), under Forestry Research Education and Extension Program (FREEP) has completed several component *viz*. landscape management (Negi 1996), study on village microplans and ecodevelopment activities (Pabla 1996), survey of phesants (Pandey 1997), study on mammals (Vinod *et al*. 1997), Ramesh and Sathyakumar (1997), study on invertebrates, (Uniyal and Mathur 1998), impact of medicinal plant collection (De Coursey 1997), (Tandon 1997), (Singh and Rawat 1998a and 1998b), (Sharma 1998), study on birds, (Ramesh *et al*. 1998), (Garson 1998), study on socio-economic aspect, (Chaudhary 1998), (Baviskar 1998), study on monitoring (Gaston 1997), impact of livestock grazing, (Mehra and Mathur 1998), (Tucker(1997), remote sensing and GIS, (Naithani 1998) and (Singh 1998).

2.0 STUDY AREA

Great Himalayan National Park (GHNP), lies in the Kullu district of Himachal Pradesh. The Park encompasses nearly 1171 km^2 area and lies between 31^0 38' 28" N to 31^0 51' 58" N lat. and 77^0 20" 11" E to 77^0 45' 52" E long. According to the recent biogeographic classification, GHNP falls under North Western Himalaya *i.e*. biotic province 2A (Rodgers and Panwar 1988). The study area is well known for its rich biological diversity (Gaston *et al.* 1981). GHNP is one of the two National Parks (NPs) in the world to support a population of endangered western tragopan (*Tragopan melanocephalus*) and a large number of rare and threatened plant species many of which are of medicinal value (Gaston and Garson 1993). The Park is bounded by Rupi Baba Wildlife Sanctuary in the east, Pin Valley NP in the north east and Kunawar WLS in the north west. The south western fringe of the Park is surrounded by a heavy human habitation, cultivation and orchards. GHNP, along with adjoining protected areas form a large, relatively undisturbed and contiguous area having great potential for long term conservation of natural resources including native flora and fauna. GHNP covers the catchment areas of Jiwanal, Sainj, Parvati and Tirthan rivers which are tributaries of Beas river. Tirthan and Sainj rivers flow in the east-west direction and criss-cross through the deep gorges. The Park boundary is approachable by road from Aut near Kullu but there is, no motorable road insides the Park.

A preliminary survey of the flora, vegetation and wildlife habitats was carried out in all the four valleys. However, intensive sampling of vegetation for community classification and population estimates of rare species were done in Tirthan and Sainj valleys because these areas represent the typical habitat types and comprise nearly 65% of the geographical area in GHNP. The study area is shown in Fig. 2.1 and 2.2.

2.2 TOPOGRAPHY

The study area is characterised by deep river valleys and steep mountain slopes with an altitudinal range of 1344 m (near Seund at the confluence of Jiwanal and Sainj river) to 6248 m, an unnamed peak in Khirganga Protected Forest, in the east of Mathan Dhar. The distribution of area under different altitudinal zones and slope categories are shown in Table 2.1 and 2.2 respectively. Nearly 50% of the area lies between the altitudinal range of 4000-5600 m. The slope-wise distribution of the area shows that more than 50% of the area lies between the slope category of 27°°-45°°. The terrain is characterised by numerous high ridges, deep gorges and precipitous cliffs, rocky crages, glaciers and narrow valleys. The eastern part of the Park being all above 5500 m asl, is perpetually snow bound. Pleistocene glaciation has greatly influenced the topography of the region and have left extensive moraines, river terraces and hanging valleys (Gaston and Garson 1993).

The topography of the area has also been influenced by avalanches and land slides. Avalanches occur frequently after heavy snow, often originating from steep southern aspect especially during April to June. Landslides are common features during rainy season.

Table 2.1 Area under different altitudinal zones within GHNP, (Source: Negi,1996)

Name of area	Altitudinal zone (m) wise area in ha							Total
	<1600	1600-2400	2400-3200	3200-4000	4000-4800	4800-5600	5600-6400	
GHNP	-	1149	8363	12743	29647	24134	464	76500
Sainj Sanctuary	-	235	2723	3068	2518	456	-	9000
Tirthan Sanctuary	-	80	2135	2900	985	-	-	6100
Ecodev. Area	505	8394	13474	3083	44	-	-	25500
Total	505 (0.4)	9858 (8.4)	26695 (22.8)	21794 (18.6)	33194 (28.4)	24590 (21.0)	464 (0.4)	117100

Table 2.2 Area under different slope classes in GHNP, (source: Negi, 1996)

Name of area	Slope wise distribution of area In ha.				
	< 33% (<19^{O})	33-50% (19-27^{O})	50-100% (27-45^{O})	>100% (>45^{O})	Total area (ha.)
GHNP	23469	12225	35252	5554	76500
Sainj Sanctuary	112	1197	7372	319	9000
Tirthan Sanctuary	232	713	5060	95	6100
Ecodev. Area	1127	4524	19552	297	25500
TOTAL	24940(21.3)	18659(15.9)	67236(57.4)	6265(5.4)	117100

2.3 GEOLOGY AND SOIL

Geologically, most of the GHNP lies in the Greater Himalayan or Central Crystaline zone *i.e*. between the main boundary thrust and main central thrust (Negi 1986). The northern range that includes Tibetan zone (Wadia 1957). The geology, rock and soil affect the vegetation of a place by influencing the moisture regime, structure, texture and drainage pattern. The underlying rock found in the area is largely quartzite, schist, phyllite, dolomites, limestone, shale, slate, gneiss and granites (Anonymous 1987). Limestone is found at Larji and extends up to Rakti in the Sainj valley. The quartzite is found in the Parvati valley below Manikaran. The Beas valley is dominated by gneiss and schist, which disintegrate into loam or clay and is marked by the absence of quartzite (Sharma 1987). These formations have given rise to sandy, alluvial and podsolic soils.

In the absence of detailed soil characteristics for this area 10 samples of surface soil were collected from various altitudinal zones covering a depth of 0-10 cm. Soil moisture content was determined by weighing fresh samples and oven dry at 105^{o}C for 24 hours and noting down weight difference. The values obtained for different stands were averaged for each forest type. All the samples for each forest type in

each altitudinal zone were mixed in order to form a composite sample. The pH was measured with the help of pH meter and soil temperature by soil thermometer, inserting to a depth of 5 cm during May to October 1997. The values were averaged for each zone (Table 3.3). In general, soil pH was 6.05 ± 0.90. High pH of 8.22 is recorded from temperate forest near camping site and low pH of 4.16 from alpine area in Tirth in the Tirthan valley.

Table 2.3. Soil parameters in various altitudinal zones

Altitudinal zone	pH	Soil Temperature °C	Soil moisture %	Organic Matter %	% Ca	% Mg	% S
Lower temperate	6.24±0.82	15.8±3.7	21.5±3.8	68.6±10.5	0.05±0.02	0.004	0.15
Temperate	6.15±0.42	12.6±3.1	25.3±5.3	71.0±12.1	0.12±0.03	0.005	0.24
Upper temperate	6.18±0.50	9.3±2.1	37.8±6.1	65.5±11.5	0.12±0.02	0.008	0.16
Subalpine	5.95±0.18	5.4±2.0	45.2±5.5	62.8±9.4	0.25±0.02	0.010	0.13
Alpine	5.52±0.34	3.6±2.2	43.8±7.3	64.7±10.2	0.04±0.2	0.007	0.27

2.4 CLIMATE

The GHNP has typically exhibits temperate and alpine climate. Most of the area (approx. 68%) falls under alpine zone, which remains snow covered during winter months (November-March). Broadly, three seasons can be recognised for the Park area *viz*. summer, (April to June), rainy (July to September) and winter (October to March). Winter experiences severe cold and main precipitation is in the form of snow. Rains are mostly confined to summer monsoon.

The mean annual precipitation in the Kullu district at middle elevation ranges between 1000-2000 mm and more than half of it falls during monsoon (Gaston *et al.* 1981). The mean annual rainfall recorded at Niharni (1800 m) in GHNP for the year 1992-94 was 1155.67 mm as shown in Fig 2.4a, while at Sainj 1450 m for 1992-94 it was 1158.26, Fig. 2.4b. The maximum snow depth recorded was 5-7 m in the subapline and alpine areas during February.

Fig. 2.4a. Mean monthly precipitation (rainfall) at Niharani (1800 m) in GHNP

(source: Forest Department, H.P. office of the Director, GHNP)

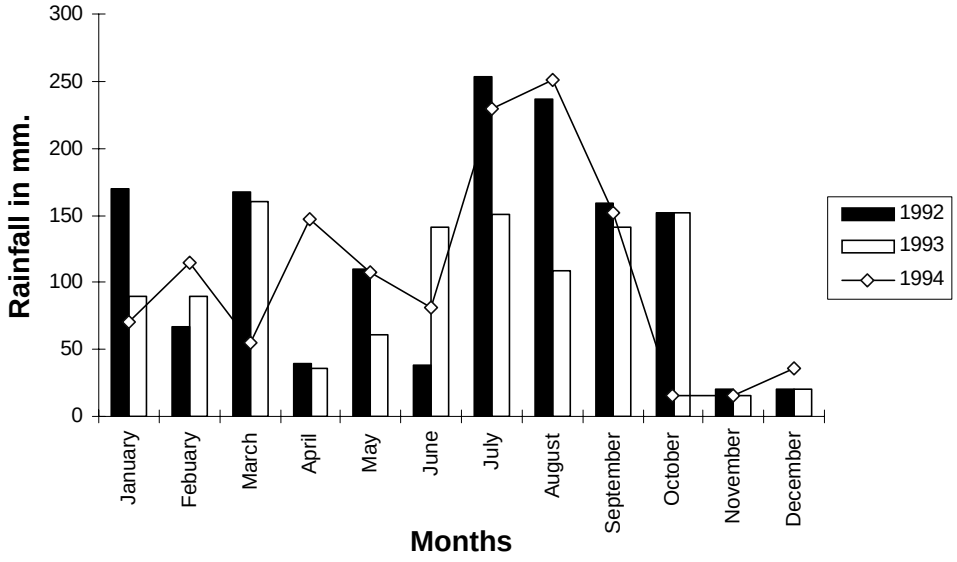
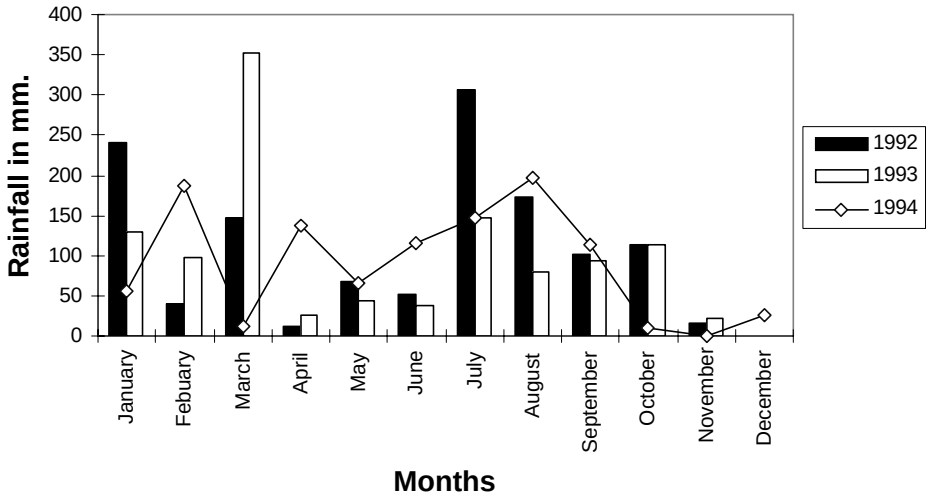


Fig. 2.4b. Mean monthly precipitation (rainfall) at Sainj (1450 m) outside GHNP

(source: Forest Department, H.P. office of the Director, GHNP)



Temperature is an important factor in determining vegetation types. The temperature recorded at the different check-posts in three valleys are shown in Fig. 2.4c. The mean minimum and mean maximum temperature for 1997 at Kharoancha (2000 m) in Tirthan, Sangard (1800 m) in Sainj and Pashi (1500 m) in Jiwanal valley are 12.65°°C, 9.59°°C and 9.69°°C and 16.38°°C, 15.03°°C and 13.46°°C respectively. January being the coldest and June the hottest months of the year.

Fig. 2.4c. Temperate in the different valleys of GHNP for the year 1996-97

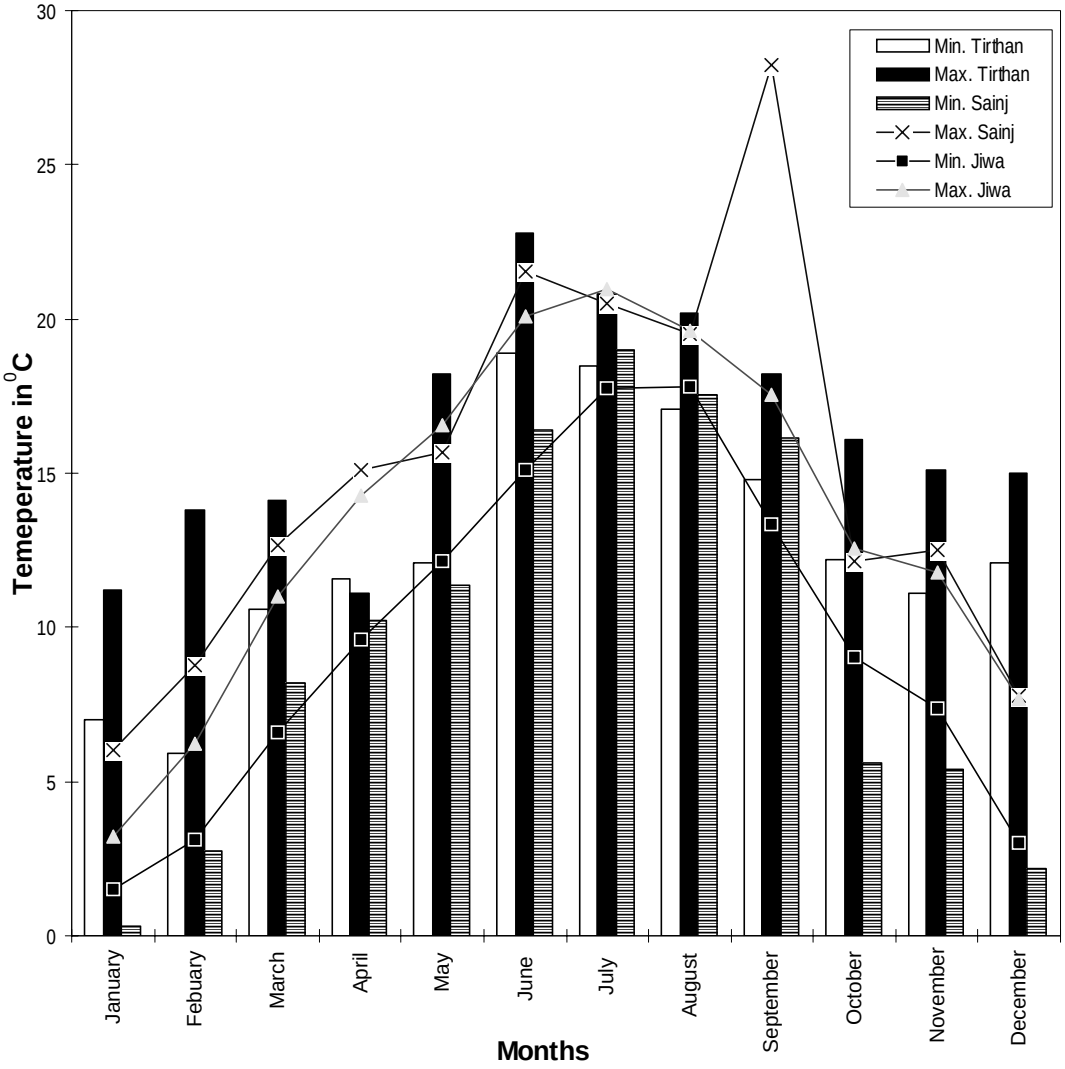
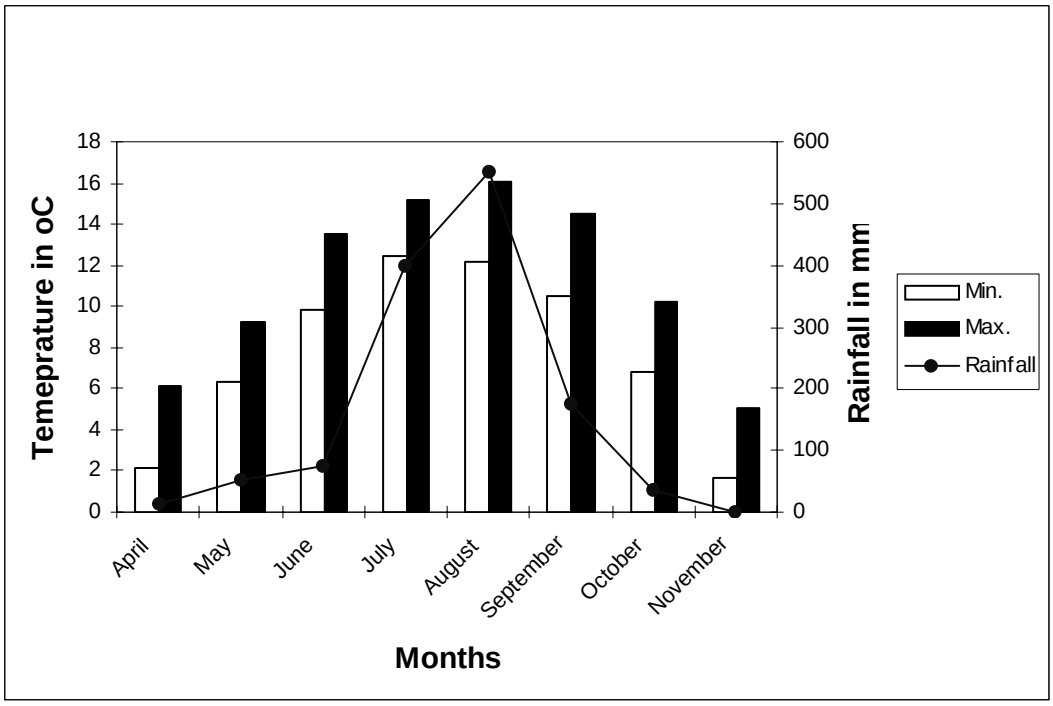


Fig 2.5d. Mean monthly rainfall and temperature at Tirth (3800 m), Nada (3400 m), and Gumtrao (3550 m).



2.5 VEGETATION

Major categories of the vegetation according to Champion and Seth (1968) in the area include: ban-oak forest, moist-deodar forest, western Himalayan mixed coniferous forest, moist temperate deciduous forest, kharsu-oak forest, western Himalayan upper oak-fir forest, montane bamboo brakes, Himalayan temperate Parkland, Himalayan temperate pasture, western Himalayan subalpine fir forest, subalpine pasture, birch-rhododendron scrub forest, deciduous alpine scrub and alpine pasture.

The GHNP has only about 17.0% geographical area under forest vegeation (Negi, 1996). This is due to preponderance of alpine areas beyond tree line such as meadows, rocky and snow bound areas.

The dominant tree species in the temperate belt are *Abies pindrow*, *Cedrus deodara*, *Pinus roxburghii*, *Pinus wallichiana*, *Picea smithiana* and *Taxus wallichiana*, among the conifers and *Quercus leucotrichophora*, *Quercus floribunda*, *Quercus semecarpifolia*, *Celtis tetrandra*, *Aesculus indica*, *Juglans regia*, *Acer* spp., *Prunus cornuta*, *Betula alnoides*, *Betula utilis*, *Toona serrata*, and *Populus ciliata* being common broad-leaved species. *Quercus semecarpifolia* forms the pure stands between 3000-3500 m. Small patches of *Quercus leucotrichophora* are found between 1800-2400 m with *Quercus floribunda* overlapped by *Quercus leucotrichophora* on the lower side and *Quercus semecarpifolia* on the upper zone. Generally *Abies pindrow* and *Picea smithiana* are seen in the northern slopes and stands of *Pinus wallichiana*, *Cedrus deodara* and *Quercus semecarpifolia* are seen on the southern slopes. *Alnus nitida*, *Populus ciliata* and *Salix wallichiana* are found near streams. Bamboo species are also found in the moist northern slopes in the Tirthan and Sainj valleys. Under growth and ground

cover comprise species of *Indigofera* , *Viburnum*, *Sarcococca*, *Berberis*, *Iris*, *Polygonum*, *Impatiens, Rumex*, *Girardinia etc*. The tree line is characterised by birch-rhododendron forest, which is replaced by scrubby *Rhododendron* and *Juniperus* species towards higher altitudes interspersed with meadows and rocky outcrops. Alpine pastures are known for preponderance of medicinal herbs such as *Aconitum heterophyllum*, *Picrorhiza kurrooa*, *Jurinea macropcephala*, *Nardostachys grandiflora*, *Dactylorhiza hatagirea etc*. Besides, there are grassy slopes in the eco-development area which have been developed and maintained as "Ghasnis" by the local people for hay.

2.6 FLORA AND FAUNA

The Park is well known for its diverse flora and fauna. Till recently, there was no systematic study on these aspects. Mehta *et al.* (1993) had reported a total of 309 species from the Park. Detailed analysis of the flora is given in Chapter 4.

The fauna of the Park comprises of 31 species of mammals (Gaston and Garson 1993; Vinod *et al*. 1997), 300 species of birds (Gaston *et al*. 1993; Ramesh *et al.* 1998) and more than 125 species of invertebrates (Uniyal and Mathur 1998). The high altitude mammals are blue sheep (*Pseudois nayaur*), brown bear (*Ursus arctos*), snow leopard (*Uncia uncia*) and Himalayan ibex (*Capra ibex*). Himalayan tahr (*Hemitragus jemlahicus*) and musk deer (*Moschus chrysogaster*) inhabit middle to high altitudes. Low to middle altitude species include serow (*Nemorhaedus sumatraensis*), rhesus macaque (*Macaca mullata*), barking deer (*Muntiacus muntjak*), jackal (*Canis aureus*) and goral (*Nemorhaedus goral*). Certain species have wide range of altitude *viz*. Himalayan black bear (*Ursus thibetanus*), common leopard (*Panthera pardus*), Himalayan yellow throated marten (*Martes flavigula*), langur (*Presbytis entellus*) and flying squirrel (*Petaurista petaurista*). Five species of pheasants are reported from the Park *viz*. western tragopan (*Tragopan melanocephalus*), cheer pheasant (*Catreus wallichii*) monal (*Lophophorus impeyanus*), Koklas (*Pucrasia macrolopha*) and Kalij (*Lophura leucomelana*).

2.7 LOCAL PEOPLE AND LAND USE PRACTICES

There are about 141 villages and 1362 families with a population of 9694 living in the buffer zone of GHNP. The literacy of the area is 17.6% (Negi 1996). The main occupation of these people is agriculture along with horticulture. However, rearing sheep and goats also fetches a good income. The extraction of medicinal plants and mushroom formed major source of cash income till recently. This activity in some cases, contributes as high as 65% of the total cash income. Rearing sheep and goats is still practised on a fairly large scale as it is the traditional practice of the villagers. Animal husbandry is common practice for the farm yard manure and for milk products. Horticulture is becoming more popular in the area and raising orchards of apple, plum, walnut and cherry *etc.* are being developed while maize, wheat and barley are generally cultivated as food crops.

The main pressures on the Park resources of GHNP are collection of medicinal and other useful herbs, edible mushrooms and grazing of sheep and goats during summer month (May-Sept.). Collection of

fodder, fuelwood, and religious *yatra* are at low key. Till 1998 about 20,000 sheep and goats visited the alpine pastures during summer which has strongly influenced the vegetation of these pastures. Local people as well as those coming from the adjacent Ani Tehsil graze their livestock in the Park. Only sheep and goats are taken to the high altitude pastures.

2.8. HISTORY OF MANAGEMENT

Recognsing the richness and abundance of wildlife, the HP goverment notified the Tirthan valley as sanctuary on 17th July 1976. Subsequently, a part of Tirthan sanctuary was included in GHNP on Ist March 1984. Settlement of rights and final notification is underway. The Park was renamed as Jawarhar Lal Nehru Great Himalayan National Park during 1989, but its original name is more popular. Administratively Tirthan and Sainj valleys fall under inner Seraj block of Kullu district and the forest come under Seraj Forest Division, while Jiwanal valley forms a part of Waziri Rupi. The forest of Kullu district were settled between 1886 and 1896, by Alex Anderson, the then Commissioner of Kullu (Anderson 1886). The area including the study area, falls in the following four categories such as Reserved Forest, Demarcated Protected Forest (D.P.F.), Unclassified Protected Forest (U.P.F. class III) and Non Forest cultivated land (Sharma 1987). The Himachal State Government imposed a ban on hunting in the state in the year 1982 and a moratorium on felling of timber trees in all the protected areas in 1984. Ban on hunting was imposed has shown a favorable result for the wildlife in this Park.

There was very little commercial exploitation of the forests in the area prior to World War II mainly because of the inaccessibility (Garson and Gaston 1985). Some felling took place during World War II to meet the increased demand for the timber. Felling of certain species, notably *Abies pindrow,* increased between 1949-50 and 1979-80 under the fourth working plan but this appears to be confined to a small area. The local people on the other hand, have been using these forests for generations and continue to exercise number of rights in this area. These rights have been recorded in Anderson's settlement report of 1886. While only limited rights such as right of way, were allowed in the reserved forest, a large number of rights were given in DPF II, including livestock grazing, extraction of timber and collection of fuel wood and NTFP. Local people have unlimited and unsettled rights in the unprotected forest UPF class III. With the lapse of time, new areas were brought under class III forests which allowed clear felling and burning of the forests (Sharma 1987). The Himachal Pradesh Government has recently suspended the rights to cultivate new areas in the UPF and rights of herb collection, grazing of livestock and collection of NTFP are being settled by the Goverment within the NP.

The survey report by Himachal Wildlife Project (HWP I and HWP III) indicated that GHNP had higher wildlife abundance in 1991compared to 1985 when the Park had not been established. The Park has now attained national as well as international significance for the conservation of flora, threatened birds and mammals (Gaston *et al*. 1981, Gaston and Garson 1993).

3.0 GENERAL METHODOLOGY

The field work pertaining to this study was carried out during October 1995 to October 1997. Summer and rainy seasons (April to October) were utilised for plant collection and vegetation sampling in temperate and alpine zones, while winter months (November-March), being inaccessible due to heavy snow were used for the ethnobotanical survey in the ecodevelopment zone (< 1800) for the plant identification and data analysis. The field and analytical methods employed are described below.

3.1 FIELD METHODS

Intensive floristic surveys were conducted covering most of the habitat types between 1500-4800 m. Field identification of flowering plants was done with the help of regional floras, research papers and reports *viz.* Collett (1921), Nair (1977), Rau (1975, 1981), Polunin and Stainton (1984), Chowdhery and Wadhwa (1984) and Aswal and Mehrotra (1994). A set of duplicate specimens were collected for less known and doubtful species and preserved at Wildlife Institute of India, Herbarium following Jain and Rao (1977). All the species were later verified by comparing the specimens housed at the Herbaria of Forest Research Institute, Dehra Dun and Botanical Survey of India (North circle), Dehra Dun.

General methods adopted for the phytosociology in the study area have been described in Chapter 4. For the study of temperate vegetation a total of 13 transects in different watersheds were laid. 7 transects in Tirthan valley, 5 in Sainj and 1 in Jiwa Nal valley covering a total of 673 plots circular plots (371 in Tirthan valley, 253 in Sainj valley and 49 in Jiwa Nal valley). The marked plots were studied during 1996 and baseline data were collected for woody species in order to monitor during subsequent years. For the herbaceous species a total of 2692 quadrats in temperate and 525 quadrats (of 1 m^2) were laid in subalpine and alpine zone in different habitat types. Summary of these plots is given in the Table 6.2. The number of plots to be laid in different valleys was determined based on the extent of the area available in various habitat types in the intensive area *i.e.* Tirthan and Sainj valleys exhibited almost all the habitat types. Most part in the Jiwa Nal valley is inaccessible.

Table 3.1a. Details of stratification and sampling areas in GHNP

Water-shed	Climatic Zone	Altitude (m)	Sampling Areas	No. of Plots
Tirthan	LT	1500-2000	Ropa, Gushani, Bathad	61
	T	2000-2800	Rolla, Chalocha, Basu, Silt, Khollepoe	100
	UT	2800-3300	Chordawar, Pardi, Balu	67
	SA	3300-3600	Gumtroa, Patal, Nada, Manoni, Majhoni	67
	A	>3600	Tirth, Koberi, Sakheti, Rikhundi	350
Sainj	LT	2000-2800	Ropa, Sangard, Sansar, Bah	63
	T	2000-2800	Sakati, Marror, Sugard, Homkhani, Khadu	90
	UT	2800-3300	Majhan galu, Sara	75
	SA	3300-3600	Parkachi, Dhela hut	31
	A	>3600	Dhela. Rakatisar	175
Jiwa Nal	LT	1500-2000	Jiwa,	16
	T	2000-2800	Gatipat, Majhan	18
	UT	2800-3300	Afgain	25

LT= Lower Temperate, T= Temperate, UT= Upper Temperate, SA= Subalpine, A= Alpine

The plant communities in various altitudinal zones were described using TWINSPAN (Hill 1979) and major characteristics of woody vegetation. Various communities were segregated within these altitudinal zones. In spite of some limitations TWINSPAN is the best available computer package for classification of plant communities. The limitations occur due to its option and format for analysis. Limitations of this technique have been narrated in Hill (1979) and Kent and Coker (1992). The dendrogram of vegetation were not scaled according to eigen values because these turned out to be complicated to interpret. Therefore, simple unscaled dendrograms were drawn based on Fores (1994). Species diversity was calculated by Shannon-Wiener Index given by Shannon and Weaver (1949), species richness and evenness were estimated using Menhinick's index (Maugurran 1988, Whittaker 1977). The relationship between distribution of communities and environmental variables were explained using canonical correspondence analysis (CCA, Ter Braak 1987). CCA is a unimodal multivariate direct gradient technique of ordination in a computer package CANOCO (*ver.* 3.12). It enables a simultaneous representation of environmental variables at a site and plant species in low dimensional slope (Ter Braak 1986). It is used to identify the environmental variables that could directly account for large amount of variables in the vegetation data.

The solution of CCA is displayed in the ordination diagram with sites and species represented by points and environmental variables by arrows. The species and site points jointly represent the dominant pattern in community composition in so far as these are explained by environmental variables. The species points and arrows of environmental variable jointly reflect the species distribution along the environmental variable. The direction and relative length of arrows indicate the strength of their correlation to ordination axes. In the present analysis the default option was used in majority of cases. The Mante Carlo permutation test (99 permutation Ter Braak, 1990) was used to test the significance of canonical correlation.

3.1.1. Stratification of the study area for the vegetation sampling

For the vegetation study, the study area was stratified into five broad climatic zones *viz*. lower temperate (LT, 1500 - 2000 m), mid-temperate (T, 2000 - 2800 m), upper temperate (UT, 2800 - 3300 m), subapline (SA, 3300 - 3600 m), and alpine zone (A >3600 m). The strata (Table 3.1) are based on the variation in the geo-morphological features, aspect, altitude, slopes, flatness of the surface, proportion of rocks and boulders, presence or absence of river/stream courses etc. The sampling areas are shown in fig. 3.1.

Table 3.1b. Details of stratification and sampling areas in GHNP

Water-shed	Climatic Zone	Altitude (m)	Sampling areas	Sampled Plots (n)
	LT	1500-2000	Ropa, Gushani, Bathad	61**
	T	2000-2800	Rolla, Chalocha, Basu, Silt, Khollepoe	100**
Tirthan	UT	2800-3300	Chordawar, Pardi, Balu	67**
	SA	3300-3600	Gumtrao, Patal, Nada, Manoni, Majhoni	67**
	A	>3600	Tirth, Koberi, Sakheti, Rikhundi	350*
	LT	2000-2800	Ropa, Sangard, Sansar, Bah	63**
	T	2000-2800	Shakti, Mararor, Sugard, Homkhani, Khadu	90**
Sainj	UT	2800-3300	Majhan galu, Sara	75**
	SA	3300-3600	Parkachi, Dhela Thach	31*
	A	>3600	Dhela. Rakatisar	175*
	LT	1500-2000	Jiwa,	16**
Jiwanal	T	2000-2800	Gatipat, Majhan	18**

LT= Lower Temperate, T= Temperate, UT= Upper Temperate, SA=Subapline A=Alpine **Plot size 12.61, *=Plot size 1 m X 1 m

Based on the micro-topography, human use and physiognomy of the area above 3300 m was further stratified into various secondary strata (Table 3.1.1b). In all, 525 sample plots of 1m X 1m were laid for studying plant communities including the rare, endemic, endangered and medicinal herbs in the different habitat.

Table 3.1b. Details of stratification of Subapline and alpine zone

Primary Strata	Secondary Strata	Landscape Characteristics	Study Site
Sub alpine (3300-3600 m)	Tree line	Transitional (ecotone) zone	Gumatroa, Nada
	Subapline meadow	Man made opening and forested thach	Nada, Majhoni
	Eroded slopes	Avalanche prone area	Majhoni, Ganesh
	Stable slopes	Slopes without erosion	Majhan Galu
Lower alpine (3600-3800 m)	Valley bottom	Flat stable lands and meadows	Majhoni
	River beds	Elevated with 20-40 % boulders and 15-40^0 slope	Tirth lake
		Depressed with >40 % boulders and 0-15^0 slope	Thartadhar, Rikhundi
	Moraine	>50 % boulders and 10-30^0 slope glacial origin	Above Saketi, Khukhari
	Lower slopes	15-40^0 slope	Bandyogei
	Plateau	Flat upland meadows with 5-10^0 slope.	Tirth
Higher alpine (>3800 m)	Stable meadow	*Kobresia* dominated slopes	Chang
	Scrubby slope	Slopes with dwarf *Rhododendron*	Palli Thartadhar
	Stony desert	Areas with >90 % boulders above 4800 m	Saketi, Khukhari

3.1.2. The size and number of plots

The size of the plots required for vegetation sampling was determined following, Mishra (1968) and Kershaw (1973). 121 m^2 area was found adequate for sampling tree layer in most of the forests. However, circular plots of 12.65 m (500 m^2) was preferred so as to cover more area. These plots were easy to lay, less time consuming, required only one field assistant and covered enough area to look at the micro-habitat parameters. Number of sample required were calculated by running mean method following

Muller-Dombois and Ellenberg (1974) and it was found that 15 to 25 samples were required to cover 90% of the species found in all forest types. All approachable habitats were covered for sampling and maximum care was taken to demarcate a sample plot but inaccessibility caused difficulties in some areas.

3.1.3. Laying of sampling plots

Foot paths or human trails covering various habitats in each strata were identified and permanently marked at an interval 250 m. Sample plots were taken at a distance 50-200 m away from the marked points depending upon the accessibility. The centre of the plot was marked by a numbered peg on the ground or painting plot number on tree or rock. 12.65 m radius area (500 m^2) was demarcated with the help of nylon rope for tree species sampling and four points, one each in East, West, North and South directions were marked along the radius of the plot to facilitate further sampling. A nested plot of 5.65 m radius (100 m^2) area was marked within the larger plot for shrubs. For the ground layer *i.e.* grasses and forbs 1 m^2 plots were laid one each in East, West, North and South directions. For studying herbaceous communities in the subapline and alpine pastures random plots 1 m^2 were used.

3.1.4 Collection of data

Following vegetation parameters were quantified from sample plot.

*3.1.4.1 Tree species***:** Name and girth at the breast height (GBH) of all species, their height, over all per cent per cent canopy cover and notes on features like cut, browsed, bird nest or any other significance wildlife value. Plants with > 20 cm cbh and > 3 m straight bole were considered as trees. Other classes *i.e.* pole (10-20 cm) and saplings (>10 cm) of the tree species were recorded only within smaller (5.65 m radius) plots.

3.1.4.2 Shrub species: Species with their number, their average height and number of woody climbers were recorded. The woody species which had gbh < 20 cm, height < 3 m and those branching from base of stem were considered as shrubs (Mueller-Dombois and Ellenberg 1974).

3.1.4.3 Ground Layer: Overall per cent ground cover (visually estimated) within the plot, number of individuals of each species, proportion of grasses and forbs with average height and phenology were recorded in both temperate and alpine zones.

3.1.4.4 Habitat parameters: The following habitat parameters were recorded within each sample plot: altitude using an altimeter, aspect using a magnetic compass and slope using a clinometer. Other habitat parameters recorded were soil characteristics, topography, terrain, vegetation type, wildlife (mammals and birds) and human use signs. From each stand about

250 gm X 10 samples of soil representing one stand was collected for the chemical analysis at the Wildlife Institute of India laboratory.

3.2 ANALYTICAL METHODS

The vegetation analysis was done with the help of computer package SPSS/PC and Excel. The following methods were used for the analysis of data on vegetation and habitat parameters.

3.2.1 Community classification

Communities were classified with the help of a computer package TWINSPAN (Two Way Indicator Species Analysis) (Hill, 1979). TWINSPAN begins with all samples together in a single group or cluster and successively divides each cluster of samples dichotomously into a hierarchy of smaller and smaller clusters until a specific size of division or clusters are attained. This classification was limited to a maximum of five division levels, because cluster size becomes too small for reliable interpretation with more division. The communities are segregated and named after dominant species, which are evident in most of the clusters. Companion species are mentioned with those species, which had near weightage to the dominant species. The species having higher weightage than other available companion species were ranked second in the community. If several companion species have equal weightage than most restricted species was chosen to name the community. Only species most strongly identified with an association were reported to avoid lengthy species list.

The interrelationship between environmental variables and species distribution was determined with the help of computer package Canonical Correspondence Analysis (CANOCO), (Ter Braak 1987). This multivariate method of direct ordination results in the correlation of environmental data as well as species variability. This programe performs correspondence analysis with principal components analysis and redundancy analysis.

3.2.2 Dominance and distribution pattern of tree species

The vegetation data were analysed for per cent frequency (F), density (D) and abundance (A). The Importance Value Index (IVI) was computed for all the tree species by adding the relative values of frequency, density and dominance (basal area) following Curtis and McIntosh (1951), Curtis (1959), Brown and Curtis (1952). The relative value of frequency, density and dominance were determined as suggested by Phillips (1959). The following formulae were used for the analysis.

1. Mean Density /Quadrat = $\frac{\text{Total number of individuals in all the quadrats}}{\text{Total number of quadrat studied}}$

2. % Frequency = $\frac{\text{Total number of quadrat in which single species occurred}}{\text{Total number of quadrat studies}} \times 100$

3. Abundance /Quadrat = $\frac{\text{Total number of individuals of a species in all the qudrats}}{\text{Total number of quadrat in which the species occurred}}$

4. Mean of the circumference (C) = $\frac{\text{Sum of all cbh}}{\text{Total number of species}}$

5. Mean basal area = $\frac{C^2}{4X\ 3.14}$

6. Total basal area = Mean basal area X Density

7. Relative Density = $\frac{\text{Density of individual species}}{\text{Density of all species}} X\ 100$

8. Relative Frequency = $\frac{\text{Frequency of individual species}}{\text{Frequency of all species}} X\ 100$

9. Relative Dominance = $\frac{\text{Basal area of individual species}}{\text{Basal area of all species}} X\ 100$

10. Importance Value Index (IVI) = Relative Density + Relative Frequency + Relative Dominance

3.2.3. Similarities and variation within communities

Sorenson's similarity Index (Sorensen 1948, Magurran 1988) was used to compare vegetation communities of various sites. In order to determine this index, any quantitative phytosociological character is taken into consideration. In this analysis similarity (S) between different sites was calculated based on density of the species using formula

$$S = \frac{2c}{a + b} \times 100$$

Where, c = Sum of minimum values of total density for the species which are common to two stands (to be compared).
a = Sum of total density of all species in one stands 'a'.
b = Sum of total density of all species in other stand 'b'.

Similarity indices are designed to equal one in complete similarity and 0 if the sites are completely dissimilar and have no species in common. One of the greatest advantages of these indices is simplicity.

3.2.4 Diversity, Richness and Eveness

Species diversity (variety and variability) was computed using Shannon-Wiener Index (Shannon and Wiener 1949) using the formula.

$$H' = \sum_{s}^{1} (Ni/N)\log 2\ (Ni/N)$$

Where H' = Shannon Wienner information index of species diversity
Ni = Total number of individuals of one species
N = Total number of individuals of all the species in one stand

The index makes the assumption that individuals are randomly sampled from an "infinitely large" population and also assumes that all the species from the community are included in the sample. The last assumption can not be met always (Kent and Coker 1992). The index was found appropriate, as it needs random sampling but the second criterion (that all the species within the community are included in the sample) could not be fulfilled. Species diversity for different sites were calculated by Shannon Wiener (1963) formula.

Richness was calculated by counting total number of species observed in each habitat and also by Menhinik's index as given by Whittaker (1977):

$$\text{Richness} = \frac{S}{\sqrt{n}}$$

Where, S = The number of species
n = Total number of individuals of all species

Evenness (Equability) was calculated using the equation

Eveness = H'/H' max. = H' log S
Where S = Number of species, H' = Diversity

4.0 FLORISTIC STRUCTURE AND SPECIES DIVERSITY

4.1. INTRODUCTION

The North west Himalaya has long been recognized as one of the distinct floristic regions in India (Hooker 1906 and Mani 1974). Owing to varied topography, wide altitudinal range and unique geographical location, this region harbours a rich flora and exhibits affinities with the Mediterranean, Siberian, Tibetan and Indo-Malayan regions. Plaeobotanical evidences indicate that many of the woody elements in the flora of Himalayan region owe their origin from the topical wet evergreen climate of the Indian peninsula (Vishnu-Mittre 1984). Orogenic changes subsequent to the final phase of Himalayan upliftment and Pleistocene glaciation influenced the Himalayan flora to a great extent. While creation of new corridors and land bridges facilitated the migration of flora and fauna from the adjoining areas, some biogeographic barriers and resultant isolation of certain populations promoted endemism in certain taxa and evolution of several ecotypes, subspecies and species. Perhaps, this region has experienced much more changes in its bioclimates during the recent geological past than any other part of India. These changes, coupled with more recent anthropogenic pressures, have shaped the present flora of the region.

According to the early phytogeographers *viz*., Clarke (1898) and Hooker (1906) the entire north west India and west part of Sharda river constituted one floristic region that was named as western Himalaya which include Jammu and Kashmir, Himachal Pradesh and hills of Uttar Pradesh. The typical families of this region are Asteraceae, Rosaceae, Poaceae, Ranunculaceae, Scrophulariaceae and Brassicaceae (Rau 1975). The characteristic genera include *Aster*, *Potentilla*, *Primula*, *Saussurea*, and *Ranunculus*.

Although, various sectors within this region, *viz*., north western, western and trans-Himalaya show a striking resemblance in their flora, there is a considerable variation in the floristic structure and diversity within these sectors. Several areas have remained unexplored floristically. Tirthan, Sainj and Jiwa valleys of GHNP were among the least explored areas of H.P. till this project was launched. This Chapter deals with the floristic analysis, species diversity, richness patterns and conservation status of rare and threatened species in GHNP. The follwoing methods were applied for the analysis of flora.

1. Systematic surveys were conducted for floral inventory covering all the habitat types and seasons.

2. A set of duplicate plant specimens were collected and preserved following Jain and Rao (1977).

3. The collected specimens were identified with the help of regional floras mentioned in section 5.3 and confirmed at the Herbarium of Wildlife Institute of India, Forest Research Institute of India and Botanical Survey of India, northern circle, Dehra Dun. Plants were arranged according to the Bentham and

Hooker system of classification (1862-1883) (Hooker 1872-97). One set of Herbarium specimens has been deposited in the office of Director, Great Himalayan National Park.

4. Information on various aspects *i.e.* medicinal, rare, endemic and endangered and valuable taxa was also collected for each species.

5. Diversity, richness and evenness were calculated for various landscape categories following the methods detailed in chapter 4.

4.2 ANALYSIS OF THE FLORA

A total of 832 plant species belonging to 427 genera and 128 families of higher plants were recorded within the study area. The species have been appended (Appendix I and Appendix II) in the alphabetical order within each family which follows the sequence of Flora of British India (Hooker 1872-97). Each species is given with authority and synonym. The nomenclature follows Rau (1975), Bennet (1988) and Aswal and Mehrotra (1994). Detailed taxonomic treatments (citation, keys for identification and description) are not given to avoid repetition from the literature cited above. Of this, 794 were Angiosperms, 11 Gymnosperms and 27 ferns. The ratio of family to genera is 1:3.33, family to species 1:6.50, and genera to species 1:1.94. The distribution of species in various groups is given in the following table:

Table 4.2. The ratio of families, genera and species

Groups		Families	Genera	Species
Angiosperms	a. Dicots	94	308	634
	b. Monocots	17	95	160
Gymnosperms		4	8	11
Ferns		13	16	27
Total		128	427	832

According to the growth habit these species are distributed over 69 trees, 113 shrubs, 28 climbers, 493 herbs, 96 graminoides and 27 ferns (Table 5.3.2). The fern species are listed under Appendix II. The ferns were distributed all over the study area with high abundance.

Table 4.2.2. Distribution of flora of GHNP according to growth habit

Habit	Angiosperms		Gymnosperms	Grasses & Sedges -	Ferns	Total
	Dicots	Monocots				
Trees	61	0	8	-	-	69
Shrubs	107	3	3	-	-	113
Climbers	25	3	-	-	-	28
Parasites	6	-	-	-	-	6
Herbs	435	58	-	-	-	493
Grasses and Sedges	-	-		96	-	96
Ferns	-	-	-	-	27	27
Total	634	64	11	96	27	832

Table 4.2.3. Habitat wise distribution of species in various altitudinal zones

Altitudinal Zones m.	Genera	Species	Trees	Shrubs	Climbers	Herbs	Grasses & Sedges
Lower							
Temperate	223	448	59	80	19	216	74
Temperate	311	624	62	92	22	368	80
Upper Temperate	220	468	35	67	14	294	58
Subalpine	135	311	8	30	3	252	18
Alpine	158	387	3	63	1	281	29

4.3 DIVERSITY, RICHNESS AND EVENNESS OF THE FLORA

Species diversity, richness and evenness calculated for various climatic zones show that subalpine zone has highest species diversity (3.20), followed by alpine (3.12) and upper temperate belt (2.56). The richness value of temperate zone is highest (2.57) and lowest for that subalpine zone (2.15). The evenness value of lower temperate zone is maximum (0.92). The diversity, richness and evenness values across the various zones are given in Table 4.3.4.

Table 4.3.1. Diversity, richness and evenness of species in various zone

Climatic Zone	Genera	Species	Diversity	Richness	Evenness
Lower Temperate	223	448	2.86	2.40	0.92
Temperate	311	624	2.62	2.57	0.78
Upper Temperate	220	408	2.56	2.16	0.82
Subalpine	135	311	3.20	2.15	0.75
Alpine	158	387	3.12	2.51	0.77

Species diversity, richness and evenness at various landscape categories are given in the Table 4.3.4. It shows that the species diversity of alpine pasture was highest, (H'= 3.15) and lowest (H'=1.10) for eroded slopes. Likewise richness of stable slope was highest (2.73) and lowest of river belts (0.77). The subalpine meadows were more evenly distributed and the results are given in Table 4.3.5.

Table 4.3.2. Diversity, richness and evenness of various landscape categories

Landscape category	Name of the Areas	Diversity	Richness	Evenness
Subalpine (3,300-3,600 m)				
Trees line	Gumatroa, Nada	1.61	2.24	0.96
Subalpine meadow	Nada , Majhoni	2.39	1.73	0.97
Eroded slopes	Majhnoi, Ganesha	1.10	0.82	0.92
Stable slopes	Majhan galu	2.41	2.73	0.92
Forest gaps	Manoni, Dhela, Hada	2.62	1.10	0.52
Lower alpine (3,600-4,000 m)				
Valley bottom	Tirth, Majhoni	1.52	0.82	0.50
River beds	Tirth lake	1.25	0.77	0.32
Morain	Saketi, Khukhari	1.61	1.15	0.92
Lower slopes	Bandyogi, Devbhalii	2.10	1.11	0.85
Plateau	Tirth, Gumatroa	3.15	1.21	0.89
Higher alpine (>4,000 m)				
Stable Meadow	Changa, Bheemdawri	2.27	0.91	0.75
Scrubby slopes	Palli thartdahar, Soopdhar	2.50	1.51	0.96
Stony desert	Saketi top	1.25	1.15	0.95

4.4 OBSERVATION ON THE FERN FLORA

A total of 27 fern species belonging to 13 families and 16 genera were collected and recorded from GHNP. The ferns were largely recorded within the sample plots for vegetation study. Extensive surveys of ferns may yield more species. Of 1171 sq. km of GHNP only < 40 % area seems to be suitable for the growth of ferns which include shady moist forests (broadleaf and conifer-broadleaf mixed), along hill streams, deep ravines and moist patches near the village pastures. *Osmunda claytoniana, Pteris quadriaurita*, and *Athyrium foliolosum* occur in gregarius patches in moist and heavily grazed sites close to alpine and sub-alpine 'Thaches'. Frequently burnt and grazed grassy slopes in the temperate zone were dominated by common bracken, *Pteridium aquilinum. Diplazium esculentum (= D. maximum),* an edible fern was common along the courses and stream banks between 1500-2800 m. Collett (1921) listed a total of 124 species belonging to 23 genera from Simla. Khullar (1994 and 1999) has described 325 species from the entire western Himalaya.

4.5 PLANTS OF CONSERVATION SIGNIFICANCE

A number of species which are locally threatened due to heavy exploitation, or rare due to their ecological and phytogeographical reasons fall in this category. The following species recorded in GHNP have been listed in the Red Data Book of Indian plants (Nayar and Sastry 1987): *Acer caesium*, *Allium stracheyi*, *Aconitum heterophyllum*, *Angelica glauca*, *Arnebia benthamii*, *Carex munroi*, *Cypripedium cordigerum*, *Cypripedium himalaicum, Meconopsis aculeata*, *Megacarpaea polyandra*, *Nardostachys grandifloa*, P*icrorhiza kurrooa*, *Podophyllum hexandrum*, *Saussurea costus* and *Thlaspi andersonii*. Most of these species occur at higher altitudes (>3000 m) and need immediate conservation measures. Besides following woody elements of GHNP can be categorised under plants of high conservation value viz., *Schizandra grandiflora* (primitive vascular plant), *Pistacia integerrima* (important gene pool for fruit crop), *Fraxinus macrantha* (religious and valuable timber tree), *Ulmus wallichiana* (timber and botanical interest), *Morus serrata* (multi-purpose species), and *Taxus wallichiana* (medicinal and timber value).

4.6 DISCUSSION

Chowdhery and Wadhwa (1984) have reported 3200 species of vascular plants (Angiosperms and Gymnosperms) from Himachal Pradesh. Systematic survey of flora of GHNP reveals that this Park represents nearly 26% of the flora of Himachal Pradesh. In all flora of GHNP was found richer compared to the flora of neighboring areas of Lahaul and Spiti where 985 species have been recorded by Aswal and Mehrotra (1994). While Nair (1977) recorded 1579 species from Bashahr Himalaya. Collett (1921) described 1236 species from Simla hills. Singh (1992) has given taxonomic account of 1027 species distributed over 149 families and 626 genera from the neighboring Mandi district covering an altitudinal gradient of 700-3000 m. Most of the above studies covered the tropical zone (<1000 m) but in case of GHNP only species growing above 1500 m were recorded. The dominant families of GHNP have been compared with *Flora Simlensis* and *Flora of Lahaul –Spiti* (Table 4.6). This shows that Ranunculaceae has more number of species in GHNP compared to Simla and Lahaul-Spiti.

Hooker (1906) described Orchidaceae, Leguminaceae (Fabaceae), Gramineae (Poaceae), Rubiaceae, Euphorbiacae, Acanthaceae, Compositae (Asteraceae), Cyperaceae, Labitae (Lamiaceae) and Urticaceae as 10 dominant families of India. Whereas in GHNP the 10 dominant families are Asteraceae (81), Poaceae (66), Ranunculaceae (48), Rosaceae (41), Liliaceae (26), Lamiaceae (25), Fabaceae) (24), Brassicaeae (24), Apiaceae (23) and Cyperaceae (23).

Table 4.6. Comparison of GHNP Flora with Flora Simlensis and Flora of Lahaul –Spiti

Family	Flora GHNP		Flora Simlensis		Flora of Lahaul-Spiti	
	Genera	Species	Genera	Species	Genera	Species
Asteraceae	36	81	59	109	45	117
Poaceae	43	66	58	133	41	102
Ranunculaceae	13	48	12	33	14	44
Rosaceae	16	41	12	42	14	50
Liliaceae	13	26	18	32	4	8
Lamiaceae	15	25	29	59	16	32
Fabaceae	14	24	45	114	18	53
Brassicaeae	14	24	11	23	26	59
Apiaceae	11	23	14	26	17	40
Cyperaceae	7	23	12	56	5	37

Approximate geographical area: GHNP=1171 km^2, Simla=***, Lahaul-Spiti=**

The woody elements largely predominated the temperate belt of GHNP. A total of 69 tree species belonging to 43 genera and 31 families were recorded. The conifer species were widely distributed in various altitudinal zones from low to high *viz*. *Pinus roxburghii*, *Pinus wallichiana*, *Cedrus deodara*, *Picea smithiana*, *Abies pindrow* and *Abies spectabilis* in the successive zones from low to high altitudes. Each of the upper coniferous belt had its characteristic oak (*Quercus* spp.). The white-oak (*Quercus leucotrichophora*) is associated with *Pinus roxburghii* and *Pinus wallichiana*; green-oak (*Quercus floribunda*) with *Picea smithiana* and *Abies pindrow*. Brown-oak (*Quercus semecarpifolia*) mainly forms the pure community at the treeline. Himalayan yew (*Taxus wallichiana*) is most abundant in the *Abies pindrow* forest. *Rhododendron arboreum* dominates between 1500-3000 m with a tendency of preference for the lower elevation on the north side mostly associated with *Lyonia ovalifolia. Cornus macrophylla* was associated with *Pinus roxburghii*. The four species of *Acer* occurred with a wide range of altitude from 1500-3500 m. *Aesculus indica*, *Alnus nitida*, *Populus ciliata*, *Betula alnoides* and *Salix wallichiana* are common near the streams. The *Prunus cornuta*, *Betula utilis* and *Rhododendron campanulatum* emerged as dominat species in the subalpine zone.

In all a total of 113 shrub species distributed over 45 genera and 33 families were recorded. The common genera of shrubs being *Berberis*, *Daphne*, *Desmodium*, *Deutzia*, *Hypericum*, *Lonicera*, *Indiofera*, *Prinsepia*, *Ribes*, *Rhamnus*, *Rhododendron*, *Rubus*, *Sarcoccoca*, *Sorbaria* and *Viburnum*. Besides, two species of hill bamboo's *viz*. *Sinarundinaria falcata* and *Thamanoclamus spathiflorus* were also categorized in this category considering their woody culms. The climbing shrubs were *Schizandra grandiflora*, *Parthenocissus semecordata var. roylei*, *Hedera nepalensis*, *Jasminum dispermum* and *Ficus sarmentosa*. The common parasitic plants were *Cuscuta reflexa*, *C. europaea, Korthalsella opuntia* and *Balanophora involucrata*.

The herbaceous layer was dominated in almost all altitudinal zones. Besides this the area rich in medicinal plants and more than 60 species have been is recorded commercially exploited by local people. Some of them are still being used by local people in traditional system of medicine. The alpine zone varied depending upon altitude, aspect, slope and other factors but the generally it is >3600 m in western Himalaya. This zone was dominated by prostrate shrubs *e.g*. *Juniperus communis*, *J. pseudosabina*, *Rhododendron anthopogon*, *R. lepidotum*, *Cassiope fastigiata*, *Salix lindleyana* and *S. flabellaris*. Common herbaceous genera of alpine zone are *Primula*, *Leontopodium*, *Corydalis*, *Pleurospermum*, *Saussurea*, and *Senecio*. *Berginia* and *Sedum* dominated the desert habitats between 3600-4200 m. Alpine scrub was dominated by *Rhododendron anthopogon* with common associates such as *Cotoneaster*, *Corydalis*, *Astragalus*, *Potentilla*, *Sedum*, *Rheum*, *Caltha*, *Cassiope*, *Lonicera etc*. The dry areas were dominated by *Juniperus* species associated with species of *Artemisia, Draba*, *Meconopsis*, *Potentilla*, *Salix*, *Carex*, *Caragana etc.* The meadows dominated with luxuriant growth of *Anemone*, *Thalictrum*, *Corydalis*, and *Arenaria*. An analysis of alpine plants of Indian Himalaya shows that nearly 113 taxa are at present threatened and are classified in various categories of threatened plants *i.e.* endangered (17 spp.) vulnerable (11 spp.), rare (79 spp.) threatened (2 spp.) and interminate (4 spp.), Samant (1994). The following species are listed in the Red Data Book (RDB) of Indian plants (Nayar and Sastry 1987) that were recorded from GHNP. *Acer caesium*, *Allium stracheyi*, *Aconitum heterophyllum*, *Angelica glauca*, *Arnebia benthamii*, *Carex munroi*, *Cypripedium cordigerum*, *Cypripedium himalaicum, Meconopsis aculeata*, *Megacarpa polyandra*, *Nardostachys grandifloa*, *Nardostachys jatamansi*, *Picrorhiza kurrooa*, *Podophyllum hexandrum*, *Saussurea costus* and *Thlaspi andersonii*.

Nardostachys grandiflora was recorded and confirmed for the first time from Himachal Pradesh. The attractive flowers bearing plants recorded were *Meconopsis aculeata*, *Caltha palustaris*, species of *Primula* and *Potentilla*. The opportunistic plants of the area were *Rumex nepalensis*, *R. acetosa*, *Polygonum polystachyum*, *P. amplexicaule*, *Impatiens sulcata* and *Urtica dioica.* The tufted species like *Arenaria festucoides* are also present. Fern species were dominant in almost all forest type, inspite of their low number of species (27). Collett (1921) listed a total of 124 species belonging to 23 genera from Simla. Khullar (1994 and 1999) has described 325 species from the entire western Himalaya.

5.0 VEGETATION STRUCTURE AND COMPOSITION

5.1. INTRODUCTION

vegetation is the most obvious physical representation of the majority of the terrestrial ecosystem. The structure and composition of the vegetation not only reflects the nature of basic trophic structure but also forms habitat for numerous organisms. Therefore, information on these parameters of the vegetation with concurrent recording of environmental factors become quite valuable in a variety of ecological problems such as an input to Environmental Impact statements, in monitoring the management practices or as a basis for predicting possible changes (Ashton 1992, Rawat 1996). Changes in vegetation overtime may also need to be described using concept of succession and climax (Kent and Coker 1992). Owing to a wide altitudinal and topographic variation, GHNP supports a large number of vegetation types. Several abiotic and biotic (largely anthropogenic) factors influence the vegetation of this Park. Quantitative information on these aspects, therefore becomes crucial for the conservation and management of biodiversity in the area.

This chapter deals with the description and analysis of vegetation in GHNP with special reference to role of abiotic factors.

5.2 PHYSIOGNOMY BASED CLASSIFICATION OF VEGETATION

Based on the general appearance the following categories of vegetation can be identified in GHNP: a) Forests, b) Scrub vegetation, c) Temperate grassland and forest blanks, d) Alpine meadows. These categories are further divisible into several physiognomic units which have been mapped.

Table 5.2. Shows major physiognomic units and their equivalent categories as per classification of Champion and Seth (1968).

S.N.	Physiognomic Unit		C & S equivalents
1.	Chir Pine Forest	9/C1b	Temperate Chir Pine Forest
2.	Temperate Broadleaf (Evergreen) Forest	12/C1a	Ban oak forest
		12/C1b	Moru oak
		12/C2a	Kharsu oak
3.	Temperate Broadleaf (Moist deciduous) Forest	12/C1e	*Aesculus – Acer – Juglans*
		12/C2c	*Acer – Carpinus – Corylus*
		12/IS1	Alder Forest (Riverine)
4.	Temperate Conifer Forest	12/C1f	Low alt. Blue Pine
		12/2S1	High alt. Blue Pine
		12/C1c	Moist Deodar
5.	Temperate Broadleaf-Conifer (mixed) Forest	12/C1d	Fir – Birch
		12/C2b	Kharsu oak – fir
6.	Sub-alpine Forest:	14/C1a	Sub-alpine fir
		14/C1b	Sub-alpine fir – birch
7.	Temperate Secondary Scrub	12/c1/DS1	Ban oak scrub
		12/c1/DS2	Temperate Scrub
		12/DS1	Bamboo Brakes
		12/DS2	Himalayan Parklands
		13/IS1	*Hippophae* Scrub
8.	Alpine Scrub	15/C1	Birch – *Rhododendron* (*Krummholz*)
		15/C2	Deciduous Scrub
		15/C2/E1	Dwarf rhododendron scrub
		-	Riverine willow scrub
9.	Temperate Grasslands	12/DS3	*Themeda, Chrysopogon Thaches Heteropogon*)
		14/DS1	Sub-alpine pastures (*Thaches* in forest blanks)
10.	Alpine Meadows	15/C3	Alpine pastures
11.	Alpine scree slopes and rocky areas	-	-

5.3 COMMUNITY CLASSIFICATION

A plant community is defined as collection of plant species growing together in a particular location that show a definite association with each other (Muller-Dombois and Ellenberg 1974). The species in a community grow together in a particular environment because they have a similar requirement for existence in terms of environmental factors such as light, temperature, water drainage and soil nutrients (Billings 1974, Muller-Dombois and Ellenberg 1974, Ter Braak 1987, Mc Alister 1997). The two concepts of community *i.e*. orgasmic concept by Clement (1928) and individualistic concept by Gleason (1917; 1939) are still controversial, but most of present day ecologists agree with the existence of plant communities that repeat themselves in space.

Species diversity is considered as a special form of textural diversity and treated in both in connection with both structure and dynamics in the plant community (Maarel 1988 a & b). The concept of diversity is generally concerned with the representation of variability involved in the natural communities. Whittaker (1975) emphasised that different environmental factors influence diversity in different groups. He concluded that species diversity of communities is an interesting property to observe and attempt to interpret, but that diversity is seldom predictable. TWINSPAN segregated 23 communities of trees from Tirthan valley and 22 communities from the Sainj valley. Subalpine and alpine zone were further classified into herbaceous communities (9 and 20 subclasses respectively). For the sake of convenient the study area has been divided into 5 altitudinal zones, *i.e.* lower temperate, temperate, upper temperate, subalpine and alpine sections as described in methodology.

5.3.1. Lower temperate zone

Five communities each were identified in the forest close (1km) to Tirthan and Sainj villages based on TWINSPAN (Fig. 6.3a. and 6.3b.). Based on the Importance Value Index (IVI) the dominant species were *Cedrus deodara* (65.06) followed by *Abies pindrow* (38.37) and *Quercus leuocotrichophora* (32.17). Maximum basal area was of *Aesculus indica* (2806.53 $cm^3/500m^2$). The average tree density was 120.80 ± 15.50 ha^{-1} and of shrubs was 2966.66 ± 155.50 ha^{-1}. The density and frequency of common shrubs show that *Sinarundinaria falcata* has maximum density (940 ha^{-1}) followed by *Sarcoccoca saligna* (946.66 ha^{-1}). The diversity, richness and evenness were 2.85, 3.77 and 0.77 for tree species and 2.16, 2.79 and 0.72 for shrubs respectively.

5.3.2. Temperate zone

A total of 14 plant communities were identified in this zone 8 were confined to Tirthan and 6 in Sainj, (Fig. 5.3a. and 5.3b.). The Importance Value Index (IVI) of *Abies pindrow* was maximum (69.09) followed by *Picea smithiana* (41.66) and *Taxus wallichiana* (32.65). Maximum basal area was of *Picea smithiana* (2846.77 $cm^3/500m^2$). The average tree density was 181.40 ± 18.50 ha^{-1}. and shrubs 945.45 ± 33.1 ha^{-1}. The density, frequency and A/F ratio of common shrubs are given in Table (5.3.16) which show

Thamnocalamus spathiflorus has maximum density (263.63 ha^{-1}) followed by *Indigofera heterantha* (127.2 ha^{-1}). The diversity, richness and evenness were 2.68, 3.16 and 0.90 for tree species and 2.56, 3.93 and 0.83 for shrubs respectively.

5.3.3. Upper temperate

A total of 13 plant communities were identified *i.e.* 7 in Tirthan and 6 in Sainj valley. *Quercus semecarpifolia,* a dominant species had maximum IVI (94.35) followed by *Abies pindrow* (37.43) and *Prunus cornuta* (33.83). The maximum basal area was of *Taxus wallichiana* (1658.53 $cm^3/500m^2$). The average density of tree was 185.46 ± 28.60 ha^{-1} and was higher as compared to lower temperate zone. The shrub density was 1360.00 ± 123.88 ha^{-1}. The density, frequency and A/F ratio of common shrubs are given in Table (6.3.13) which showed that *Rhododendron anthopogon* had maximum density (437.14 ha^{-1}) followed by *Rhododendron campanulatum* (280.00 ha^{-1}). The diversity, richness and evenness were 2.55, 3.57 and 0.84 for tree species and 1.98, 2.43 and 0.71 for shrub species respectively.

6.3.4. Sub-alpine

Only 3 communities were segregated in Tirthan and 5 in Sainj valley. Importance Value Index (IVI) of *Abies pindrow* was maximum (89.00) followed by *Abies spectabilis* (85.99) and *Quercus semecarpifolia* (60.49). The maximum basal area was of *Abies spectabilis* (1802.10 $cm^3/500m^2$). The average tree density was 120.00 ± 20.00 ha^{-1} and that of shrubs was 809.09 ± 55.74 ha^{-1}. The density, frequency and A/F ratio of common shrubs given in Table (6.314.) showing that *Thamnoclamus spathiflorus* had maximum density (250.00 ha^{-1}) followed by *Rhododendron anthopogon* (195.45 ha^{-1}). The diversity, richness and evenness were respectively 3.24, 2.90 and 0.93 for tree species and 1.92, 1.98 and 0.82 for shrubs. A total of 9 herbaceous communities were identified by TWINSPAN as shown in the Fig. 5.3.4.

5.3.5. The Alpine zone

The zone (>3600m) is characterised by the absence of tree cover so that ground vegetation is exposed to fury of cold winds, blizzards and snow storms. The zone is rich in the herbaceous flora, many of them are of medicinal value. The zone is heavily influenced by anthropogenic activities such as summer grazing by sheep and goats and medicinal herb collection. The TWINSPAN community classification is given in (Fig. 5.3.5.). The density, frequency of dominant species are given in Table (5.3.15.), where *Danthonia cachemyriana* had a maximum tiller density (160.37 ± 15.17 m^{-2}) and *Rumex nepalensis* with highest frequency (24.21) The density and frequency of the common herbaceous species in the alpine zone are given in Table (5.3.15).

Table 5.3.1. Vegetation parameters and Importance Value Index (IVI) of dominant tree species, Tirthan valley

TREE SPECIES	D	RD	F	RF	A	BA	R.DOM.
Abies pindrow	1.60	1.64	3.33	1.77	1.85	1.77	1.77
Acer pictum	1.00	1.03	5.00	2.65	3.52	2.65	2.65
Acer villosum	6.40	6.55	3.33	1.77	2.56	1.77	1.77
Aesculus indica	3.40	3.48	11.67	6.20	6.32	6.20	6.20
Alnus nitida	1.40	1.44	3.33	1.77	2.82	1.77	1.77
Betula alnoides	5.00	5.12	11.67	6.20	4.59	6.20	6.20
Cedrus deodara	6.60	6.75	10.00	5.31	6.16	5.31	5.31
Celtis tetrandra	4.00	4.09	11.67	6.20	4.14	6.20	6.20
Cornus capitata	2.40	2.45	5.00	2.65	3.51	2.65	2.65
Cornus macrophylla	3.60	3.68	11.67	6.20	5.56	6.20	6.20
Ilex dipyrena	0.60	0.61	3.33	1.77	1.16	1.77	1.77
Juglans regia	1.00	1.03	5.00	2.65	2.15	2.65	2.65
Lyonia ovalifolia	1.40	1.44	5.00	2.65	2.45	2.65	2.65
Machilus odoratissima	0.40	0.41	1.67	0.89	1.20	0.89	0.89
Picea smithiana	3.00	3.07	5.00	2.65	3.24	2.65	2.65
Pinus wallichiana	14.60	14.92	20.00	10.62	6.58	10.62	10.62
Prunus cornuta	3.00	3.06	5.00	2.65	3.44	2.65	2.65
Pyrus pashia	0.20	0.20	8.33	4.42	2.20	4.42	4.42
Querculus leucotrichophora	4.00	4.09	8.33	4.42	4.41	4.42	4.42
Quercus floribunda	2.00	2.04	5.00	2.65	2.25	2.65	2.65
Quercus semecarpifolia	22.00	22.49	16.67	8.85	9.52	8.85	8.85
Rhododendron arboreum	4.60	4.71	13.33	7.08	3.20	7.08	7.08
Rhus succedanea	1.60	1.64	3.33	1.77	2.30	1.77	1.77
Ulmus wallichiana	4.00	4.08	11.67	6.20	4.51	6.20	6.20
Total	97.80		188.33			99.99	

D= Density per hectare, RD= Relative Density, F= Frequency, RF= Relative Frequency, R.DOM.= Relative Dominance, BA= Total basal area (cm sq. /500 sq.m), IVI= Importance Value Index

Table 5.3.2. Vegetation parameters and Importance Value Index (IVI) of dominant species, Sainj Valley

TREE SPECIES	D	RD	F	RF	A	BA	R.DOM.
Abies pindrow	20.80	13.72	11.11	7.01	4.52	1072.66	5.52
Acer caesium	4.40	2.90	3.70	2.33	1.52	226.47	1.17
Aesculus indica	1.40	0.92	3.70	2.33	1.10	5177.15	26.65
Betula utilis	3.00	1.98	11.11	7.01	3.20	857.01	4.41
Celtis tetrandra	4.40	2.90	7.41	4.68	3.16	498.99	2.57
Corylus jacquemontii	2.20	1.45	7.41	4.68	1.55	905.87	4.66
Juglans regia	1.40	0.92	7.41	4.68	2.62	2233.78	11.50
Picea smithiana	3.00	1.98	11.11	7.01	3.92	2438.30	12.55
Pinus wallichiana	11.80	7.78	22.22	14.02	6.12	1471.26	7.57
Populus ciliata	0.80	0.53	3.70	2.33	1.50	199.04	1.02
Prunus cornuta	11.80	7.78	18.52	11.68	4.11	627.11	3.23
Quercus floribunda	6.60	4.35	14.81	9.34	3.62	495.50	2.55
Quercus semecarpifolia	69.60	45.91	10.44	6.59	2.50	892.07	4.59
Rhododendron arboreum	1.40	0.92	3.70	2.33	1.26	1146.50	5.90
Rhus wallichii	0.80	0.53	3.70	2.33	1.21	199.04	1.02
Taxus wallichiana	6.00	3.96	11.11	7.01	1.16	618.31	3.18
Ulmus wallichiana	2.20	1.45	7.41	4.68	2.92	371.77	1.91
Total	151.60		158.50			19430.83	

D= Density per hectare, RD= Relative Density, F= Frequency, RF= Relative Frequency, R.DOM.= Relative Dominance, BA= Total basal area (cm sq. /500 sq.m) IVI= Importance Value Index

Table 5.3.3. Vegetation parameters and Importance Value Index (IVI) of tree species for lower temperate zone, Tirthan valley

TREE SPECIES	D	RD	F	RF	A	BA	R.DOM.	IVI
Abies pindrow	20.00	16.66	33.33	12.77	3.25	1526.02	8.941	38.37
Aesculus indica	4.40	3.66	16.67	6.39	1.50	2806.53	16.444	26.50
Betula alnoides	2.20	1.83	5.56	2.13	4.05	1516.24	8.884	12.85
Cedrus deodara	34.40	28.65	55.56	21.29	6.15	2581.47	15.125	65.06
Celtis tetrandra	10.00	8.33	33.33	12.77	4.18	954.87	5.594	26.69
Cornus macrophylla	12.20	10.16	11.11	4.26	6.32	559.35	3.277	17.69
Juglans regia	3.40	2.83	11.11	4.26	3.25	940.16	5.508	12.60
Pinus wallichiana	2.20	1.83	11.11	4.26	5.22	2739.67	16.052	22.14
Pyrus pashia	2.20	1.83	5.56	2.13	4.15	1560.51	9.143	13.11
Quercus floribunda	18.80	15.66	33.33	12.77	6.16	638.18	3.739	32.17
Rhododendron arboreum	2.20	1.83	16.67	6.39	6.15	496.89	2.911	11.13
Ulmus wallichiana	8.80	7.33	27.78	10.64	3.22	747.19	4.377	22.35
Total	120.80		261.12			17067.08		

D= Density per hectare, RD= Relative Density, F= Frequency, RF= Relative Frequency, R.DOM.= Relative Dominance, BA= Total basal area (cm sq. /500 sq.m), IVI= Importance Value Index

Table 5.3.4. Vegetation parameters and Importance Value Index (IVI) of tree species of lower temperate zone, Sainj valley

TREE SPECIES	D	RD	F	RF	A	BA	R.DOM.	
Abies pindrow	70.60	32.86	53.00	16.21	6.62	2540.54	16.21	76
Acer caesium	4.00	1.86	6.00	1.83	3.00	1450.56	1.83	
Betula alnoides	8.00	3.72	6.00	1.83	1.00	1486.85	1.83	11
Cedrus deodara	12.00	5.58	20.00	6.12	3.00	1582.05	6.12	17
Celtis tetrandra	8.00	3.72	13.00	3.98	3.00	1138.65	3.98	1
Cornus capitata	2.67	1.24	6.00	1.83	2.00	1125.69	1.83	
Cornus macrophylla	2.67	1.24	6.00	1.83	1.00	156.82	1.83	8
Ilex dipyrena	1.60	0.74	6.00	1.83	1.00	165.48	1.83	
Juglans regia	2.67	1.24	6.00	1.83	2.00	188.50	1.83	
Picea smithiana	46.67	21.72	60.00	18.35	3.88	2684.80	18.35	65
Prunus cornuta	2.67	1.24	6.00	1.83	1.00	159.55	1.83	6
Quercus floribunda	33.33	15.51	40.00	12.23	4.16	2445.60	12.23	46
Rhododendron arboreum	16.00	7.45	27.00	8.26	3.00	1225.50	8.26	23
Taxus wallichiana	2.67	1.24	6.00	1.83	2.00	140.65	1.83	5
Ulmus wallichiana	1.33	0.62	66.00	20.18	2.00	135.50	20.18	4
Total	214.88		327.00			16626.74		

D= Density per hectare, RD= Relative Density, F= Frequency, RF= Relative Frequency, R.DOM.= Relative Dominance, BA= Total basal area (cm sq. /500 sq.m), IVI= Importance Value Index

Table 5.3.5 Vegetation parameters and Importance Value Index (IVI) of tree species for temperate zone, Tirthan valley

TREE SPECIES	D	RD	F	RF	A	BA	R.DOM.	
Abies pindrow	60.00	33.08	63.64	25.45	4.35	1868.21	10.56	69
Acer caesium	11.80	6.50	22.73	9.09	3.21	1251.7	7.08	22
Acer villosum	12.80	7.06	9.09	3.64	2.35	654.95	3.70	14
Aesculus indica	1.00	0.55	4.55	1.82	1.52	127.39	0.72	3
Betula alnoides	2.80	1.54	4.55	1.82	2.2	2300.96	13.01	16
Cedrus deodara	4.60	2.54	9.09	3.64	3.51	1987.58	11.24	17
Celtis tetrandra	5.40	2.98	9.09	3.64	2.85	718.55	4.06	10
Ilex dipyrena	2.80	1.54	4.55	1.82	1.2	212.54	1.20	4
Juglans regia	7.20	3.97	18.18	7.27	3.15	754.93	4.27	15
Machilus odoratissima	1.80	0.99	4.55	1.82	2.15	118.01	0.67	3
Picea smithiana	20.00	11.03	36.36	14.54	5.12	2846.77	16.10	41
Pinus wallichiana	1.00	0.55	4.55	1.82	2.55	2579.62	14.59	16
Prunus cornuta	1.00	0.55	4.55	1.82	2.58	718.55	4.06	6
Quercus floribunda	14.60	8.05	18.18	7.27	2.15	251.92	1.42	16
Quercus semecarpifolia	2.80	1.54	4.55	1.82	1.55	212.54	1.20	4
Rhododendron arboreum	1.80	0.99	4.55	1.82	1.5	161.23	0.91	3
Taxus wallichiana	30.00	16.54	27.27	10.91	4.25	919.82	5.20	32
Total	181.40		250.03			17685.27		300

D= Density per hectare, RD= Relative Density, F= Frequency, RF= Relative Frequency, R.DOM.= Relative Dominance, BA= Total basal area (cm sq. /500 sq.m), IVI= Importance Value Index

Table 5.3.6. Vegetation parameters and Importance Value Index (IVI) of tree species for temperate zone, Sainj valley

TREE SPECIES	D	RD	F	RF	A	BA	R.DOM.	
Abies pindrow	10.00	4.21	20.00	9.52	2.50	2564.87	18.59	12
Acer caesium	10.00	4.22	10.00	4.76	5.00	1507.65	10.93	12
Cedrus deodara	22.00	9.28	40.00	19.05	2.75	1895.65	13.74	27
Picea smithiana	6.00	2.53	20.00	9.52	1.50	875.50	6.34	12
Pinus wallichiana	6.00	2.53	20.00	9.52	1.50	652.50	4.73	7
Prunus cornuta	4.00	1.69	10.00	4.76	2.00	452.50	3.28	5
Quercus floribunda	120.00	50.63	50.00	23.81	12.00	2892.67	20.96	150
Rododendron arboreum	34.00	14.35	20.00	9.52	5.66	1488.09	10.78	42
Taxus wallichiana	22.00	9.28	10.00	4.76	11.00	1265.36	9.17	27
Ulmus wallichiana	2.00	0.84	10.00	4.76	1.00	203.70	1.48	2
Total	236.00		210.00			13798.49		

D= Density per hectare, RD= Relative Density, F= Frequency, RF= Relative Frequency, R.DOM.= Relative Dominance, BA= Total basal area (cm sq. /500 sq.m), IVI= Importance Value Index

Table 5.3.8. Vegetation parameters and Importance Value Index (IVI) of tree species for upper temperate, Sainj valley

TREE SPECIES	D	RD	F	RF	A	BA	R. DOM.	I
Abies pindrow	86.40	44.26	42.26	30.59	3.54	1478.03	12.57	87.4
Acer caesium	0.80	0.41	3.40	2.46	2.95	435.25	3.70	6.5
Betula utilis	5.60	2.87	11.11	8.04	3.50	1025.87	8.73	60.(
Prunus cornuta	3.20	1.64	4.40	3.19	3.25	699.76	5.95	10.7
Quercus semecarpifolia	96.00	49.18	68.96	49.92	4.15	5849.47	49.76	107.8
Taxus wallichiana	3.20	1.64	8.00	5.79	4.50	2267.25	19.29	26.7
Total	195.20		138.13			11755.63		

D= Density per hectare, RD= Relative Density, F= Frequency, RF= Relative Frequency, R.DOM.= Relative Dominance, BA= Total basal area (cm sq. /500 sq.m), IVI= Importance Value Index

Table 5.3.7. Vegetation parameters and Importance Value Index (IVI) of tree species for upper Temperate zone, Tirthan valley

TREE SPECIES	D	RD	F	RF	A	BA	R.DOM.	I
Abies pindrow	14.00	7.07	10.00	15.38	6.67	1505.27	13.34	37.4
Acer caesium	12.00	6.06	5.00	7.69	2.14	1244.02	11.02	23.(
Betula utilis	13.00	6.56	5.00	7.69	2.11	1658.53	14.70	28.9
Picea smithiana	12.00	6.06	5.00	7.69	1.56	1975.01	17.50	29.5
Prunus cornuta	13.00	6.56	10.00	15.38	3.22	1345.54	11.92	33.8
Quercus semecarpifolia	122.00	61.61	20.00	30.76	8.15	1778.28	15.76	94.3
Taxus wallichiana	12.00	6.06	5.00	7.69	2.55	1146.49	10.16	22.7
Total	198.00		60.00			11280.25		

D= Density per hectare, RD= Relative Density, F= Frequency, RF= Relative Frequency, R.DOM.= Relative Dominance, BA= Total basal area (cm sq. /500 sq.m), IVI= Importance Value Index

Table 5.3.10. Vegetation parameters and Importance Value Index (IVI) of tree species for subalpine zone, Sainj valley

TREE SPECIES	D	RD	F	RF	A	B.A.	R.DOM.	IV
Abies pindrow	26.00	19.07	48.50	23.29	4.21	1538.75	26.13	68.4
Abies spectabilis	31.25	22.92	29.22	1.87	5.26	1850.25	31.43	56.2
Acer villosum	2.16	1.58	10.50	6.12	2.15	142.20	2.42	10.1
Betula utilis	7.16	5.25	9.50	2.43	3.25	215.40	3.66	11.3
Prunus cornuta	5.75	4.22	5.20	38.01	2.85	315.20	5.35	47.5
Quercus semecarpifolia	35.65	26.14	56.50	4.41	6.15	1575.35	26.76	57.3
Rhododendron campanulatum	28.40	20.83	22.00	76.14	11.20	250.65	4.26	101.2
Total	136.37		181.42			5887.80		

D= Density per hectare, RD= Relative Density, F= Frequency, RF= Relative Frequency, R.DOM.= Relative Dominance, BA= Total basal area (cm sq. /500 sq.m), IVI= Importance Value Index

Table 5.3.9. Vegetation parameters and Importance Value Index (IVI) of tree species for subalpine zone, Tirthan valley

TREE SPECIES	D	RD	F	RF	A	BA	R.DOM.	I
Abies pindrow	28.00	23.33	50.00	34.12	5.60	1736.4	31.54	89.
Abies spectabilis	25.00	20.83	47.5.00	32.42	5.28	1802.1	32.73	85.
Acer villosum	3.00	2.50	5.00	3.41	4.10	183.77	3.33	9.
Betula utilis	10.00	8.33	10.00	6.82	6.10	365.45	6.63	21.
Prunus cornuta	6.00	5.00	5.00	3.41	3.20	139.67	2.53	10.
Quercus semecarpifolia	30.00	25.00	22.00	15.01	8.76	1127.26	20.47	60.
Rhododendron campanulatum	18.00	15.00	7.00	4.77	10.50	149.69	2.71	22.
Total	120.00		146.50			5504.34		

D= Density per hectare, RD= Relative Density, F= Frequency, RF= Relative Frequency, R.DOM.= Relative Dominance, BA= Total basal area (cm sq. /500 sq.m), IVI= Importance Value Index

Table 5.3.11. Density (D) and Frequency (F) and abundance of shrubs of lower temperate zone

Shrub Species	D ha^{-1}	RD	F	RF	A
Sinarundinaria falcata	940.00	31.69	23.33	9.59	40.29
Berberis aristata	243.33	8.20	33.33	13.70	7.30
Berberis lycium	83.33	2.81	6.67	2.74	12.50
Daphne papyracea	33.33	1.12	13.33	5.48	2.50
Desmodium elegans	83.33	2.81	10.00	4.11	8.33
Desmodium triflorum	13.33	0.45	10.00	4.11	1.33
Deutzia corymbosa	50.00	1.69	3.33	1.37	15.00
Deutzia straminea	6.67	0.22	6.67	2.74	1.00
Elaeagnus parvifolia	6.67	0.22	3.33	1.37	2.00
Indigofera atropurpurea	33.33	1.12	3.33	1.37	10.00
Indigofera heterantha	73.33	2.47	6.67	2.74	11.00
Indigofera sp.	6.67	0.22	3.33	1.37	2.00
Prinsepia utilis	193.33	6.52	23.33	9.59	8.29
Rhamnus virgatus	6.67	0.22	6.67	2.74	1.00
Rosa webbiana	90.00	3.03	10.00	4.11	9.00
Sarcoccoca saligna	646.67	21.80	60.00	24.66	10.78
Sorbaria tomentosa	33.33	1.12	6.67	2.74	5.00
Thamnoclamus spathiflorus	250.00	8.43	3.33	1.37	75.00
Viburnum cotinifolium	6.67	0.22	6.67	2.74	1.00
Total	2966.67		243.33		

D=Density ha^{-1}, RD= Relative Density, F= Frequency, RF= Relative frequency

Table 5.3.12. Density (D) and Frequency (F) and abundance of shrubs in temperate zone

Shrub Species	D ha^{-1}	RD	F	RF	A
Berberis lycium	4.55	0.48	4.55	2.08	1.00
Buddleja crispa	27.27	2.88	9.09	4.17	3.00
Buddleja sp.	9.09	0.96	4.55	2.08	2.00
Coriaria nepalensis	4.55	0.48	4.55	2.08	1.00
Cotoneaster acuminata	45.45	4.81	9.09	4.17	5.00
Cotoneaster affinis	27.27	2.88	9.09	4.17	3.00
Desmodium elagans	45.45	4.81	13.64	6.25	3.33
Desmodium sp.	18.18	1.92	4.55	2.08	4.00
Indigofera heterantha	127.27	13.46	22.73	10.42	5.60
Indigofera pulchella	9.09	0.96	4.55	2.08	2.00
Jasminum humile	36.36	3.85	9.09	4.17	4.00
Lonicera purpurascens	31.82	3.37	13.64	6.25	2.33
Prinsepia utilis	27.27	2.88	9.09	4.17	3.00
Rhamnus purpureus	13.64	1.44	4.55	2.08	3.00
Rosa macrophylla	27.27	2.88	9.09	4.17	3.00
Rosa niveus	68.18	7.21	4.55	2.08	15.00
Rosa webbiana	22.73	2.40	13.64	6.25	1.67
Sorbus lanata	13.64	1.44	4.55	2.08	3.00
Sorbaria tomentosa	72.73	7.69	22.73	10.42	3.20
Syringa emodi	13.64	1.44	4.55	2.08	3.00
Thamnoclamus spathiflorus	263.64	27.88	22.73	10.42	11.60
Viburnum grandiflorum	36.36	3.85	13.64	6.25	2.67
Total	*945.45*		218.18		

D=Density ha^{-1}, RD= Relative Density, F= Frequency, RF= Relative frequency,

Table 5.3.13. Density (D) and Frequency (F) and abundance of shrubs in upper temperate zone

Shrub Species	D ha^{-1}	RD	F	RF	A
Berberis chitria	22.73	1.32	4.55	2.63	5.00
Berberis jaeschkenia	36.36	2.12	4.55	2.63	8.00
Cotoneaster microphyllus	50.00	2.91	9.09	5.26	5.50
Juniperus communis	281.82	16.40	22.73	13.16	12.40
Juniperus seudosabina	9.09	0.53	4.55	2.63	2.00
Lonicera sp.	13.64	0.79	9.09	5.26	1.50
Rhododendron anthopogon	695.45	40.48	40.91	23.68	17.00
Ribes alpestre	4.55	0.26	4.55	2.63	1.00
Rododendron lepidotum	295.45	17.20	18.18	10.53	16.25
Rosa sericea	100.00	5.82	18.18	10.53	5.50
Rosa webbiana	36.36	2.12	9.09	5.26	4.00
Salix elegans	22.73	1.32	4.55	2.63	5.00
Thamnoclamus spathiflorus	113.64	6.61	9.09	5.26	12.50
Viburnum cotinifolium	4.55	0.26	4.55	2.63	1.00
Viburnum nervosum	31.82	1.85	9.09	5.26	3.50
Total	1718.18		172.73		

D=Density ha^{-1}, RD= Relative Density, F= Frequency, RF= Relative frequency

Table 5.3.14 Density (D) and Frequency (F) and abundance of shrubs in subalpine zone

Shrub Species	D ha^{-1}	RD	F	RF	A
Berberis chitria	36.36	4.49	4.55	4.17	8.00
Berberis jaeschkenia	31.82	3.93	9.09	8.33	3.50
Cotoneaster microphylla	81.82	10.11	4.55	4.17	18.00
Indigofera heterantha	18.18	2.25	9.09	8.33	2.00
Juniperus pseudosabina	68.18	8.43	4.55	4.17	15.00
Rhododendron anthopogon	195.45	24.16	18.18	16.67	10.75
Rhododendron lepidotum	54.55	6.74	13.64	12.50	4.00
Rosa sericea	36.36	4.49	13.64	12.50	2.67
Salix lindleyana	9.09	1.12	4.55	4.17	2.00
Thamnoclamus spathiflorus	250.00	30.90	18.18	16.67	13.75
Viburnum grandiflorum	27.27	3.37	9.09	8.33	3.00
Total	809.09		109.09		

D=Density ha^{-1}, RD= Relative Density, F= Frequency, RF= Relative frequency,

The density and frequency of dominant species were calculated. *Danthonia cachymeriana* had highest (160.37 ±± 15.17) density followed by *Carex setosa* (91.37 ±± 83.54) and *Poa alpina* (67.76 ±± 82.57). The highest frequency was of *Rumex nepalensis* (24.21) followed by *Selinum vaginatum* (20.42) and Polygonum *polystachyum* (18.74). Density and frequency of some other dominant species of the area are given in the Table 5.3.15.

Table 5.3.15. Density and Frequency of the common herbaceous species in alpine zone, GHNP

Species	Density / m^2	Frequency
Agrostis pilosa	41.18 ± 30.95	4.63
Anaphalis triplinervis	21.80 ± 14.24	5.26
Capsella bursa-pastoris	45.77 ± 34.30	4.63
Danthonia cachemyriana	160.37 ± 15.17	12.63
Epilobium wallichianum	11.16 ± 8.99	6.11
Galium aparine	50.08 ± 53.89	7.58
Geranium pratense	9.67 ± 9.15	6.32
Hackelia uncinata	15.56 ± 14.32	10.32
Impatiens sulcata	23.19 ± 21.72	6.95
Kobresia sp.	17.10 ± 11.26	4.42
Morina longifolia	4.77 ± 2.52	7.37
Nepeta erecta	10.87 ± 7.85	5.05
Pedicularis bicornuta	9.05 ± 5.20	4.42
Phleum alpnium	36.95 ± 26.45	13.89
Phlomis bracetosa	13.98 ± 9.18	9.05
Poa alpina	67.76 ± 82.57	11.37
Polygonum amplexicaule	21.12 ± 17.70	8.84
Polygonum polystachyum	21.44 ± 19.22	18.74
Polygonum viviparum	15.95 ± 13.75	4.42
Potentilla atrosangunea	14.54 ± 9.62	17.89
Potentilla fruticosa	8.62 ± 4.11	4.42
Ranunculus hirteulus	17.24 ± 19.39	7.79
Rumex nepalensis	20.23 ± 14.15	24.21
Selinum vaginatum	17.51 ± 11.87	20.42
Tanacetum longifolium	17.10 ± 15.27	4.42

The over all density of trees and shrubs in different zones showed that upper temperate had maximum density (185.6 ± 28.60 ha^{-1}) and lower temperate with minimum (120.8 ± 15.50 ha^{-1}). The shrub density was highest for lower temperate (2966.66 ± 155.50 ha^{-1}) and lowest for subalpine (809.09 ± 55.74 ha^{-1}). The tree diversity was highest in lower temperate and lowest in subalpine. The richness showed almost a decreasing trend with increasing altitude for both trees and shrubs. There was no such demarcation in evenness and was constant in all the zones except for the lower temperate zone (Table 6.3.316).

Table 5.3.16. Average Density (D), Diversity, Richness and Evenness of woody species at various altitudinal zones

Climatic zones	Species habit	Avg. D ha^{-1}	Diversity	Richness	Evenness
Lower	Trees	120.8 ± 15.50	2.85	3.77	0.77
temperate	Shrubs	2966.66 ± 155.50	2.16	2.79	0.72
Temperate	Trees	181.4 ± 18.50	2.68	3.16	0.90
	Shrubs	945.45 ± 33.17	2.56	3.93	0.83
Upper	Trees	185.6 ± 28.60	2.55	3.57	0.84
temperate	Shrubs	1360.00 ± 123.88	1.98	2.43	0.71
Subalpine	Trees	120.0 ± 20.00	3.24	2.90	0.93
	Shrubs	809.09 ± 55.74	1.92	1.98	0.82

Table 5.3.17. Tree density (ha^{-1}), tree species diversity (H') and total species (R) (including tree, shrubs and herbs) in the various communities of Tirthan valley

Climatic zone	Plant community	Average density/ha	Diversity	(R)
Lower temperate	*Cornus macrophylla + Rhus semialata*	170.0±60.0	2.71	128
	Quercus floribunda + Aesculus indica	100.0±20.0	2.81	155
	Celtis tetrandra + Betula alnoides	100.0±35.2	2.71	103
	Ulmus wallichiana + Celtis tetrandra	113.8±28.2	1.04	192
	Quercus leucotrichophora	130.0±26.6	1.02	123
Temperate	*Pyrus pashia*	140.0±22.2	1.00	108
	Pyrus pashia + Rhododendron arboreum	90.0±20.0	0.69	141
	Pinus wallichiana + Rhododendron arboreum	105.0±29.4	1.61	114
	Cedrus deodara + Picea smithiana	153.0±44.5	2.92	111
	Cedrus deodara + Quercus glauca	160.0±40.0	2.10	133
	Juglans regia + Acer caesium	166.6±17.7	2.89	117
	Picea smithiana + Abies pindrow + Cedrus deodara	182.8±59.5	1.79	141
	Abies pindrow + Picea smithiana	196.0±24.0	1.10	173
Upper temperate	*Abies pindrow + Acer caesium + Taxus wallichiana*	160.0±13.7	1.29	121
	Abies pindrow + Taxus wallichiana	150.0±10.0	0.64	115
	Prunus cornuta + Abies pindrow	133.3±22.0	1.04	150
	Prunus cornuta	130.0±20.0	1.10	106
	Betula utilis	130.0±10.0	1.11	140
	Quercus semecarpifolia + Taxus wallichiana	130.0±10.0	0.69	141
	Quercus semecarpifolia	188.8±78.8	1.30	95
Subalpine	*Betula utilis + Quercus semecarpifolia*	120.0±20.0	1.10	173
	Quercus semecarpifolia + Acer villosum + Abies pindrow	120.0±40.0	2.05	120
	Quercus semecarpifolia + Abies pindrow	210.0±10.0	1.69	141

Table 5.3.18. Tree density (ha^{-1}), tree species diversity (H') and total species (R) (including tree, shrubs and herbs) in the various communities of Sainj valley

Climatic Zone	Vegetation community	Average density/ha	Diversity	(R)
Lower temperate	*Pinus roxburghii + Cornus capitata*	150.5 ± 25.5	1.69	121
	Cedrus deodara + Pyrus pashia	120.0 ± 20.0	1.81	120
	Cedrus deodara + Quercus leucotrichophora	140.0 ± 40.0	1.39	153
	Populus cilliata	120.0 ± 20.0	1.10	150
	Pinus roxburghii + Lyonia ovalifolia + Rhododendron arboreum	113.8 ± 28.2	1.04	135
Temperate	*Rhododendron arboreum + Alnus nitida + Prunus cornuta*	120.0 ± 10.0	1.71	133
	Quercus leucotrichophora + Acer pictum	105.0 ± 29.5	1.10	100
	Hippophae salicifolia	160.0 ± 40.0	1.21	94
	Populus ciliata + Hippophae salicifolia	130.0 ± 10.0	1.61	141
	Juglans regis + Ulmus wallichiana	166.6 ± 17.7	1.69	152
	Prunus cornuta + Acer caesium	150.0 ± 10.0	1.39	145
Upper temperate	*Celtis tetrandra + Acer pictum*	153.0 ± 44.5	1.79	120
	Aesculas indica + Betula alnoides + Celtis tetrandra	133.3 ± 22.0	1.56	150
	Quercus floribunda + Pyrus pashia	140.0 ± 22.0	1.04	119
	Taxus wallichiana + Pinus wallichiana	120.0 ± 20.0	1.48	141
	Picea smithiana + Pinus wallichiana	182.0 ± 44.4	1.07	77
	Abies pindrow + Taxus wallichiana	160.0 ± 20.0	1.66	47
Subalpine	*Ulmus wallichiana + Prunus cornuta + Salix wallichiana*	130.0 ± 10.0	1.53	141
	Abies pindrow + Acer caesium	160.0 ± 13.7	1.69	124
	Quercus semecarpifolia + Acer caesium	160.0 ± 15.5	1.61	173
	Quercus semecarpifolia + Abies pindrow	200.0 ± 40.0	1.10	200
	Quercus semecarpifolia + Rhododendron campanulatum + Abies spectabilis	220.0 ± 28.6	1.39	195

Table 5.3.19. Tree density (ha^{-1}), tree species diversity (H') and total species (R) (including tree, shrubs and herbs) in various communities of subalpine zone

Vegetation community	Density/ $m^2 \pm$ SD	Diversity	(R)
Hackelia uncinata + *Primula denticulata* + *Dactylorhiza hatagirea*	255 ± 25	2.05	122
Athyrium schimperi	321 ± 41	1.85	100
Oxygraphis polypetala + *Caltha palustris* + *Cortia depressa* + *Primula involucrata*	185 ± 31	1.69	173
Agrostis munroa + *Anaphalis triplinervis* + *Ranunculus hirtellus* + *Geranium pratense*	325 ± 62	2.71	110
Anemone rupicola + *Danthonia cachemyriana* + *Kobresia* sp.+ *Poa alpina*	422 ± 71	1.39	115
Rumex nepalensis + *Polygonum polystachyum* + *Selinum vaginatum* + *Potentilla atrosangunea*	82 ± 12	3.22	166
Rumex nepalensis + *Polygonum amplexicaule* + *Urtica dioca* + *Carex setosa*	120 ± 32	2.75	141
Anaphalis royleana + *Bergenia stracheyi* + *Podophyllum hexandrum*	112 ± 21	1.82	89
Polygonatum verticillatum	70 ± 18	1.05	63

Table 5.3.20. Tree density (ha^{-1}), tree species diversity (H') and total species (R) (including tree, shrubs and herbs) in various communities of alpine

Plant community	Density/ m^2 ± SD	Diversity	(R)
Urtica dioica + Rumex nepalensis+ Impatiens sulcata	242 ± 22	2.21	58
Primula denticulata + Gentiana cachemirica + Trillium govanianum	40 ± 20	1.55	36
Polygonum amplexicaule + Geranium pratense	95 ± 31	2.19	75
Androsace rotundifolia + Aconitum heterophyllum	25 ± 14	2.61	121
Potentilla atrisanguinea + Gypsophylla cerasioides + Agrostis pilosula	152 ± 31	2.14	111
Achillea millefolium + Tanacetum longifolium	105 ± 28	1.75	85
Anaphalis nubigena + Carex setosa + Agrostis pilosula	232 ± 52	2.10	111
Rumex nepalensis + Selinum vaginatum + Potentilla atrosanguinea + Geranium pratense	220 ± 26	2.50	224
Athyrium schimperi	120 ±16	1.80	59
Berberis jaeschkeana + Anaphalis royleana + Polygonum viviparum	40 ± 14	1.89	115
Bergenia stracheyi + Polygonum viviparum	62 ± 18	2.55	122
Artemisia parviflora + Agrostis munroan a	105 ± 24	1.61	155
Rhododendron anthopogon + Poa alpina + Juncus thomsonii	320 ± 41	2.64	200
Phleum alpinum + Danthonia cachymeriana	958 ± 222	2.25	120
Rosa sericea + Morina longifolia	15 ± 5	1.95	84
Danthonia cachymeriana + Kobresia pygmaea	865 ± 242	1.73	68
Arnebia benthamii + Epilobium latifolium	18 ± 8	1.21	95
Nepeta podostachys + Aster falconeri	25 ± 8	1.93	125
Waldheimia tomentosa + Anaphalis nubigena + Carex alpina	80 ± 22	1.86	93
Oxygraphis polypetala + Ranunculus pulchellus	40 ± 18	1.22	110
Arenaria festucoides + Aster falconeri	32 ± 14	2.20	128
Saussurea obvallata + Delphinium brunonianum + Primula stuartii	16 ± 7	1.69	175

5.4. SIMILARITY INDICES

Sorensen's (1948), similarity coefficient measure was used to see the similarity in woody species between different zones of Tirthan and Sainj valleys. The phytosociological analysis showed that similarity of woody species was different between the valleys and also found to be different among the zones. The highest similarity was found in the subalpine zones (78.51) and lowest between subalpine and lower temperate zones (12.79) of the two valleys. Among the various altitudinal zones temperate and upper temperate zones were most similar (44.42) and lower temperate and upper temperate were least similar (Table 5.4.2.)

Table 5.4.1. Table showing similarities between various altitudinal zones of Tirthan and Sainj valley, GHNP

Sainj valley ↓	**Tirthan valley →** Lower temperate	Mid-Temperate	Upper temperate	Subalpine
Lower temperate	47.85	51.91	31.18	27.31
Mid-Temperate	28.60	38.45	21.56	25.99
Upper temperate	12.79	37.79	66.74	60.16
Subalpine	12.79	29.87	43.38	78.51

Table 5.4.2. Similarity per cent between various altitudinal zones

Zones→	Lower temperate	Mid-Temperate	Upper temperate	Subalpine
Lower temperate ↓	100.00	39.27	12.47	12.79
Mid-Temperate	39.27	100.00	44.42	29.79
Upper temperate	12.47	44.42	100.00	43.55
Subalpine	12.79	29.79	43.55	100.00

5.5. EFFECTS OF ABIOTIC FACTORS ON VEGETATION

Ordination of vegetation using canonical correspondence analysis was done to see the effects of abiotic factors on the vegetation. Summary of the analysis is given below.

Number of samples	299
No. of active samples	296
Number of species	323
Number of occurrences	1481
No. of passive samples	3
No. of active species	251

A correlation biplot of canonical correspondence analysis (CCA) for the high altitude herbs is shown in Figs. 5.3.5a. and 5.35b. The summary of the statistics for four axes of CCA with 323 species and 5 forward selected environmental variables are given in table 6.4.1. The abbreviations for the species issued in CCA are given in Appendix III. All axes were significant (<0.1) indicated by Monte Carlo permutation test. Altitude, pH and habitat types were found to be more important factors influencing the species distribution. The similarity among various environmental variables showed that altitude is negatively correlated with pH. (Table 5.3.19)

Table 5.4.1. Table showing similarity between various environmental variables

	ENVI AX1	ENVI AX2	ENVI AX3	ENVI AX4	ENVI AX5
Aspect	1.0000				
Habitat	-.0534	1.0000			
p H	.0980	-.1199	1.0000		
Slope	.3648	-.0948	-.0323	-.1467	1.0000
	Aspect	Aspect	Habitat	pH	Slope

Table 5.4.2. Statistical analysis of environmental variable

Name	Weighted mean	SD	Inflation factor
Aspect	3720.4290	284.2983	1.2787
Habitat	0.3949	0.2265	1.1573
pH	0.2391	0.1684	1.0536
Altitude	0.2857	0.2631	1.0487

Eigen values:	0.434	0.329	0.280	0.266	71.919
Species-environment correlations:	0.800	0.735	0.692	0.693	
Cumulative percentage variance					
of species data:	0.6	1.1	1.5	1.8	
of species-environment relation:	21.9	38.5	52.7	66.1	

Sum of all unconstrained eigen values: 71.919
Sum of all canonical eigen values: 1.980
P-value 0.010 (number of permutations=99)

Summary of Monte Carlo test Test of significance of first canonical axis: eigen value =0.43
F-ratio =1.75
P-value =0.01
Overall test: Trace = 1.98
F-ratio = 1.17
P-value = 0.01

The analysis revealed that the values are significant (p=<0.01) and some species were more influenced by altitude *viz*. *Salvia hians* (Sal han), *Artemisia vularis* (Art vul) and *Aconitum chasmanthum* (Aco cha). *Saussurea roylei* (Sau roy), *Berginia stracheyi* (Ber sta), *Stipa orientalis* (Sti ori), *Potentilla nepalensis* (Pot nep) were more influenced by pH. Degree of slope had a little effect on *Danthonia cachymeriana* (Dan cac). *Phleum alpinum* (Phl alp) was found in the lower slopes classes whereas *Nardostachys jatamansi* at the higher slope classes. *Astible rivularis* (Ast riv), *Ranunculus trichophyllus* (Ran tri), *Potentilla penducularis* (Pot pen), *Dactylorhiza hatagirea* (Dac hat) were found more in the bouldery and *Jurinea macrocephala* (Jur dol), *Chaerophyllum villosum* (Cha vil) were more in the flat areas.

5.6. POPULATION STRUCTURE

Among the various methods to know the status of forest regeneration such as density-diameter curve (Spurr 1952, Kunchel1953, Rollet 1974, Saxena and Singh 1984, Bargali *et al*. 1989, Reddy 1989 and

Rawal 1991), dominance-diversity curve (Whittaker 1972) and population structure (Singh and Singh 1987). The latter seems to be most appropriate method seems to be the population structure (Singh and Singh 1987). Several studies have been done to assess the regeneration of tree species in central Himalaya *e.g.* Saxena (1979), Tiwari (1982), Saxena and Singh (1982), Upreti *et al*. (1985) and Rawal (1991). Population structure of main tree species is given in Fig. 5.4.1

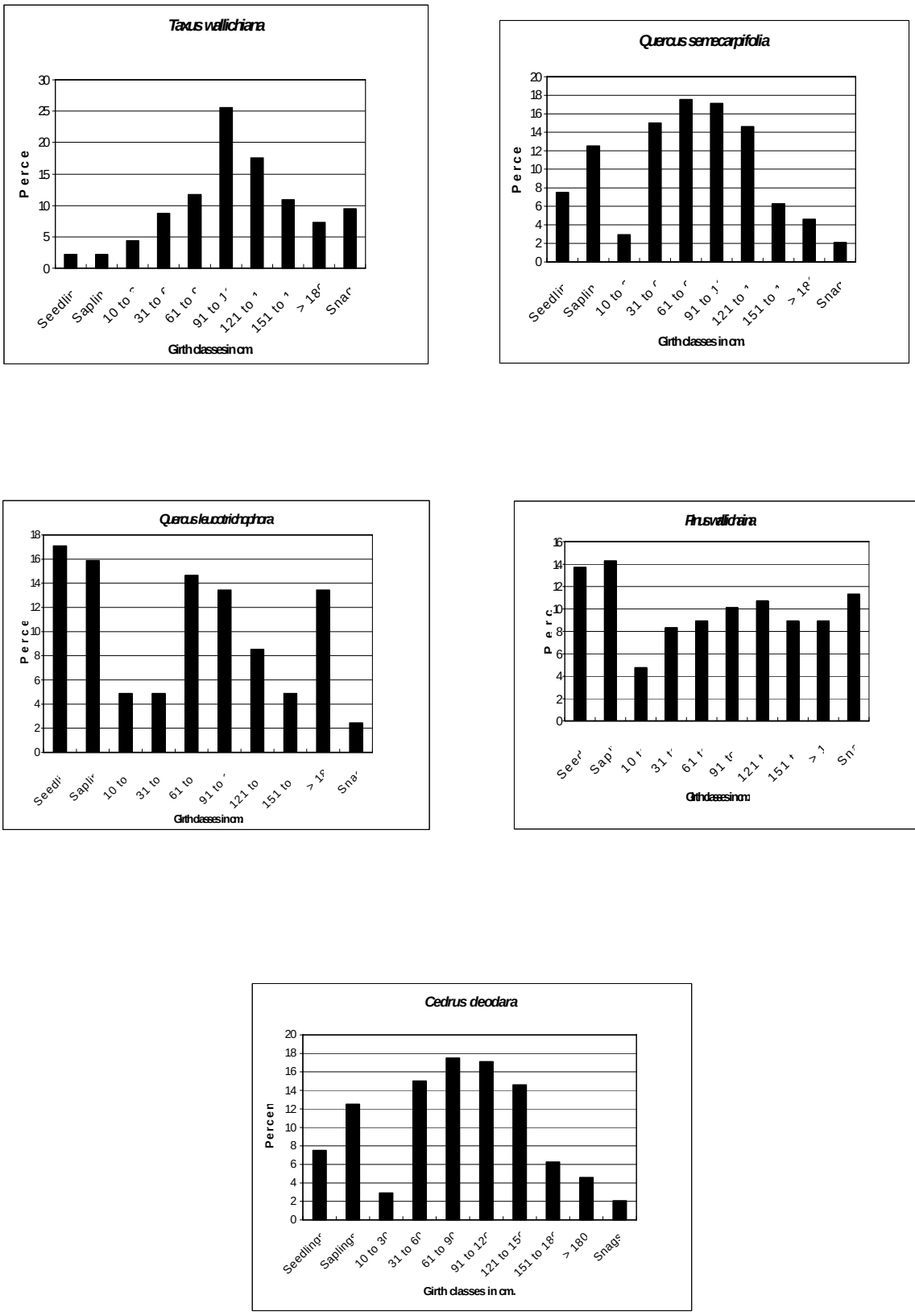


Fig.5.4.1. Population structure of important species

5.7. DISCUSSION

The result on the woody communities of Tirthan and Sainj valleys showed total of 45 communities out of that only three communities were similar in both valleys. The herbaceous communities of subalpine and alpine zones showed that *Athyrium* sp. and *Polygonum verticillatum* formed mono-specific communities in the subalpine zone but there were no such communities in the alpine zone. Since TWINSPAN takes only abundance values into account for community analysis, *Danthonia* and *Poa* seemed to dominate in the alpine zone. Some communities were common in all the camping sites forming communities of their own *e.g. Rumex nepalensis* and *Polygonum polystachyum*. The communities with strong single species dominance has been attributed to grazing, species competition, seed predation, disease, stability and niche diversification (Whittaker and Levis 1977, Harper 1977).

The tree density was higher in temperate zones of both Tirthan and Sainj valleys compared to the lower temperate zones. This may be attributed to the biotic disturbances as also reported in Kumaun Himalaya (Tiwari 1982, Upreti *et al.* 1985, Singh and Singh 1987). The shrub density however exhibited contrasting results showing higher density in lower temperate zone but was higher compared to similar zones of Kumaun Himalaya (Rawal 1991). Total basal area in the various zones showed a decreasing pattern with the increase in altitude. In the temperate regions the basal area of trees have been reported to be 1560-5930 cm^2 /100 m^2 (Whittaker and Woodwell 1969, Dabel and Day 1977). In the present investigation the values of total basal area in temperate zone were higher in comparison to other reports from Kumaun Himalaya (Saxena and Singh 1985, Tiwari 1982, Upreti *et al.* 1985 and Rawal 1991). However, in subalpine zone the basal area was considerably low (5504.34 cm^2 / 500 m^2 and 5887.80 cm^2 / 500 m^2) respectively for Tirthan and Sainj compared to subalpine communities of New Zealand (5100-8100 cm^2 / 100m^2). This may be due to sudden changes in the environmental conditions at this zone. Singh and Singh (1987) have summarised similar situations in response to a sudden decline in rainfall, severe cold and windy conditions, tree height, stratification, diversity and canopy density is reduced drastically due to these factors.

Shrub species form important habitat for wild animal in the Himalayan region. Certain species also indicate the level of disturbance in the area. In GHNP the dominant species recorded from the north facing slopes were *Sinarundinaria falcata*, *Berberis lycium*, *Desmodiu*m spp. and *Indigofera heterantha* and from south facing slopes *Sinarundinaria falcata, Thamnocalamus spathiflorus*, *Desmodium* spp., *Rosa webbiana*, *Lonicer*a spp. In general species of bamboo were found to dominate in all zones except alpine and were more common in oak forests. *Sinarundinaria falcata* has been considered as a common shrub of undisturbed ban-oak forest by Upreti *et al*. (1985). The species is not only important for wild animals but also for the local people who collect the leaves and culms for fuel, fodder and basket making thus putting tremendous pressure on the species and habitat. In the higher altitudes *Sinarundinaria falcata* is replaced by *Thamnocalamus spathiflorus*. The altitudinal variation in shrub showed that in the lower temperate zone the dominant species were *Sinarundinaria falcata*, *Berberis aristata*, *Desmodium elegans*, *Indigofera heterantha*, *Prinsepia utilis* and *Sorbaria tomentosa*. In temperate zones both the

species of bamboo along with *Berberis lycium*, *Desmodium multiflorum*, *Rhamnus purpureus*, and *Rubus niveus* were dominant. In upper temperate only *Thamnocalamus spathiflorus* along with *Berberis chitria*, *Juniperus communis*, *Rhododendron lepidotum* and *Salix* sp. and in subalpine zone *Thamnocalamus spathiflorus*, *Berberis chitria*, *Cotoneaster microphyllus*, *Juniperus indica*, *Rhododendron anthopogon* dominated. The composition of shrub layer of alpine was distinct and only few patches of *Juniperus pseudosabina*, *J. communis, Rhododendron anthopogon* and *R. lepidotum* were recorded.

The dominant herb species in the alpine meadows based on density were *Danthonia cachemyriana* (160.57 ± 15.17 m^2), a tussocks forming grass and *Poa alpina* (67.76 ± 82.57 m^2). Almost all camping sites were dominated by *Rumex nepalensis*, *Impatiens sulcata*, *Polygonum amplexicaule* and *Polygonum polystachyum*.

Sorensen's index was used for the comparison between various habitat types. The similarity coefficients were calculated on the basis of Importance Value Index of tree layer. The values of per cent similarity are given in Table (6.4.1). Similarities between tree layer of different zones of Tirthan and Sainj were very low. Highest similarity was exhibited by subalpine zone of these valleys (78.51) and among the zones temperate and upper temperate exhibited more similarity, this may be due to the fact that woody species of temperate and upper temperate showed a wider altitudinal range. Lower temperate showed less similarity per cent indicating that the zone differed almost completely from other zones. Changes in floristic composition were also abrupt as expected.

Canonical correspondence analysis provides an integrated description of species-environment relationships by assuming a response model that is common to all species and the existence of single set of underlying environmental gradient to which all the species respond. The same strong assumption is implicit in all ordination techniques. Thus canonical correspondence analysis has the advantage over other technique in that it focuses on the relations between species and measured environmental variable and so provides an automated interpretation of the ordination axes. It is difficult to generalise the pattern to indicate vegetation-environment relationship in the arctic and alpine regions (Billings 1974). Multivariate analysis (*e.g.* CANOCO) can be useful to some extent for determining relationship between distribution and assemblages of species and environmental variable (Kindscher and Wells 1995, Weckstrom *et al.* 1997, Mc Alister 1997). In the present investigation it is shown by CCA ordination diagram that the distribution of species in alpine meadows of GHNP is significantly correlated with altitude, steepness of slope, pH and habitat types. Using CCA, Fernandez-Palacios and de Neicolos (1995) observed that altitude is the major environmental determinant of the variation of Tenerife Macaronesian island located between 2000-3718 m. Altitudinal variation is considered to lead to variation in temperature (Mani 1974) related humidity and radiation (Fernandez-Palacios and de Neicolos 1995) thus influencing plant communities. The species that are more influenced by altitude *e.g. Salvia hians* (Sal han), *Artemisia nilagirica* (Art vul) and *Aconitum chasmanthum* (Aco cha). *Saussurea roylei* (Sau roy), *Bergenia stracheyi* (Ber sta), *Stipa orientalis* (Sti ori), *Potentilla nepalensis* (Pot nep) were more influenced by pH. Degree of slope had a little effect on *Danthonia cachemyriana* (Dan cac). *Phleum alpinum* (Phl alp) was found

in the lower slopes classes whereas *Nardostachys jatamansi* at the higher slope classes. *Astible rivularis* (Ast riv), *Ranunculus trichophyllus* (Ran tri), *Potentilla pendicularis* (Pot pen), *Dactylorhiza hatagirea* (Dac hat) were found more in the bouldery areas and *Jurinea macrocephala* (Jur dol), *Chaerophyllum villosum* (Cha vil) on plain areas. The results were similar as recorded by Kala (1998) in Western Himalaya.

Measurement of tree diameter is often used to describe population structure where it is difficult to measure the age of the tree. There are four categories of population structure *i.e.,* i) expanding or stable type with many seedlings and smaller number of tree size classes, ii) declining type with nodal values in small classes and individuals of many size classes, iii) interrupted indicating gap phase of regeneration and iv) youthful with seedling and sapling only (Singh and Singh 1992). This interpretation, assumes the size corresponding with the age of individual while it is not always true (Knowles and Grant 1983). In the present study population structure of important species was used to investigate the state of regeneration. Only important trees were considered for population structure *e.g. Taxus wallichiana*, *Cedrus deodara* and *Quercus semecarpifolia* that showed a stable population growth and *Quercus leucotrichophora* and *Pinus wallichaina* showed expanding type of population structure. This may be because *Taxus wallichiana*, *Cedrus deodara* and *Quercus semecarpifolia* have more biotic pressure and species especially *Taxus wallichiana* does not seem to regenerate easily.

6.0 IMPACT OF ANTHROPOGENIC PRESSURES ON VEGETATION

6.1. INTRODUCTION

The Himalayan region is inhabited by a large number of ethnic communities, many of them with distinct tradition, culture and life style. Most of the local communities at higher altitudes (>2000 m) are subsistence farmers or agropastoralists with a long history of settlement and landuse practices ranging from few to several centuries (Atkinson 1882, Tucker 1986). The hostile climatic conditions and steeper mountains have restricted human settlements to the flatter valley bottoms. As a result, quite a few interior pockets of Himalaya are relatively less influenced by man and support rich natural vegetation. The natural vegetation, usually above 2000 m in the western and north-western Himalaya abounds in numerous economically important species. At lower altitudes the forests meet the fuelwood, fodder and timber demand of the local people while steeper and frequently burnt grassy slopes are left for the fodder grasses. Other temperate grassy slopes and alpine meadows are used as summer grazing grounds by local people as well as several migratory pastoral communities (Phillimore 1981, 1984, 1989, Tucker 1986, Rawat and Uniyal 1993). The alpine and subalpine regions are also well known for the large number of rare and valuable medicinal herbs, which are consumed locally or sold in the local markets. Demand for several medicinal plants in national and international markets has increased rapidly in the recent decades (De Coursey 1997, Tandon 1997, Sharma 1998). This has resulted in the selective removal of highly valuable species from many sectors of the Himalaya. Thus, traditional practices of livestock grazing, harvest of commercially important species and demand for fuelwood and fodder are the major anthropogenic activities throughout the north western Himalaya. This chapter deals with a few anthropogenic pressures operating in and around GHNP, and their impact on the structure and composition of vegetation and wildlife habitat. The pressures include livestock grazing, extraction of medicinal plants and mushroom collection. The impact assessments are based on the comparison of heavily used and relatively protected sites within the Park as well as based on the data collected along various pressure gradients.

6.2 METHODOLOGY

Long term monitoring of vegetation parameters and experimental studies are ideal ways to find out the impacts of anthropogenic pressures and changes in the vegetation structure (Goldsmith 1991, Westmann 1985). For the present work, a separate vegetation monitoring programme has been initiated in GHNP by collecting baseline data from different pressure zones (Singh and Rawat 1998). Part of the data collected for the vegetation studies (Chapter 5) and baseline data for future monitoring have been pooled for comparable sites of known pressure and analysed in this chapter. A total of six alpine pasture and seven temperate pastures were sampled to assess impact of various activities. The study area was divided into following resource zones and sampling was done using plots of appropriate size.

i) **Village pastures**: Usually gentle (< 15°), south facing slopes below 2200 m are used by the local villagers for animal grazing throughout the year. Species composition, tree and shrub density and vegetation cover at shrub and ground layers have been compared for the areas close to the village (<5 km) and far away (>5 km) from the village. A total of four village pastures and secondary scrubs were selected for the study. A comparison of species density and diversity of tree, shrub and herb layer alongwith the human use gradient from edge of the village to distant area in the Park has been made to assess the impact of lopping, fuelwood and fodder collection. For this three anthropogenic pressure gradients *viz*. ecodevelopment, buffer and core zones, have been developed to show the trends in vegetation structure.

ii) **Alpine and subalpine pastures**: The remote sensing data of GHNP reveals that nearly 18.5% area of this Park is under alpine and subalpine pastures. Of this nearly 5.1% area is occupied by the camping sites (Naithani 1998). The migratory graziers follow a fixed, traditional route for the summer grazing grounds (subalpine and alpine meadows). Large and better quality forage meadows are located in the upper parts of Tirthan and Sainj valleys. Therefore, graziers stay at the higher altitudes of these two valleys. A total of six alpine meadows (Dhela (3650 m), Gumtrao (3500 m), Nada (3300 m), Patal (3500 m), Sakheti (4200 m) and Tirth (3800 m) were selected to assess the impact. Pressure by livestock grazing in terms of livestock units, duration of stay in the meadows, per cent cover of grasses, forbs and weeds have been compared for these sites. In all a total of 525 plots were established to study the impact of grazing.

iii) **Areas of medicinal plant extraction**: Dhela *Thach* (3500-4500 m) and Tirth (3300-4700 m) are extensively used by the local people for the extraction of medicinal herbs. These sites were compared with moderately used sites located on comparable altitudes and aspects such as Koberi (3600-4600 m) and Sakheti (3800-4700 m). Per cent ground cover and exposed soil in heavily exploited areas give an assessment of impact on the ground. Possibility of local extinction of valuable species and decline in the population of other species were explained by interviewing the traditional herb collectors.

iv) **Mushroom collection areas**: 50 plots of 20 m x 20 m were selected randomly and searched in the Tirthan valley to find out the abundance of morel mushroom (*Morchella esculenta*). Virtually all the areas between 1500 to 3800 m elevation were traversed by the local people for the collection of mushroom during March-April hence it was not possible to separate the plots according to pressure levels. Possible impact of this practice on the vegetation and wildlife are discussed based on the survey of these areas.

v) **Camping sites**: Impact of fuelwood and bamboo collection at higher altitudes were assessed by sampling the vegetation within the plots close to regular camping sites and away from camping sites or areas rarely visited by graziers and herb collectors.

6.3 VEGETATION STRUCTURE AND COMPOSITION ALONG THE GRADIENT OF PRESSURE BY THE VILLAGERS

The villagers remove the resource from the pastures (forest) throughout the year. They remove fuelwood, fodder, medicinal plants and graze their animals frequently in the forest near the villages. The village forests within five kilometres distance were (Rolla and Sangard) and forests more then five kilometres away from the villages were (Chalocha and Khadu). The density of different vegetational layer was significantly higher (p=0.0001) in the forests situated away from the villages. The forests away from the villages showed higher number of seedlings and saplings compared to the forest situated near the villages that indicates better regeneration of forest (Table 7.3.1). The over all density of trees, shrubs and herbs were higher in the forests away from villages compared to the forests close to villages due to collection of these species for fuelwood, fodder and also by resident grazing livestock. The canopy cover, diversity and richness was also higher in forests away from the villages compared to the forests near the village.

Table 6.3.1a Comparison of vegetation parameters at different sites (of varying human pressure in GHNP)

Parameters	< 5 kms from village, N=25		> 5 kms from village, N=25	
	Rolla 2100 m	Sangard 2000 m	Chalocha 2400 m	Khadu 2400 m
No. of households	107	165	82	65
Tree density ha^{-1} ± SD	118.8±5.5	112.5±5.4	131.4±8.5	121.6±5.5
Shrub density ha^{-1} ± SD	2552±470	1780±420	4255±618	3280±615
Herb density m^{-1} ± SD	45.6±5.8	29.7±6.3	58.4±12.5	45.6±18.6
Seedling density /100 m^2	6.1±2.5	5.6±3.5	21.4±5.8	11.8±6.5
Sapling density /100 m^2	3.6±2.1	2.9±2.2	10.3±4.5	9.5±3.5
% Canopy cover (Trees)	21.7±8.5	18.5±10.8	38.6±12.5	32.8±9.5
% Shrub cover	27.4±8.5	16.9±6.4	40.7±12.5	32.7±5.8
% Herb and grass cover	42.9±10.5	38.5±14.4	52.5±18.5	45.6±15.5
% Weedy species	15.8± 6.5	18.8±8..4	12.4±4.4	9.8±3.4
Diversity (H')	1.85	1.18	1.58	1.34
Richness (R)	127	92	158	135

± SD =Standard deviation (R) =Number of species, Weed cover = Disturbance indicating species

Wilcoxon's singed ranked test Test (Paired varied) N=10

	Rolla	Sangard	Chalocha	Khadu
Rolla	**	Z=-2.803	Z=-2.001	Z=-2.0547
		P=0.005	P=0.001	P=0.011
Sangard		**	Z=-2.803	Z=-2.803
			P=0.005	P=0.005
Chalocha			**	Z=-2.803
				P=0.005
Khadu				**

Friedman's test for k-paired samples (n=10), X^2 =26.363, P=0.0001, df =3. In both tests, there is significant difference at P<0.05

Table 6.3.1b. Relative density of important trees and shrubs along the increasing disturbance gradient

Parameters	**< 5 kms from village, N=25**		**> 5 kms from village, N=25**	
	Rolla 2100 m	**Sangard 2000 m**	**Chalocha 2400 m**	**Khadu 2400 m**
Abies pindrow	6.04	5.54	18.54	10.5
Aesculus pseudosabina	8.21	6.44	5.31	4.4
Cedrus deodara	6.62	25.84	12.5	16.5
Lyonia ovalifolia	9.21	8.52	-	-
Picea smithiana	8.04	5.24	4.5	11.5
Pinus wallichiana	12.50	12.54	16.4	15.5
Pyrus pashia	6.62	6.56	-	-
Quercus floribunda	7.08	4.85	1.2	2.8
Shrubs species				
Berberis lycium	4.20	11.51	2.44	6.54
Daphne papyracea	4.88	41.55	3.24	11.52
Desmodium elegans	3.66	4.64	5.54	8.25
Indigofera heterantha	2.44	8.15	6.54	6.51
Rosa webbiana	1.55	3.25	2.30	1.54
Sarcococca saligna	2.86	15.8	3.61	4.61
Sinarundinaria falcata	33.92	12.64	34.50	21.5

6.3.1. Impact of livestock grazing on alpine and subalpine pastures

The area of different meadows varies from 1.5 km^2 to 6 km^2. The maximum number of livestock graze in Tirth (2800 units) and minimum in Patal (1100 units). The duration of stay varies from 12 to 28 days (Table 7.3.2a). The maximum plant density was (115.5±30.4 m^{-2}) in Tirth and minimum in Sakheti (62.5±15.8 m^{-2}). The species diversity was higher in Dhela (2.81) followed by Tirth (2.45). The average height of herbs at Nada was higher due to dominance of *Polygonum polystachyum* and *Polygonum amplexicaule* the tall forbs there (Table 6.3.2b.). The comparison of the ground cover in various subalpine and alpine pastures showed the high percentage of live shoot in Tirth and dead shoot (4.00) for Dhela. Live shoot cover and height was significantly higher (P=0.001) in grazing areas, while the dung, rock and soil was significantly lower (P=0.05). The opportunistic herbs recorded were *Polygonum amplexicaule*, *Polygonum polystachyum*, *Impatiens sulcata* and *Urtica dioca* at the camping sites. *Cirsium falconeri*, a weedy species was common in Gumtarao, Nada and Patal. *Morina longifolia* and *Athyrium schimperi* were common in some pockets of frequent livestock grazing.

Table 6.3.2a. Impact of grazing in various subalpine and alpine pastures

lame Alti. m	Ap. Km^2	As	Lvs. Unit	DS1 Days	Density m^2±SD	Diversity	Mean Ht. m	Mean percent cover LS	DS	Wd	RS
)hela (3650)	5.00	E	2500	35	105.2±21.0	2.81	0.81	78.00	4.00	1.56	16.44
;umtrao (3500)	1.50	E	1200	18	90.4±31.2	1.94	0.75	79.50	3.50	3.20	13.80
lada (3300)	1.50	SE	1400	14	89.5±21.5	1.71	1.05	80.25	2.51	0.80	16.44
atal (3500)	1.60	SE	1100	16	72.4±18.4	1.88	0.52	79.50	2.50	2.13	15.87
akheti (4200)	1.50	W	1200	12	62.5±15.8	1.67	0.34	54.50	1.15	0.42	33.93
'irth (3800)	6.00	SW	2800	38	115.5±30.4	2.45	0.78	82.50	1.25	1.12	15.13

Ap= Approx. area, Alti.= Altitude, AS= Aspect, Lvs= Livestock, DS1. = Duration of stay, Ht= Height, LS= Live shoots, DS= Dead shoots, Wd= Weed, RS= Rock and soil cover

The most dominant species in these pastures were *Phleum alpinum*, *Rumex nepalensis* and *Polygonum viviparum*. *Rumex nepalensis* was most common plant in almost all the pastures (Table 7.3.2b.). The other opportunistic herb species were *Polygonum amplexicaule, Polygonum polystachyum*, *Impatiens sulcata* and *Urtica dioca* that were mainly restricted to the camping sites. *Cirsium* species was common in Gumatrao, Nada and Patal where as on other areas it was almost absent. *Morina longifolia* and *Athyrium schimperi* were common in some pockets. *Jurinea macrocephala* was common species but with a low number of mature plants. Even different plant genera responded differently to the ecological impacts occurring in the study sites as a result of varying level of livestock impacts. *Anemone tetrasepala*, *Geum elatum, Geranium wallichianum, Potentilla atrosanguinea*, appeared to be largely intolerant to

grazing where as *Delphinium cachymeriana*, *Jurinea macrocepala, Pedicularis* spp., *Phlomis bracteosa, Tanacetum longifolium* moderately intolerant and *Impatiens sulcata, Plantago erosa, Rumex nepalensis, Polygonum polystachyum* and *Athyrium foliolosum* had high density near camping sites (tolerant to grazing).

Table 6.3.2b. Density (plant m^{-2}) of dominant species in various alpine pastures (n=525)

SPECIES	% Cv	Dhela	Gumtarao	Nada	Patal	Sakheti	Tirth
Anaphalis triplinervis	12.5	3.80±0.25	3.19±0.39	5.66±1.22	4.00±1.94	0.55±0.00	1.05±0.51
Anemone rupicola	8.2	5.04±1.12	3.37±0.44	1.54±0.28	2.67±0.19	1.25±0.29	2.12±0.48
Cirsium sp.	2.5	-	1.05±0.05	0.12±0.00	1.24±0.42	-	-
*Danthonia cachymeriana**	38.8	1.20±0.51	0.25±0.00	-	0.25±0.05	1.51±0.51	1.25±0.85
Delphinium cashmerianum	5.6	0.37±0.00	1.79±0.22	0.65±0.11	2.67±1.24	2.38±1.25	2.65±1.25
Gentiana sp.	0.8	1.51±0.15	3.18±0.80	0.67±0.02	1.30±0.41	1.25±0.25	2.37±0.97
Geranium wallichianum	2.5	0.86±0.03	0.79±0.25	4.32±1.28	0.80±0.00	0.35±0.01	1.24±0.54
Geum elatum	5.5	2.25±1.02	2.59±0.95	2.56±1.22	1.67±1.10	0.53±0.08	1.25±0.68
Hackelia uncinata	4.5	0.28±0.00	0.39±0.00	0.60±0.03	0.33±0.00	-	0.10±0.00
Impatiens sulcata	22.5	3.35±2.25	2.78±1.22	1.46±0.72	1.33±0.75	0.65±0.07	2.25±1.24
Jurinea macrocephala	8.9	1.05±0.30	1.38±1.00	-	0.67±0.02	2.24±0.52	1.86±1.20
Kobresia nepalensis	16.4	0.25±0.00	0.46±0.20	-		1.74±0.94	2.24±1.24
Morina longifolia	2.2	0.05±0.00	0.09±0.01	0.08±0.04	0.33±0.01	-	0.24±0.00
Nepeta connata	4.5	0.88±0.01	3.19±0.14	0.08±0.00	0.07±0.00	3.24±2.28	3.55±2.54
Pedicularis bicornuta	2.1	0.65±0.00	0.39±0.00	1.43±0.64	0.30±0.00	0.45±0.00	0.22±0.00
Pedicularis oederi	0.1	1.26±0.20	2.79±1.21	0.37±0.00	0.33±0.11	0.21±0.00	0.14±0.00
Phleum alpinum	18.6	2.10±0.85	1.22±0.54	-	-	14.25±6.4	16.25±8.2
Phlomis bracteosa	12.3	2.26±0.80	3.37±1.35	2.65±1.35	3.67±2.14	1.25±1.11	2.25±1.01
Polygonum amplexicaule	35.1	3.45±2.30	3.18±2.52	5.31±2.65	3.45±1.82	2.24±1.15	4.02±2.12
Polygonum polystachyum	24.5	4.35±1.80	3.59±2.35	4.36±2.81	3.67±1.25	1.11±0.12	2.55±1.55
Polygonum viviparum	7.5	1.25±0.85	1.59±0.25	1.26±0.45	2.37±1.21	4.25±2.40	4.50±2.00
Potentilla atrosanguinea	16.4	2.36±0.55	4.38±1.50	3.38±1.24	4.33±1.25	2.35±1.33	3.33±1.82
Potentilla fruticosa	6.5	1.28±0.61	0.58±0.00	0.26±0.00	1.08±0.25	1.85±1.01	0.94±0.31
Ranunculus hirtellus	3.2	0.58±0.01	0.79±0.02	1.26±0.58	0.30±0.00	5.45±3.25	2.45±1.12
Rumex nepalensis	41.1	6.54±4.20	5.79±3.65	7.26±2.81	4.30±1.21	2.21±1.04	4.51±1.5
Selinum vaginatum	5.3	3.15±2.00	1.20±0.50	3.56±1.76	2.30±1.08	1.82±1.20	3.25±1.45
Tanacetum longifolium	2.2	0.82±0.00	0.98±0.21	-	1.40±0.65	1.25±0.80	2.85±0.70
Urtica parviflora	3.6	1.02±0.65	2.39±1.52	2.11±1.15	2.17±0.96	0.02±0.00	0.81±0.04
Athyrium schimperi	6.4	3.68±2.56	1.59±1.22	2.88±1.53	1.66±0.74	-	0.01±0.00

* in tussocks, % Cv = Over all per cent cover

6.3.2. Impact of herb collection on alpine vegetation

In the Tables (6.3.3a and 6.3.3b.) the two areas of extensive and moderate collection have been compared as there was no area of low or no collection. The density and frequency of plants in these areas are compared to see the impact. Some species *viz*., *Aconitum violaceum*, *Saussurea obvallata*, *Rhododendron anthopogon* and *R. lepidotum* were found to have higher density in higher altitudes moderate area of collection (Sakheti). In some cases viz., *Allium humile*, *Dactylorhiza hatagirea*, *Meconopsis aculeata*, *Podophyllum hexandrum*, *Selinum tenuifolium* and *S. vaginatum* the species had higher density in extensive harvested areas not because of the collection but due to the altitude that seemed to be favourable for their growth. The temperate species also showed higher density and frequency in moderate collection areas. In Rolla (extensive collection area) few species *viz. Angelica glauca*, *Berberis lycium*, and *Thymus linearis* were not observed.

Herb collection is one of the most important source of income for the people living in the fringe areas of GHNP. Nearly 85% families from the ecodevelopment area are dependent on this and nearly 65 to 75 per cent of total annual income is generated by collecting and selling wild medicinal plants and mushrooms from the Park (Table 6.3.3c). Data on the density and frequency of various medicinal plants within the Park show that all the species have higher density in moderate collection. The density of most preferred species such as *Aconitum heterophyllum*, *Aconitum violaceum*, *Dactylorhiza hatagirea*, *Jurinea macrocephala* and *Picrorhiza kurrooa* were more in areas of moderate collection (mostly in inaccessible areas). *Jurinea macrocephala* was most preferred herb followed by *Aconitum violaceum* and *Dactylorhiza hatagirea* from alpine areas. In the temperate zone (< 3000 m) *Valeriana jatamansii*, *Valeriana hardwickii* and *Dioscorea deltoidea* were most preferred species for collection.

Table 6.3.3a. Density (plant m^{-2}) and frequency (%) at two sites of extensive and moderate collection in the alpine pastures

Species	Extensive collection n=125				Moderate collection n= 125			
	Dhela		Tirth		Koberi		Sakheti	
	D	F	D	F	D	F	D	F
Aconitum chasmanthum	-	-	0.35±.1.1	12	0.55±0.2	5	-	-
Aconitum heterophyllum	0.05±0.0	8	0.56±0.4	22	0.05±0.0	2	0.12±0.1	8
Aconitum violaceum	0.15±0.1	6	1.55±1.2	15	4.12±2.5	18	15.4±4.5	52
Allium humile	5.15±3.5	11	0.51±0.5	7	0.05±0.0	2	-	-
Arnebia benthamii	-	-	0.12±0.1	9	-	-	0.11±0.0	2
Bergenia stracheyi	1.51±0.8	22	1.31±1.1	12	1.81±1.1	16	0.82±0.7	6
Dactylorhiza hatagirea	0.91±0.5	25	1.21±0.4	32	0.51±0.2	6	0.57±0.3	3
Fritillaria roylei	6.15±2.5	35	7.25±2.8	40	2.5±1.1	14	3.25±2.4	15
Jurinea macrocephala	1.31±0.8	38	1.67±0.7	51	1.81±0.5	59	1.82±0.6	56
Meconopsis aculeata	1.13±1.1	40	0.90±0.2	28	0.51±0.3	25	0.42±0.2	15
Nardostachys grandiflora	0.16±0.1	6	0.13±0.1	7	0.92±0.2	12	-	-
Picrorhiza kurrooa	2.51±1.5	8	3.25±1.2	17	4.22±2.5	23	2.35±1.5	16
Podophyllum hexandrum	0.22±0.1	6	0.55±0.2	13	0.35±0.4	8	-	-
Polygonatum verticillatum	2.56±2.3	12	-	-	-	-	-	-
Rheum australe	-	-	0.01±0.0	2	0.23±0.0	9	0.02±0.0	3
Rhododendron anthopogon	-	-	14.35±5.6	23	18.2±6.5	26	22.5±4.6	25
Rhododendron lepidotum	0.15±0.2	3	1.21±0.4	12	16.5±6.5	20	32.1±9.2	22
Saussurea gossypiphora	0.21±0.0	5	1.25±0.2	20	3.11±1.1	32	2.99±2.1	19
Saussurea obvallata	-	-	-	-	0.32±0.2	14	0.52±0.3	26
Selinum wallichainaum	6.15±4.1	42	7.2±3.9	24	3.2±2.1	21	2.85±1.1	18
Selinum vaginatum	7.11±2.1	52	5.21±2.1	25	2.5±0.2	18	3.22±1.1	13

D=Density / m^2, F=Frequency

Table 6.3.3b. Density (plants / m^{-2}) and frequency (%) in extensive and moderate collection sites at lower altitudes <3000 m of GHNP

Species	Extensive collection n=55				Moderate collection n=55			
	Rolla		Basu		Khollepoe		Homkhani	
	D	F	D	F	D	F	D	F
Ainsliea aptera	1.4±0.8	20	2.4±1.2	24	2.5±1.1	26	2.2±1.2	25
Angelica glauca	-	-	0.5±0.1	8	0.8±0.1	15	0.9±0.5	28
Berberis aristata	3.9±1.2	15	1.1±0.4	5	-	-	-	-
Berberis lycium	-	-	0.1±0.0	4	1.2±0.5	15	2.5±2.1	17
Dioscorea deltoidea	1.6±1.1	14	2.1±1.2	16	1.9±1.3	13	3.2±1.2	26
**Diplazium maximum*	3.2±1.2	21	0.5±0.1	9	1.1±0.8	8	3.2±1.1	21
Hedychium spicatum	2.4±2.1	20	1.1±0.7	14	2.1±1.4	11	2.1±0.9	16
Hypericum patulum	0.2±0.0	4	0.1±0.0	3	-	-	-	-
Thalictrum foliolosum	1.2±0.8	8	3.2±1.1	19	3.5±2.0	20	3.4±1.0	12
Thymus linearis	-	-	1.5±0.8	3	1.1±0.5	8	2.5±1.1	5
Valeriana jatamansi	2.8±1.6	25	3.4±1.4	29	3.1±0.7	24	4.1±2.2	20
Viola spp.	15.9±2.5	45	12.5±6.5	38	15.8±4.5	42	14.4±2.9	25

*collected for vegetable, D=Density / m^2, F=Frequency

6.3.3a. Impact of fuel and fodder collection on the temperate forests

The species diversity and other parameters were found to be significantly higher (p=0.002) in buffer zone (Table 6.3.5a.). The number of lopped trees were higher in ecodevelopment area indicating greater pressure on the area. Most of the trees and shrubs were found to be used for fuelwood in ecodevelpoment zone. The number of snags and logs were less in ecodevelpomet area may be because they are collected for fuelwood by the villagers. Fodder is collected from both buffer and core zones during winter months. Mainly the green leaves of oaks *e.g. Quercus semecarpifolia*, *Quercus floribunda* and *Quercus leucotrichophora* are collected from these zones. Some of the shrub genera *viz. Indigofera*, *Desmodium, Sinarundinaria* and *Thamnoclamus* are used as alternatives of fodder grasses.

Table 6.3.5a. A Comparision of various parameters in different pressure zones of GHNP

Parameters	Ecodevelopment area	Buffer zone	Core zone
Tree density ha^{-1}	72.5±10.4	98.4±12.5	125.2±12.5
Shrub density ha^{-1}	2365.5±415.8	3251. 0±508.7	2851.8±512.6
Species diversity	1.16	1.53	1.42
Canopy cover %	18	35	41
Shrub cover %	26	32	38
Ground cover %	26	39	48
No. of lopped trees ha^{-1}	42.5	25.4	8
No. of snags ha^{-1}	3.25	5.4	8.8
No. of fallen logs ha^{-1}	4.65	6.50	10.5

6.3.3b. Impact of fuelwood and bamboo collection at higher altitudes

The woody species such as *Rhododendron campanulatum*, *Rhododendron lepidotum*, *R. anthopogon*, *Betula utilis*, *Juniperus communis* and *J. pseudosabina* were used as fuelwood in the alpine areas. Shepherds and herb collectors often carry logs / twigs of *Quercus semecarpifolia*, *Thamanocalamus spathiflorus* and *Abies spectabilis* to alpine zone (3600 m) for fuelwood. Fuelwood collection is much higher near treeline zone compared to temperate forests. People visiting these pastures *i.e.* graziers, medicinal plant collectors, patrolling staff and pilgrims are also responsible for the destruction of these species. The density, frequency and abundance of these species compared for camping and far from camping site show that there is more pressure near the camping sites (Table 7.3.5b). Few species such as *Juniperus communis*, *Juniperus pseudosabina* and *Betula utilis* were totally absent from camping site. These species are highly used / consumed as fuelwood.

Table 6.3.5b A comparison of woody species near and away from camping sites near treeline in GHNP

Species	Near camping site (CS)			Away form (CS)		
	Density ha^{-1} ± SD	Freq	Abund	Density ha^{-1} ± SD	Freq	Abund
Abies pindrow	5.6 ± 2.4	28	2.5	12.9 ± 3.2	32	3.5
Abies spectabilis	8.5±3.3	15	1.9	15.8±5.5	29	2.1
Betula utilis	-	-	-	7.6±2.2		
Juniperus communis	-	-	-	112.4±25.5	15	125.5
Juniperus pseudosabina	-	-	-	68.5±15.8	12	25.5
Quercus semecarpifolia	22.8±5.6	28	3.8	32.7±	38	4.1
Rhododendron anthopogon	25.6±8.6	9	12.5	195.9±45.5	35	20.4
Rhododendron campanulatum	21.3±6.4	16	11.2	26.8±6.5	21	16.2
Rhododendron lepidotum	15.6	3	8.8	45.6±10.6	22	16.5

The various groups using the fuelwood in the higher altitudes are graziers, herb collectors, people going for religious ceremonies, tourists and patrolling staff. The daily consumption of fuelwood by various groups show that graziers and herb collectors burn more fuelwood compared other groups and their groups size, duration of stay is also larger thus maximum pressure comes from them. The per camp consumption, average number of days spent and total consumption of fuelwood is Table 6.3.5c. The total consumption of fuelwood is estimated to be 342.90 tonnes per year from this area.

Table 6.3.5c. Fuelwood consumption by various groups in alpine pastures

Groups	N	S	C	C1
1. Graziers	23	120	40±5	1,10,400
2. Herb Collectors	450	12	40±4	2,16,000
3. Religious ceremonies	25	6	30±3	4,500
4. Tourist	50	6	20±5	6,000
5. Staff	30	8	25±3	6,000
Total				3,42,900

N = Number of groups visiting, S = Mean number of days in alpine pasture, C= Consumption./Day/ Group in Kg., C1= Consumption/Year in Kg.

6.3.6. Comparison of bamboo near and away from the camping sites

Bamboo, the most preferred species for fuel and fodder, also used for making baskets (Kilta) and walking sticks. Two species of bamboo found in GHNP are *Sinarundinaria falcata* and *Thamnocalamus spathiflorus*, both forms important habitat for many wild animals. The green leaves and twigs were found to feed the cattle, sheep and goats during the winter months. The migratory graziers carry the dried culms to alpine pastures for the fuelwood and torch wood. The leaves are relished by goral, and rhesus macaque. Black bear and common langur eat young shoots. Total number of clumps, culms with cut and uncut were recorded in various pastures, near and far from camping sites to assess the impact on these species (Table 6.3.6).

Table 6.3.6a Comparison in number of clumps, culms of bamboo near and away (1 km.) from camping site

Pastures	Near camping site (100 m) (CS) # individuals ha^{-1} (n=50)				100 m away form (CS) # individuals ha^{-1} (n=50)			
	Clumps	Culms	Cut	Dead	Clumps	Culms	Cut	Dead
Chaloacha	25	350	180	120	40	800	130	100
Dhela	-	-		-	5	25	12	13
Gumatrao	-	-		-	11	120	22	20
Homkhani	42	950	225	375	60	1409	150	360
Khollepoe	15	58	18	17	45	224	22	60
Nada	12	53	20	16	35	640	65	55
Pardi	8	75	12	8	29	510	70	60
Shilt	15	620	140	100	40	1240	230	330

Sample size 5.65 m radius, N=25

6.4. DISCUSSION

It is believed that most of the temperate forests in the world were cleared before people noticed or cared (Wilcove *et al*. 1986). In the Himalayan temperate zone, the rapid population growth in the recent decades and various activities by man have caused several environmental problems (Ives and Messerli 1989). Despite its the remoteness and status as a protected area GHNP is not free from human interference's. The study area has 141 villages, 1362 families and a population of 9694 with literacy rate of 17.6% (Negi, 1996). Most of these villages are located close to the western boundary of the Park. The H.P. Forest Department has designated these villages as ecodevelopment area and various schemes have been proposed to reduce the people's pressure that are in the form fuelwood, fodder, mushroom,

herb collection and livestock grazing. Precise data on the rate of deterioration of vegetation is, however, lacking but can be easily visualised with the increase human and cattle pressures in the area.

In some ecosystems grazing is thought to have very little influence in plant composition and maintaining species diversity effect (Noy-Meir 1993). At the same time other studies have revealed that grazing is essential to maintain species diversity (Naithani *et al.* 1992, Negi *et al.*,1993, Saberwal 1996) mainly in Himalayan region. Some studies (Tansley and Adamson 1925, Harper 1969, Dirzo 1984, Joss *et al.* 1986, Ram *et al*. 1989, Sundriyal and Joshi 1990, Singh 1991, Hik *et al.* 1992, Rawat and Uniyal 1993 Negi *et al.* 1993, and Kala 1998) have shown that intermediate level of grazing maintains species diversity. Based on the intermediate disturbance hypothesis few author (Kumar and Joshi 1992, Rawat and Rodgers 1985) have argued that the moderate level of grazing may enhance the diversity in the alpine meadows. Besides livestock grazing abiotic factors like soil, snowfall, altitude, aspect also influence the structure and composition of these pastures (Kala *et al*. 1995).

Although, the Wildlife (Protection) Act 1972 (Anonymous 1972) prohibits human settlements, cattle camps and grazing inside the National Parks, but in practice this is not the case in many of the PAs in India. Similar is the case with GHNP, where several high altitude pastures, throughout the region are used extensively by the migratory graziers during summer months. About 20,000 sheep and goats are known to graze in the Park (Mehra and Mathur 1998). These alpine pastures have been modified by human interference through livestock grazing. In the present investigation six subalpine and alpine pastures with well known livestock grazing history of more than hundred and twenty years (Anderson 1886) were compared. The climates and geological history of all these pastures were similar. The result show that grazing area (pastures) were scattered in almost all altitudes, aspect and slopes. The pastures with larger area were found to have higher density and diversity of herbaceous species, this may be due to proportionately less grazing pressure in these pasture and topographic variation. At higher altitude (4200 m) the density of herbs was low and per cent of rock and soil cover was high thus reducing the forage volume as well as duration of stay in these pastures. Camping sites were found to be dominated with opportunistic herbs such as *Rumex nepalensis*, *Polygonum amplexicaule*, *P. polystachyum*, *Impatiens sulcata* and *Urtica dioca*. The vegetal cover of camping site is destroyed during the stay of large animal herds and the site undergoes secondary succession in the successive year (Rikhari *et al*. 1992). In short intensive grazing adversely affects regeneration. It also impairs the capacity of plant growth and also makes topsoil naked which in turn is subjected to erosion. Uncontrolled and unregulated grazing also result in the loss of productivity, biotic pressure on natural habitat, site quality *etc.* It finally leads to the ecological degradation.

There is an ecological balance in nature. This is easily disturbed by human interventions that have effect on the structure and dynamics of the plant species. All the type of resource exploitation will have an impact on the system that may not be immediately visible. In general the overall ecological impact of forest utilisation depends on the floristic composition of the forest, nature and intensity of harvesting and the particular species or type of the resource under exploitation.

Chowdhery and Wadhwa 1984 have recorded a total of 3200 species of flowering plants from Himachal Pradesh, of which 175 species are used in Indian pharmaceutical industry (Singh 1985). In the present study area, invasion of market forces and lack of opportunities for employment, better education and unplanned rural development schemes have forced the local people towards over exploitation of the surrounding natural resources leading to severe environmental problems as else where in Himalayan region. The investigation shows that the area had undergone a rapid socio-economic change during recent decades, as a result subsistence economy based on agropastoralism has been taken over by market economy based on the forest products. The impact of improper and over exploitation of medicinal herbs from the area can lead to local extinction of some of the important species. The various conservation issues are dealt in Chapter 8.

Morel mushroom (*Morchella esculenta* and its allies) locally known as *Gucchii* is found between 1000 to 4000 m in the states of Jammu and Kashmir, hills of Uttar Pradesh and Himachal Pradesh. GHNP is an important habitat of this mushroom and people have been collecting this species ignoring its impacts. The dangerous spin off from mushroom collection is the destruction of understorey which is an ideal home of many ground dwelling wildlife. Habitat destruction of most of the mammals like *goral*, *tahr*, and pheasants such as *monal, kokklas, khalij, cheer* and *western tragopan* whose breeding season coincides with mushroom collection (K. Ramesh *per. comm*.). There are several reports of mushroom collectors destroying nest of pheasants (egg collection from the nest) and killing of goral for meat. The more dangerous effects are due to the fire that the villagers set every year to get a better yield of mushrooms during subsequent year due to which most of the snags and logs are burnt destroying micro and macro-biota which may lead to an ecological imbalance. While collecting mushroom litter is removed from the ground which is ideal habitat of many invertebrates that may slow down the rate of decomposition ultimately reducing in soil nutrients. Besides, there are many indirect effects such as soil erosion, over harvest of fuelwood, collection of other species *e.g.* lichens and trampling.

Fuelwood and fodder for cattle are important biomass need for the people living in the buffer zone of GHNP. It is estimated that in GHNP the requirement of the fuelwood in the ecodevelopment area to the tune of 3.6 tonnes per family per year (Negi 1996). This amounts to the total approximately 4817 tonnes per year as against this the annual production of about 20,000 tones (Negi 1996). In the higher altitudes near treeline and alpine zone fuelwood is not available easily and the visitors camping in these areas have to carry the fuelwood from the temperate and subalpine forests. At present fuelwood consumption in the higher altitudes is higher than its production and if the present rate continues, some of the preferred species such as *Rhododendron campanulatum*, *R. lepidotum*, *R. anthopogon*, *Betula utilis*, *Juniperus communis* and *J. pseudosabina* are bound to face the danger of local extinction.

Fodder collection takes place only in winter months when there is scarcity of green fodder and mainly leaves of oaks *viz*. *Quercus semecarpifolia*, *Q. floribunda* and *Q. leucotrichophora* are collected from almost all zones. Some of the shrub genera such as *Indigofera*, *Desmodium* , *Sinarundinaria* and *Thamnoclamus* are used as alternative fodder. The extraction of fodder during winter months is about

1.5 bundles (40 kg.) per day. The direct impact of lopping for fodder is exposure of canopy resulting in loss of regeneration, seed germination and seed production. The grazing and browsing animals also effects the regeneration either by grazing or by trampling.

Bamboo makes important habitat for the wild animals by giving them shelter. The decrease in cover of these species opens up the area thus increasing predation and illegal poaching of some birds and animal species. The number of clumps and clums in the various pastures showed that the density per hectare was lower near camping site and higher far from camping site. So, it is the management that should look after for the better regeneration of these species near the camping site.

7.0 ETHNOBOTANY OF THE LOCAL PEOPLE

7.1 INTRODUCTION

Majority of the rural communities, especially in the developing world, are extremely knowledgeable about the wild plants and other natural resources, on which they are intemately dependent. The traditional knowledge on the use of wild plants by various ethanic groups that has been inherited through generations (Martin 1995). At the same time increase in human population, change in socio-economic condition and altered landuse practices have caused decline in the population of valuable species due to over – expolitation. Ethnobotanical surveys and documentation of avalability of valuable plant species in the wild helps in identification of conservation and development issues. Local communities in and around the Great Himalayan National Park (GHNP), as in the other sectors of Himalaya, have undergone rapid socio-economic changes during recent decades. As a result, subsistence economy based on agro-pastoralism and a variety of non-timber forest products (NTFPs) has been taken over by market economy based on a few commercially important species.

This chapter deals with the traditional verses commercial use of various plants and plant products by the people living in and around GHNP. This information is based on the ethnobotanical surveys conducted in the study area during 1995-1998.

a. Traditional use of wild plants:

More than 250 ethnobotanically important plant species have been identified from the Park (Singh and Rawat 1998). Of these, 60 species are of medicinal value and many of them are extracted at commercial scale causing a serious threat to their existence. Some of these species have been listed in Red Data Book of Indian plants and CAMP work shop, Kullu, H.P. (1998).

b. Extraction of medicinal herbs for commercial purpose:

The earliest reference of the medicinal herbs collection has been made by Anderson (1886) who stated "I have seen girls bringing to Sultanpur little baskets of wild violets and getting in exchange some salt: so also karoo (*Picrorhiza kurrooa*) and patis (*Aconitum heterophyllum*). The medicinal herbs are found in a variety of locations including the forest, meadows and the rocky cliffs, most of them occurring at higher altitudes (>4,000 m). The method of the herb extraction involves uprooting of the plants using sharp edged trowel for root medicines while other species e.g. *Phytolacca acinosa* and flowers *Viola odorata* are not uprooted because the parts used in case of these herbs are leaves and flowers respectively. In case of morel mushroom (*Morchella esculenta*) the entire plant is uprooted. Herb collection is a physically strenuous activity involving ca 4 to 6 trips to the alpine areas (mostly within the Park) per person. At times people collect the herb from inaccessible areas of high altitudes risking their lives. Herb collectors carry upto 40 kg of ration and camping gear during their trip to alpine areas and almost same amount of herbs is brought down. Mostly the herbs dried in the sun or sometime over the fire in the field itself.

Herbs are collected during May to November, peak month being June-July and August-September. One of the reasons of the decline in the availability and quality of herbs is their "early extraction". The best time for the collections is after "seeding" has taken place but for most of the plants this does not occur till July and herb collection starts much before July.

Herb collection within GHNP is reported to carry out on the basis of a "right" to the local people. All the herb collectors of the area claim to be the "right holders". Nevertheless it still remains unclear what is right and what qualifies a "right holder". The studies on the impact of herb collection on the habitat or on the ecological status of herbs shows that there is great stress on some habitats and pressure on some of the species (Singh and Rawat 1998). Interviews with the herb collectors also indicate a progressive decline in the quality and quantity of herbs. For example, Dhoop (*Jurinea macrocephala*) roots, according to the local people was used to be as thick as a persons fore arm some 10 years ago and today it is difficult to get a root even as thick as finger of a person. Under the original settlement plan by Anderson (1886) the collection of medicinal plants was permitted for 2 months annually from 15th August.

In terms of quantity removed Dhoop (*Jurinea macrocephala*) is the most important plant in GHNP although it commands a relatively low market price. It is used in preparation of incense. The deep taproot of the mature plant is dug up and dried over a slow fire at temporary camps established by the herbs collectors. In 1995 signs of removal of Dhoop roots were seen on all meadows visited in the upper Dhela, Gumatrao, Koberi and Tirth. Locally, as much as 50% of the ground was found disturbed. At least three other alpine plants yield an important crop *Viz*. *Aconitum hetrophyllum, Dactylorhiza hatagirea* and *Valeriana jatamansii.*

7.2 METHODS

A preliminary survey of villages located in the eco-development was carried out. In order to check the authenticity of such information, interviews of individuals from various cross sections of the community, and a number of formal and informal group discussions were conducted during the investigation.

To monitor these valuable herbs the entire study area was stratified into two broad altitudinal zones. (i) Alpine meadows (Species occurring > 3,300 m) and (ii) Herbaceous medicinal plants in the forest (species occurring < 3,300 m).

Various monitoring sites were located and the number of plots in an area in which single species occurs and their number of individuals can easily be monitored on every year in the month of September and October in these sites taking the random sampling plots in these areas

The study area has 141 villages, 1362 families and a population of 9694 with a literacy rate of 17.6 %. Nearly 85 % families earn part of their cash income by medicinal herbs collection. Nearly 65% of annual income is generated by collecting and selling wild medicinal plants and mushroom from the Park. Data were also collected on the frequency and abundance of various medicinal plants within the Park along with seasonality and extent of the commercial harvest by the local people.

Of the 832 species of vascular plants recorded by us within GHNP and surrounds, local people have been using nearly 200 species in traditional medicines. Of the total population residing within the ecodevelopment area only 40 persons (age groups 25-75 years) are recognised as 'traditional healers'. Nearly 25% people had moderate knowledge on the use of herbal medicines. There are 19 species locally used in fever, 18 in gastric troubles, 21 in external injuries, 12 in cuts and boils, 24 in cough and cold, 10 in skin diseases, 9 in stomach ache, 4 in liver problems and 7 in diarrhoea and 5 are used in digestion 11 in cut and boil, 9 in headache, 7 in toothache etc. There was no indication that any of these herbs have become rare due to traditional use.

On the other hand, 61 species are currently being exploited at commercial scale from the Park. Of these more than 30 are listed in Red Data Book of Indian plants. On an average, 7,564 persons visit the Park area per year for the harvest of medicinal plants. Each person spends roughly 1-10 days within the Park and earns approximately Rs 2709 per year.

Table 7.3 Income generated from medicinal plant collection (data collected through village survey)

Species	Approx. number of Collectors yr.$^{-1}$	Total collection in Kg yr.$^{-1}$	Rates /Kg in Rs	Approx. income from selling in the local market
Aconitum heterophyllum	345	1050	800	840000
Aconitum violaceum	842	5100	750	3825000
Acorus calamus	65	158	50	7900
Ainsliea aptera	95	252	60	15120
Angelica glauca	368	4675	45	210375
Dactylorhiza hatagirea	462	1285	850	1092250
Diplazium maximum	38	1085	5	5425
Dioscorea deltoidea	583	45000	30	1350000
Hypericum patulum	15	500	75	37500
Jurinea macrocephala	880	82800	75	6210000
Morchella esculenta	1224	1092	2300	2511600
Nardostachys grandiflora	125	320	100	32000
Parmelia sp	658	105280	24	2526720
Picrorhiza kurrooa	355	8350	85	709750
Podophyllum hexandrum	215	450	65	29250
Polygonum amplexicaule	335	4800	22	105600
Taxus wallichiana	35	9750	12	117000
Thymus linearis	15	25	40	1000
Valeriana hardwickii	125	3055	100	305500
Valeriana jatamansi	448	4652	90	418680
Viola spp.	336	1170	120	140400
TOTAL				**20491070**

7.3 MUSHROOM COLLECTION

Collection and selling of mushroom constitutes one of the major economic activities of most people living adjacent to the GHNP. The preliminary result showed that the species is found in almost every forest types between 1200-3600 m, in all possible aspects and slopes. However, south eastern slopes dominated by *Pinus wallichiana* and *Picea smithiana* between 2,800 to 3,300 m had higher density (Table 7.3.4). The species collected from all parts of forest by the people living in and around the Park. The collection of mushroom which was used to be source of secondry income have now been taken over by market forces and people are now exploiting it ignoring its impacts, that have resulted in the decline of its population. There are 11 species edible of edible mushroom (*Morchella*) reported from the Himalayan region. These species are known with their characteristic names *i.e.* thick footed (*M. crassipes*), yellow (*M. esculenta*), gray (*M. deliciosa*), gray-black (*M. conica*), black (*M. angusticeps*), half-free (*M. semilibra*) *etc*. The most common mushroom collected from the area is *Morchella esculenta* that contributes about 85% of the total mushroom collected by the local people. At present about 1200 to 1500 people are reported to visit the different parts of the Park and each individual collects about 500 gms to 750 gms of fresh (about 125-150 gms dry), earning approximately Rs 250 to 300 per day. In this way each household collects about 1 to 10 kg of dry mushrooms per season depending upon the number of collectors from each household. A survey conducted in the three valleys of the Park reveals that more than 25 lakhs rupees are generated by sailing these mushroom is (Singh 1997).

7.4 DISCUSSION

Medicinal plants are means of secondary income for the people living in and around GHNP. A large quantity of various medicinal plants has been commercially exploited in the recent past, since early sixties, and presently is at an alarming rate. Therefore there is an urgent need for monitoring these plants and their habitats. Various species were identified for monitoring after extensive field study and their importance for the local people.

Locally used medicinal plants of Great Himalayan National Park

LT=Lower Temperate (1500-2000m), T=Temperate (2000-2800m), UT=Upper Temperate (2800-3300m), SA=Sub-Alpine (3300-3600m), A=Alpine (>3600m)

S#	BOTANICAL NAME	LOCAL NAME	FAMILY	ZONE	USES
1	*Acetea spicata*		Ranunculaceae	T	Used for snake bite and considered to be useful in treatment of nervous system and rheumatic fever.
2	*Aconitum hetrophyllum*	Patis	Ranunculaceae	A	Roots febrifuge. It is poisonous if eaten.
3	*Aconitum voilaceum*	Mita patish	Ranuanculaceae	A	Used for caring stomach ache in children.
4	*Acorus calamus*	Bach	Araceae	T	Rhizome used in mental ailments and dysentery.
5	*Ainseliaea aptra*	Sathjalari	Asteraceae	T,UT	Roots used as diuretic and stomach ache.
6	*Allium humile*	Farn	Liliaceae		Used as spice and flavouring.
7	*Anemone riviularis*		Ranunculaceae	T,SA	Seeds if taken internally produce vomiting. The oil extracted is used in rheumatism. Plant yield a toxic substance termed as Anemonium.
8	*Angelica gluaca*	Chora	Apiacea	T,UT	Roots for treatment of stomach ache and also flavours food items.
9	*Artemisia sp*	Seski, Kirmala	Compositae	UT	Whole plant as laxative, floral tops are vermifuge.
10	*Atropa belladonna*	Jharki	Solanaceae	T,UT	Yield atropin which has property of dilating the pupil of the eye. The roots and leaves which are much used. Its berries are very poisonous. Sometimes the plant is confused for the Phytollacca and eaten causing serious problems.
11	*Berberis lycium*	Kasmal, Kirmora	Berberidaceae	T	Roots used for dying.
12	*Bergina ciliata*	Sabala	Saxifragaceae	T,UT, SA	Roots chewed and used to clean eyes of livestock.
13	*Caltha palustris*		Ranuncalaceae	SA,A	Roots are considered to be poisonous.
14	*Cimicifuga foetida*		Ranunculaceae	T	Roots contain resinous substance termed cimicifugin and is said to posses medicinal properties.
15	*Codonopsis ovalata*		Campanulaceae	SA,A	The roots and leaves are said to be used in the form of poultices for the treatment of ulcers and wounds.
16	*Colchium luteum*		Liliaceae	T	All parts contain the poisonous alkaloid colchincine which is used in relieving pain. The plant is poisonous to cattle.
17	*Dactylorhiza hatagirea*	Hath panja	Orchidaceae	A	Roots are used to treat wart and boils.
18	*Daphane canabina*	Gandiri	Thymeliaceae	T	Roots, leaves, bark and fruits are said to posses medicinal properties. It appears to be poisonous to animals as it is not browsed sheep and goat.
19	*Dioscorea deltoidea*	Singli-Mugali	Dioscreaceae	LT,T	Tubers used for soap making for washing wool, silk, and hair. Also used for fish poisoning.
20	*Juglans regia*	Akhrot	Juglandaceae	LT,T, UT	The root bark is used for the cleaning of teeth and prevent it from decaying.
21	*Girardiana hetrophylla*	Beechi booti	Compositae	LT	Leaves used for `saag' and `chatani'.
22	*Juniperus communis*	Bittal	Cupressaceae	SA	Used for incense and offerings to God
23	*Jurinea dololmiaea*	Dhoop	Compositae	A	Roots used for incense.
24	*Laptadenia ruticulata*	Dori		A	Whole plant is used as stimulant and restoractive.
25	*Meconopsis aculeata*	Poppy	Papveraceae	A	The roots are said to posses narcotic properties and are considered to be poisonous.
26	*Pistacio integerrima*	Kakar Singi	Anacardiaceae	LT	Fruit ash is used to treat cough.
27	*Phlomis rotata*	Chukhari	Labiate	A	Used for burns and boils.
28	***Physochilania praealata*	Bajar Banj		T,SA	Leaves narcotic. Seeds vermiform to treat round worms.
29	*Phytollcca acinosa*	Jharka	Phytolaccaceae	T	The leaves are being eaten after being cooked, it is being considered that the poisonous properties which produce delirium are destroyed on boiling.

30	*Picrorhiza kurroa*	Karoo	Scrophulariaceae	SA,A	Roots and rhizomes are used as adulterant of gentian, cholagogue laxative. Also used for stomach ache
31	*Pleurospermum densiflorum*	Lossar	Apiaceae		Massage with Ghee on various body joints to relieve pain.
32	*Podophyllum hexdrum*	Ban kakri/Galakada	Berberidaceae	T,SA, A	Used as ailments. The roots yield podophyllin which is much used in medicine in the form of podophyllin pills.
33	*Poeonia emodi*		Ranunculaceae	T	The tubers, flowers and seeds have medicinal properties. It was common belief that poeny roots if worn round the neck prevent attack of epilepsy.
34	*Polygonatum verticillatum*	Salam Misri	Liliaceae	T,UT	
35	*Rheum emodi*	Reward, Chini,Dolu	Polygonaceae	T,SA	Roots and rhizome purgative, assurgent tooth powder.
36	*Rhododendron anthopogon*	Talsi	Ericaceae	SA	Leaves used for preparation of tea.
37	*Rhododendron campanulatum*	Kashmiri patta	Ericaceae	T,SA	Leaves and twigs are said to be medicinally used. Leaves are not eaten by sheep and goat and are considered poisonous to them.
38	*Rhododendron arboreum*	Brass	Ericaceae	T	Used for treatment for blood dysentery in children.
39	*Salvia moorcroftiana*	Thoot,Thut	Labiate	T	Whole plant used for vermifuge, poultematic and roots for incense.
40	*Saussurea lappa*	Kuth	Compositae	A	The useful portion is roots which dug out dried and explored to market. Kuth cure almost all diseases.
41	*Saxifraga ligulata*		Saxifragraceae	T	The roots posses medicinal properties which used as tonic.
42	*Skimmia laureola*		Rutaceae	T	Yield an essential oil. The plant is not eaten by animals. The plant is useful to those pandits who prepare incense from the dried leaves and also garlands from leaves used in wedding ceremony.
43	*Taxus baccata*	Rakhal	Taxaceae	T,UT	Leaves are collected for the production of `Taxol' which is used for the cure of cancer. The bark is also used for preparation of tea.
44	*Thalictrum foliolosum*	Mimiri	Ranunculaceae	T	Roots diuretic and purgative
45	*Thymus serpyllum*	Ban ajwain	Labitae		Shoots for flavouring, leaves as beverages, seeds as vermifuge, leaf and floral tops as aromatic.
46	*Valeriana jatamansi*	Muskbala/Nahani	Valerianaceae	A	Roots and rhizome for incense and for treatment of hysteria and hypochondria.
47	*Viola odorata*	Banafsha	Violaceae	T,SA, A	Flowers and leaf for treating wounds, and fever. Leaves as pain killer and perfume. Roots emetic.
48	*Zanthoxylum armatum*	Timaru	Zanthoxylaceae	LT	Twigs used for brushing teeth and seeds for relieving thooth ache.
49	*Morchella esculanta*	Gucchi	FUNGUS	T	Whole plant is eaten.
50	*Foilage Lichen*			LT,T, UT	Whole plant is used for decorating hand and feet as `henna'.

LIST OF SPECIES USED FOR VARIOUS PURPOSES

1. Cough and Cold

Achillea meilefolium
Aconitum heterophyllum
Acorus calamus
Berginia ciliata
Carum carvi
Cerastium cersatoides
Dactylorhiza hatagirea
Gaultheria trichophylla
Girardiana diversifolia
Jurinea macrocephala
Nardostachys jatamansi
Origonum vulgare
Pistacio interrigrima
Podophyllum hexendrum
Rhododendron anthopogon
Rhododendron campanulatum
Salvia moorcroftiana
Saussurea graminifolia
Saussurea simpsonia
Selinum vaginatum
Taxus baccata
Viola odorata
Viola serpens

2. Headache

Aconitum heterophyllum
Acorus calamus
Anemone rivularis
Carum carvi
Cerastium cerastoides
Corydylis govanianum
Picrorhiza kurrooa
Rhododendron arboreum
Viola spp.

3. Stomach Ache

Ainsileae aptera
Angelica glauca
Cannabis stiva
Carum carvi
Corydalis govaniana
Ficus pamata
Iris kumaonsis
Micromeria biflora
Picrorhiza kurrooa

4. Skin Diseases

Aconitum chasmanthum
Arisaema jacquemontii
Artemisia sp.
Berberis aristata
Berberis lycium
Cannabis stiva
Lyonia ovalifolia
Podophyllum hexendrum
Polygonum amplexicaule
Rhododendron campanulatum

5. Diarrhea and Dysentery

Aconitum heterophyllum
Acorus calamus
Asparagus recemosus
Hedychium sp.
Hippophae salicifolia
Rhododendron arboreum
Trillidium govinanum

6. Fever

Aconitum heterophyllum
Actea spicata
Anemone rivualris
Berberis aristata
Carum carvi
Daphane papyracea
Megacarpa polyandra
Origonum vulagre
Paris polyphylla
Picrorhiza kurrooa
Rheum australe
Saussurea gossypiphora

Thalictrum foliolosum
Viola odorata
Viola wallichiana
Zanthaxyllum

7. Mental Disorders

Acorus calamus
Rubia cardifolia

8. Liver Disorders

*Bupleurum longi***
Hedychium spicatum
Taraxcum officinale
Thymus serpyllum

9. Digestion

Allium humile
Angelica glauca
Oxyria dignia
Picrorhiza kurooa
Rumex hastatus

10. Gastric Troubles

Achillea milefolia
Aconitum violaceum
Actea spicata
Aesculus indica
Ainsliaea aptra
Ajuga bracteosa
Berberis aristata
Berginia ciliata
Capsella virsa-palustaris
Codonopsis ovata
Elaeganus parviflora
Hedychium spicatum
Juglans regia
Nardostachys jatamansi
Paris polyphylla
Plantago major
Pleurospermum densiflorum
Taraxcum officinale

11. Cuts and Boils

Ajuga bracetosa
Berginia ciliata
Caltha palustaris
Dactylorhiza hatagirea
Geranium wallichianum
Girardiana diversifolia
Podophyllum hexendrum
Prensepia utilis
Rheum webbiana
Ribes alpestre
Urtica dioca

12. Diabetes

***Aujga* sp.**
Picrorhiza kurrooa

13. Tooth Ache

Delphinum dendualtum
Fragaria sp.
Juglans regia
Potentilla nepalensis
Thalictrum foliolosum
Thymus linearis
Zanthoxyllum sp

14. Snake Bite

Actea spicata
Hedychium spicata
Berberis aristata

15. Contraceptive

Phytolacca acinosa
Urtica dioca
Berberis aristata

16. Eye

Phlomis bracteosa
Thalictrum foliolosum

17. Injuries

Berginia cilata
Viola odorata
Discorea deltoidea
Artemisia sp.
Urtica dioca
Podophyllum hexendrum
Cynanthus lobotus
Berginia stachyei
Fritilaria royli
Megacarpa polyandra
Potentilla atrosanguinea
Polygonum amplexicaule
Rheum webbiana
Polygonatum sp.
Hypericum patalum
Cannabis stiva
Daphane cannabina
Prunus cerastoides
Rumex nepalensis
Rubia cardifolia
Polygonum viviparum
Artemisia parviflora
Oxlis corniculata
Urtica dioca

Asthma

Juniperus communis
Taxus baccata

Piles

Tagatus minuta

Narcotics

Cannabis stiva
Meconopsis acuelata
Stromonuium **

Stimulants

Arnebia benthemi
Codonopsis ovata

8.0 CONSERVATION AND MANAGEMENT

8.1 INTRODUCTION

8.2 PRIORITY SPECIES FOR CONSERVATION

8.3 PRIORITY AREAS / KEY VEGETATION TYPES FOR PROTECTION

8.4 GENERAL RECOMMENDATIONS FOR MANAGEMENT OF VEGETATION

For an effective and successful conservation, it is necessary to take adequate steps that warrant participatory approach towards management of natural resources and penalizing those who directly / indirectly cause the destruction of forests. Extensive herb collection and their marketing has been carriedout in GHNP without the least regard for conservation till recently. Efforts should, therefore, be made to cultivate these species and establish drug farms that can relieve the pressure on the wild population. Certain regions which are rich in medicinal plants wealth should be protected so that a gene pool can be maintained. Herbs and mushrooms are collected primarily during summer months when a large number of people enter the Park. This practise is evidently the most destructive of all the pressures that challenge the viability of wild populations of these herbs in this Park. The collection of medicinal plants and mushrooms has been carried out for several years, but the intensity of collection increased only in the recent years when the market demand ascended sharply. It is estimated that most of these herbs have been over exploited as is obvious from the fact that they are becoming harder and harder to find (Gaston and Garson 1992). Some of the species collected earlier in large quantity are no longer found in certain area and might even have become locally extinct. Current estimate suggests that almost 2500 people enter the Park each year to collect herbs and mushrooms. This collection fetches the local people sufficient money that caters the need for almost whole year. The data collected by village survey reveals that herb collection only makes more than 20 million rupees per year. Based on broad findings the following conservation measures are suggested for the Park management to tackle the problem of herb and mushroom collection.

I. Since herb and mushroom collection cause major pressures on the Park, alternative income generation programmes should be initiated.

II. The herb collectors and the department staff should be educated with the sustainable harvest of these species.

III. Awareness and capacity building of collectors and traders about each plant, its uses, biology, protection strategies, method of harvest and marketing *etc*. should be initiated for its conservation.

iv. Research and development efforts should be made to see whether these herbs and mushroom can be cultivated, naturally or through tissue culture outside the Park.

The second major form of pressure in the Park is over grazing of alpine pastures by huge herds of sheep and goats of local as well as migratory graziers. The impact of grazing is discussed in Chapter 6. There is a need for management activities that cater to both, the interest of local people and wild animals. Rotational grazing is possible provided the people coming from outside the ecodevelopment area are given alternatives. Several practical approaches can be suggested to overcome this pressure on the Park , *viz*.

i. Controlled and rotational grazing of 2 to 3 years interval based on the carrying capacity of the pastures should be initiated.

ii. In alpine, the graziers move from pasture to pasture, but the movement is not fast enough to prevent overgrazing, so, a time table should be prepared and followed.

iii. Most important task would be to educate local people for careful, thoughtful, conservative and rational use of these pastures. Discussion with the local people on conservation programmes can also yield better results.

Fuel and fodder wood pressure is mainly from the villages adjacent to the Park. Although the area is self sufficient in fuelwood still there is pressure of fuelwood in the alpine (Negi 1996). Fuelwood is a major problem in subalpine and alpine causing destruction of some of the woody species. Even some of the species are in danger of local extinction (Singh and Vinod 1998). The following measures have been suggested to reduce the destruction.

i. The people visiting the alpine should not be permitted to enter the Park without Kerosene stove.

ii. Management and monitoring of species like *Juniperus*, *Rhododendron, Quercus semecarpifolia*, *Betula utilis* near the camping site should be done on regular basis and plantation of theses species should be tried.

Fodder is collected mainly during February to May from the Park. The leaves of oaks and bamboo species are collected. The following conservation measure should be employed to conserve the fodder species.

i. Plantation of fuel and fodder species in the ecodevelopment area with the help of local people may reduce the pressure on the Park.

ii. Proper maintenance of the temperate grazing grounds (*Ghasanis*) and introduction of better quality grasses should be undertaken.

iii. Only lower 2/3rd portion should be allowed to be lopped and upper 1/3rd should not be disturbed.

iv. Small plants and shoots more than 75 cm thick should not be lopped.

The baseline data have already been generated on vegetation monitoring (Singh and Rawat 1998) and a training to the filed staff has already been given for future monitoring of medicinal plants, bamboo and important tree species. The exclosure study could not be taken up in the present investigation but such study can give more quantitative information on the impacts on the vegetation by various anthropogenic pressures. Further exploration in the remote areas of the Park and critical examination may yield more plant species. Aut ecology of individual of rare and threatened species in terms of phenology, regeneration and micro-habitat preference may also help in formulating further conservation plan and understanding the Himalayan ecosystem in better way.

8.5 CONCLUSIONS

i. GHNP has rich diversity of vascular plants (128 families, 427 genera and 832 species) many of which are rare and threatened especially the medicinal plants. Long term plans are required to conserve this rich biodiversity in the Park.

ii. *Nardostachys grandiflora* (Valerianaceae) was recorded for the first time from Himachal Pradesh. This species should be given high priority for conservation by protecting its habitat from over exploitation and livestock grazing.

iii. Occurrence of large number of plant communities (45 in temperate, 9 in subalpine and 22 in alpine) in the study area indicates rich assemblages and varied environmental conditions, which have, in turn, given rise to various faunal communities. Of these, *Quercus semecarpifolia - Rhododendron campanulatum - Abies spectabilis* and *Taxus wallichiana - Abies pindrow* among the tree and *Arnebia benthamii - Epilobium latifolium* among the herbaceous communities are considered important from conservation point of view because of their intensive use by wild animals as well as local people.

iv. Based on Canonical Correspondence Analysis (CCA), it was evident that altitude and soil pH were the most important factors governing the distribution of species in the alpine zone. On the other hand, aspect and slope had less pronounced effect.

v. Of the 61 species of medicinal plants extracted from the Park, 36 bears tuberous roots or rhizomes. Intensive collection by digging out these herbs has resulted in the loss of ground cover and top soil in many sites.

vi. Detailed study on mushroom collection could not be taken up due to its short growing season. However, the collection per se seems to have little impact on the plant communities. the indirect impact of mushroom collection comes from the people visiting the Park at the time of the year when pheasants are nesting and mammals are nursing young ones.

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PLATE I

a. **Sub-alpine meadow of Dhela 'Thach' (3300-3700m) intermingling with *Quercus semecarpifolia* and *Abies pindrow***

b. **Alpine meadows in Tirthan valley (4200 m) of GHNP dominated by *Phleum alpinum***

PLATE II

a. Temperate, Subalpine and Alpine zones of Tirthan valley

b. A view of Tirth alpine pasture, heavy biotic pressure area

PLATE III

a. Vegetation sampling in the permanent monitoring plots

b. Grazing by sheep and goats in Nada Thach (3300 m)

PLATE IV Rare medicinal plants

a. Aconitum heterophyllum Wall. ex Royle

b. *Nardostachys grandiflora* DC. (A new record for Himachal Pradesh)

PLATE V Rare medicinal plants of alpine

***b. Arnebia benthamii* (Wall. ex G.Don) Johnston**

***a. Dactylorhiza hatairea* (D.Don) Soo.**

PLATE VI Medicinal plants of temperate zone

b. Delphium brunonianum Royle

a. Phytolacca acinosa Roxb.

PLATE VIII Rare medicinal plants

a. Saussurea obvallata **(DC.) Edgew**

b. Jurinea macrocephala **(DC) Benth.**

PLATE VII Rare medicinal plants

a. Podophyllum hexandrum **Royle**

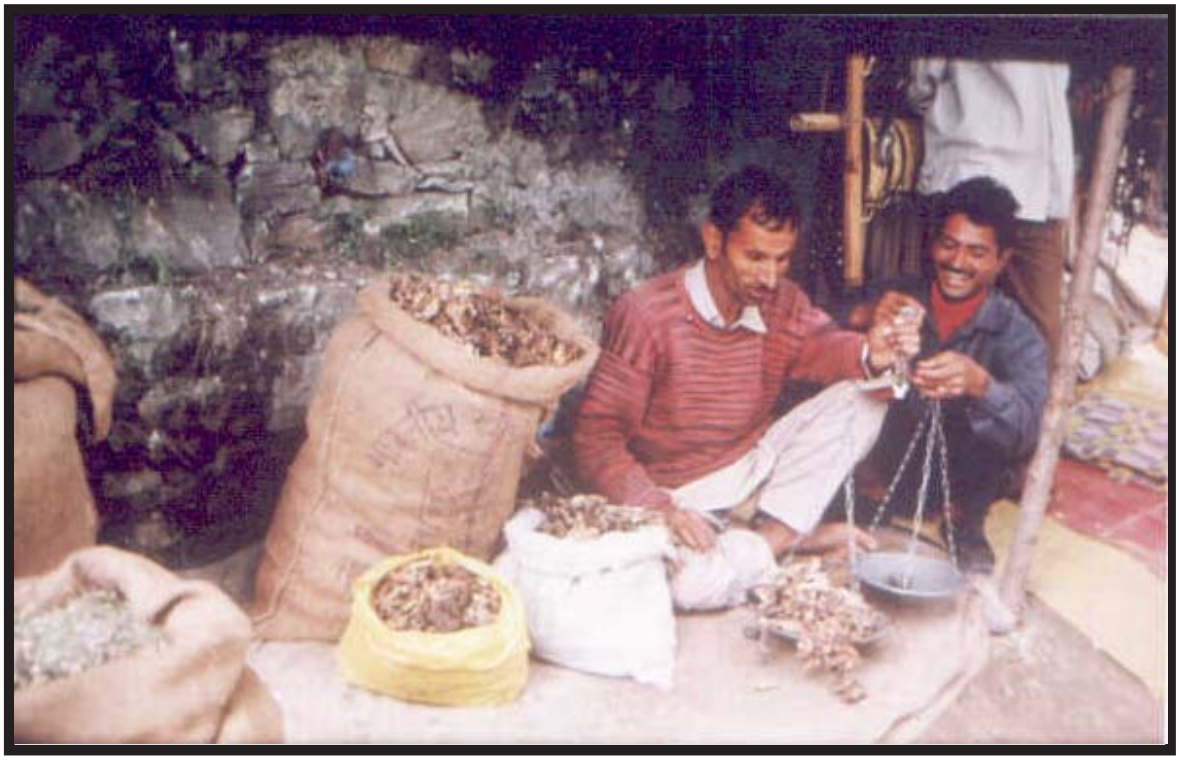
b. Meconopsis aculeata **Royle**

PLATE IX Rare medicinal plants

a. Cypripedium himalaicum **Royle**

b. Arenaria festucoides **Benth.**

PLATE X Biotic pressure in GHNP



Marketing of medicinal plants