

**PHYTOSOCIOLOGICAL AND ETHNOBOTANICAL  
STUDIES IN SHILLI WILDLIFE SANCTUARY,  
DISTRICT- SOLAN, HIMACHAL PRADESH**

*Thesis*

by

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(F-2016-31-M)**

submitted to



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## **CERTIFICATE-I**

This is to certify that the thesis entitled, “**Phytosociological and Ethnobotanical Studies in Shilli Wildlife Sanctuary, District- Solan, Himachal Pradesh**” submitted in partial fulfillment of the requirements for the award of degree of **MASTER OF SCIENCE (FORESTRY) FOREST GENETIC RESOURCES** of Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan (HP)-173230 India is a record of bonafide research work carried out by **Ms. Akshiptika Chandel (F-2016-31-M)** Daughter of Sh. Rakesh Chandel under my supervision and that no part of this thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of investigations have been fully acknowledged.


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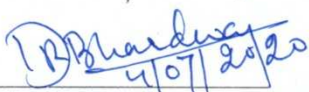
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## CERTIFICATE-II


This is to certify that the thesis entitled, "Phytosociological and Ethanobotanical Studies in Shilli Wildlife Sanctuary, District- Solan, Himachal Pradesh". submitted by Ms. Akshiptika Chandel (Admission No. F-2016-31-M) Daughter of Sh. Rakesh Chandel to the Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan (HP)- 173230 India in partial fulfillment of the requirements for the award of degree of **MASTER OF SCIENCE (FORESTRY)** in the discipline of **FOREST GENETIC RESOURCES** has been approved by the Advisory Committee after an oral examination of the student in collaboration with the Internal Examiner.

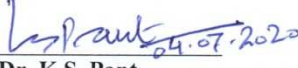
  
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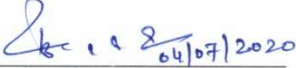
  
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Ending is inevitable for any kind of work. Though acknowledging is an endless task, I end by saying endless thanks to all those whom I am able to recall here and those whom I might have left unknowingly.

**To err is human. Needless to say all errors and omissions are mine.**

**Place: Nauni, Solan**

**Date:**

**(AKSHIPTIKA CHANDEL)**

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## ABBREVIATIONS USED

%	:	Per cent
&	:	And
°C	:	Degree Celsius
A	:	Abundance
Cm	:	Centimetres
HP	:	Himachal Pradesh
H	:	Shannon index of diversity
S	:	Species richness
F	:	Frequency
D	:	Density
IVI	:	Importance Value Index
E	:	Evenness
Ds	:	Simpson index
/ha	:	per hectare
amsl	:	Above mean sea level
m	:	Meter
Z	:	Zone
L	:	Left
R	:	Right
M	:	Middle
UHF	:	Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan
COF	:	College of Forestry
Km	:	kilometre
sq	:	Square
Fig	:	Figure

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## *Chapter-1*

# INTRODUCTION

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Vegetation is the most valuable gift that nature has provided to us, as it is meeting all kinds of essential requirements of the humans in the form of food, fodder, fuel, medicine, timber, resins, etc. (Gaur, 1999). Plant community plays an essential role in sustainable management by maintaining biodiversity and conserving the environment (Farooquee and Saxena, 1996). The knowledge of the floristic composition of a plant community is an imperative to understand the overall structure and function of an ecosystem (Whittkar, 1972). The living world is composed of more or less distinct entities which are called species. They represent an important level of consolidation in living nature (Venu, 2002). Fundamental botanical research revolves around floristic and monographic works. Flora enumerates plants of a particular geographical area with a purpose to recognize them (Venu, 2002).

India has a rich and varied heritage of biodiversity covering ten biogeographical zones, viz., the Trans-Himalaya, the Himalayan, the Indian Desert, the Semi-arid Zones, the Western Ghats, the Deccan Peninsula, the Gangetic Plain, North-East India, and the Islands and Coasts (Rodgers *et al*, 2000). India is rich at all level of biodiversity and is one of the 12 mega biodiversity countries in the world (Kushwaha and Kumar, 2000) having 47,000 plant species, consisting of more than 17,000 species of flowering plants. India's wide range of climatic and topographic features has resulted in high level of ecosystem diversity encompassing forests, wetlands, grasslands, deserts, coastal and marine ecosystems, each with a unique assemblage of species (Anonymous, 2002). India's biogeographical location at the junction of the Agrotropical, Indo-Malayan and Paleo-Arctic realms has contributed to the biological richness of the country. The endemism of biodiversity is also high, about 33 per cent of the country's recorded flora is endemic to the country and is concentrated mainly in the North-East, Western Ghats, North-West Himalayas and the Andaman and Nicobar islands (Anonymous, 1999). The Red Data Books (Jain and Sastry, 1984; Nayar and Sastry, 1988 and 1990) listed 623 threatened species of which 550 are endemic including some valuable medicinal plants. Although biodiversity is essential to mankind as it provides innumerable benefits and other important values. Humans have had strong cynical impacts on biodiversity during past few decades. Various ecosystem functions and services had been negatively affected by the loss of biodiversity. The survey and documentation of biodiversity and other

structural characters of the disturbed as well as protected natural resources is necessary for understanding the ecosystem function for its conservation (Whittaker, 1972).

The Himalayas are considered as a reservoir of biological and cultural diversity. Himalayas are one of the largest and youngest mountain chains in the world and the Himalayas ranges about 2500 km long, extending from 73° E to 97° E longitude, and from 27° N to 37° N latitude, covering an area of approximately 236,000 sq. km. There are three ranges, viz., outer, middle and the inner or great Himalayan running almost parallel from east to west with altitude ranging from few hundred to over 8000 m above mean sea level. Thus, there are three factors, viz., longitude, latitude and altitude, which add together to multiplicity of habits and thus provide varied microclimates and ecological niches not only for plants and animals, but also for human beings (Bhatt *et al.*, 2004).

Taxonomy is an integrated and perhaps the intuitive science of identifying, naming and classifying plants. This may be considered as one of the oldest of sciences in the world, as the primitive man had to distinguish the plants that he can eat safely, from those which are poisonous and inedible. But, often this branch of botany is considered as out moded and out dated and the appearance of many subjects making use of modern technologies and sophisticated instruments, only added contempt to the neglect (Subramanyam and Nayar, 1974a; Henry and Daniel, 1988). Presently there is great resurgence of this subject in view of the alarming erosion of species and ecosystems. The realization of the economic potential of the biodiversity and the necessity for its preservation for the future welfare of mankind has suddenly boosted the stock of the subject of Taxonomy (Manilal, 1997). Our knowledge about the diversity and distribution of plant species is very indigent and inadequate that we still do not know exactly how many species exist on our earth. Wilson (1988) calculated that the total number of named species is about 1.4 million. It was estimated that around 7500 species of organisms are becoming extinct every year (Chatterjee, 1995) and many of them disappear even before known to the scientific world (Myers *et al.* 2000; Pimm and Raven, 2000). The current decline in biodiversity largely through human activities is a critical threat to our ecosystem. It is anticipated that about 20 per cent of all the species are expected to be lost within 30 years and 50 per cent or more by the end of the 21<sup>st</sup> century (Myers, 1993).

Phytodiversity reveals species composition in a plant community. The forest ecosystems are inhabited by complex community structure and function. The sustainability of forest ecosystem can be accessed on the basis of plant species therein. Study of plant diversity is an important aspect of forest ecology which entails the status and contribution of various

species. The structure and function of ecosystem and their periodical measurements gives information about the addition, replacement, aggregation and abundance of species caused by habitat changes (Fisher *et al*, 1943; Mac Arthur and Wilson, 1967; Diamond, 1975; Schafer, 1990; Pimm *et al*, 1995). Phytodiversity studies particularly in and around protected areas serves as nascence information and would be useful in predicting the future course of succession and habitat conditions and also as indicator of level of disturbance.

Quantitative description of diversity is of two kinds, one dealing with Alpha, Beta and Gama diversities which describes turnover and the size of species pool in large region, respectively (Whittaker, 1972) and the other dealing with the different types of diversity indices (Shannon-Weiner diversity index, Simpson's index, etc.), which attempt to summarize the information on the number of species together with that on their abundance in a single number (Pielou,1975; Ludwig and Reynolds, 1988). Several studies on species diversity, community structure and vegetation analysis of different forest ecosystem have been carried out by various workers in India and abroad (Raizada and Samara, 2000; Nath *et al*. 2000; Pandey and Shukla, 2001). Some other studies with various parameters of species diversity were carried out by Balvanera *et al*. (2002), Bhatt *et al* (2004), Mani and Parthasarthy (2005) in different forest ecosystems. However the quantitative assessment of vegetation was mostly carried out in the western Himalayas, but very few studies have been conducted in protected areas and therefore, it has been stressed that extrapolation of ecological data from one region to the other essentially require much caution and that patterns shown by a taxon or type in one area may not be reflected in others, even though it may be dominant at both places (Zobel and Singh, 1997).

The structure and the composition of the Himalayas forest vegetation is primarily determined by altitude, rainfall, latitude, topography and the aspect (Singh, 1998). Of these, altitude and aspects is most widely accepted but least studied parameters. It plays an important role in determining the vegetation structure and composition of the area (Pande *et al*. 1996). Thus varied vegetation in the Himalayas provides scope for ecological studies and vegetation status. Protected areas add vital contributions to the conservation of the world natural forest genetic resources and accordingly 102 National Parks and 515 Wildlife Sanctuaries covering an area of 1.21 per cent and 3.65 per cent of the geographical area of the country, respectively (Anonymous, 2012) have been created exclusively for protecting the wild flora and fauna in India, as a part of broad management perspective, so that natural flora and fauna occupy their natural habitat under natural and protected conditions.

Loss of biological diversity in the World's forests has been identified by some ecologists as the environmental issue of the time—a crisis of extinctions that will reveal the loss of dinosaurs over 65 million years ago (Simberloff, 1986 and Wilson, 1988). Yet, whether this actually is a so-called crisis, has also been questioned due to lack of data. It should not be considered as a crisis to stimulate concern for biological diversity.

Ethnobotany records the history and current state of human kind, even while foretelling the future. As a discipline ethnobotany gives us a profound understanding and appreciation of the richness and intimacy of relationships between human and nature. Traditional ethno-botanical studies in recent years have received much attention due to their wide local acceptability and clues for new or lesser known medicinal plants (Tripathi, 2000). Indigenous traditional knowledge of medicinal plants of various ethnic communities, where it has been transmitted orally to the next generation and others for centuries, is fast disappearing due to the advent of modern technology and transformation of traditional culture. Tribals are a distinct ethnic group who are usually confined to definite geographical areas, speak a common dialect and are culturally homogenous and unifying social organization (Gupta, 1995). India is perhaps the richest repository of traditional knowledge uses of plants. The country possesses an ancient system of health care based chiefly medicinal plants of diverse nature, ranging from higher plants to microorganisms, from which more than 80 per cent of therapeutic products are derived (Balakrishnan *et al.*, 2009). About 350 million people of the world are almost entirely dependent for their daily needs and sustenance on forest (Anonymous, 1991). In India about 2500 species of ethnobotanical importance are known (Jain, 1991). People living in farflung areas depend completely on forest resources for maintaining their day-to-day needs like medicine, food, fuel and household articles (Chhetri *et al.* 2005).

The use of medicinal plants is as old as human civilization. India has a glorious tradition of health care system based on plants, which dates back to Vedic era. Approximately 70 per cent of India's medicinal plants have been found to be in tropical regions, whereas in temperate and alpine areas their occurrence is less than 30 per cent, but they include species of high medicinal value (Nautiyal and Kaul, 2003). India is one of the richest medicinal plants resources of the world. This vast wealth is widely distributed in different parts of country having specific phytogeographical entities. In India, out of 17,000 species of flowering plants about 17 per cent are considered to be of medicinal value (Jain, 1968). As per an estimate, over 1600 species of medicinal plants are traditionally used in India, more than 50 per cent

species come from the Himalayan region (Uniyal *et al.* 2002). The World Health Organization has estimated that 80 per cent of the developing world relied on their traditional medicine and that of these 85 per cent use plants or their extracts as the active substance (Sheldon *et al.* 1998).

Himachal Pradesh is bound between 30°22'40" to 33°12'40" N latitude and 75°47'55" to 79°04'20" E longitude. Being situated in the centre of the Western Himalayas, it is bestowed with a rich flora, the diversity of which is spread over Shivalik belt, temperate forests, deep ravines, open grassy slopes and alpine pastures. Out of the 47,000 plant species found in the country as many as 3245 species (7.32%) are available in the state of Himachal Pradesh (Verma, 2000). The faunal and floral wealth in the state of Himachal Pradesh is tremendous but due to various development activities the various ecosystem are threatened for floral and faunal diversity. Therefore, there is an urgent need to conserve the endemic diversity of its flora before it is wiped out from the nature for good.

India is one of twelve mega diversity countries globally recognized for its rich biodiversity, since its geographical position extends from sea levels to the highest mountain ranges in the world. Gadgil and Meher Homji (1982) in the analysis of India's biological diversity have distinguished 43 major vegetation types including cold deserts.

Himachal Pradesh occupies a pivotal location in the country for its rich and varied biodiversity and to conserve this, five national parks and 32 sanctuaries have been established. Shilli sanctuary in Himachal Pradesh with an area of 2.15 km<sup>2</sup> is the smallest sanctuary in Himachal Pradesh. Sanctuary came into existence in year 1963 and on 27<sup>th</sup> March 1974 it was re-notified. The altitude ranges from 1200 to 1800 m and above mean sea level. It is situated in district Solan with latitude ranges from 30° 54' 15" to 30° 54' 41" North and longitude from 70° 07' 45" to 77° 09' 13" East. Being a reserve area, it is rich in plant diversity. Therefore, present study has been undertaken to study the phytosociology and ethanobotany of Shilli Wildlife Sanctuary of District Solan (H.P.) for forest management and to develop forest working plans/prescriptions and silviculture practices. Present investigation entitled "**Phytosociological and Ethanobotanical Studies in Shilli Wildlife Sanctuary in District Solan, Himachal Pradesh**" has been carried out under the following objectives:-

- i) To conduct phytosociological studies in different altitudinal zones of Shilli Wildlife Sanctuary.
- ii) To identify the species of ethanobotanical importance.

## *Chapter-2*

# **REVIEW OF LITERATURE**

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India is bestowed with unique diversity in culture and natural vegetation and exhibiting rich plant diversity. Because of living in close harmony with the Mother Nature for sustenance of different activities of life, a quest to know and understand plants arose in the man's behavior which then leads to the birth of science of Botany. First phase of this science was devoted to the recordings and observations of the naturalists and the herbalists those covered various facts of plant's life certainly followed by subsequent developments in related field. The information was collected by individuals was then passed on verbally from one generation to another. Theophrastus (372-282 BC) – the Great Greek philosopher cum scientist, later gave scientific footing to the knowledge of plants. Continual observations and studies on plant resources further kept on adding to the repository of facts and figure including discovery of new and useful products. This huge compilation ultimately necessitated the identification, classification and documentation of their status on the scientific lines and the phenomenon is still continuing. Survey, identification, inventorization and documentation of plants act as a source of information to assist planning and operation of any germplasm handling activity and are a very important step in germplasm management. The present work “**Phytosociological and Ethnobotanical Studies in Shilli Wildlife Sanctuary, District Solan, Himachal Pradesh**” is based upon the vegetational survey conducted in the study area. The brief resume of the work has been presented under the major following sub heads:

1. **PHYTOSOCIOLOGY:** is the branch dealing with plant communities, their composition and development, and the relationship between the species within them.
2. **ETHNOBOTANICAL STUDIES:** is the study of a region's plants and their practical uses through the traditional knowledge of local culture and people.

### **1.1 PHYTOSOCIOLOGY**

Plants growing together have natural relationship among them and with the environment. This interaction among different plants and their environment result in the outcome of different vegetation types in different areas. The quantitative relationship

between rare and profusely growing species is an important structural property of a community. The quantitative study of vegetation called “phytosociology” and its principle aim is to describe the vegetation, explain or predict its pattern and classify it in a meaningful way. Species diversity determines the distribution of individuals among the species in a particular habitat. Hence, studies of the structure and function of the vegetations in relations to their environment certainly form the basis for complete understanding of dynamics of an ecosystem which then certainly lead towards formulation of suitable strategies. Clements (1916) developed a system of classification based on successional relations, i.e., on change in time that is deduced from spatial similarities and differences in dominant species and their community environments. Plants growing together have natural relationship among themselves and with the environment.

Curtis and McIntosh (1950), Curtis (1959) and Philips (1959), quantitatively analysed the vegetation data for frequency, density and abundance. The relative values of frequency, density and dominance were also determined. The IVI for each plant species was determined as the sum of relative frequency, relative density and relative dominance. The ratio of abundance of frequency (A/F) has been used to analyze the distribution pattern of species within the site studied. A value below 0.025 was considered as a regular distribution; 0.025-0.05 as random and more than 0.05 as contiguous distribution pattern (Curtis and Cottam, 1956). Plant population in community varies from habit to habitat and these characteristics play a basic role in determining the kind of a community. The ecosystem response to external stimuli follows certain common pattern regardless to ecosystem type or stimuli (Platt, 1965; Lugo, 1978). Misra (1968) carried out phytosociological analysis, through randomly laid 1m x 1m quadrats for each site, with at least 10 quadrats per sample for grasses and herbaceous species. According to Odum (1971) contiguous distribution is common in nature random distribution is found only in very uniform environment and regular distribution occurs where severe competition exists between individuals. Walter (1979) holds that the wide spread assumption regarding the distribution of plant species directly depend upon the physical conditions prevailing in the habitat is incorrect.

Gupta *et al.* (1982) studied floristic composition of Western Himalayas sub-alpine coniferous forests in Parbati Range, Himachal Pradesh. Whereas, changes in floristic composition of herbaceous vegetation under three different forest communities was studied (Singh and Verma, 1983) in and around Summer Hill, Shimla.

Variation in the distribution pattern across the slopes and vegetation strata seems to be associated with multiple factors specially micro-environment and biotic (Joshi and Tiwari, 1990). Singh *et al.* (1991) carried out detailed investigation on the phytosociology of tree vegetation in three selected sites around Shimla, Himachal Pradesh and on the basis of IVI values formation of the plant communities like *Quercus incana- Rhododendron arboreum* (Site-1); *Cedrus deodara- Pinus roxburghii- Quercus incana* (Site-II) and *Picea smithiana- Pinus roxburghii* (Site-III) were recorded at four different slopes (hilltop, upper slope, lower slope and hill base), respectively. The vegetation showed mainly contiguous distribution pattern followed by random and then regular. Singh and Gupta (1992) conducted detailed vegetation survey and ecological studies of ground vegetation under silver fir and spruce forests of Himachal Pradesh.

Gargya *et al.* (1998) conducted a phytosociological analysis of *Nardostachys jatamansi* DC. at three different sites at Yamnotri (3300 m), Kedarnath (3550 m) and in Dayyara meadows (3600 m). They reported that in all the three sites *N. jatamansi* had the highest values for IVI and average basal area. Singh (1998) studied vegetational structure in Temperate zone of the Western Himalayas. The species composition, distribution pattern, diversity, concentration of dominance and community coefficient of the forest vegetation were determined under two aspects (north and south slopes) in the Tirthan Valley, of Himachal Pradesh.

Ghildiya *et al.* (1998) carried out vegetation study in a series of representative Oak forests in relation to their analytical and synthetic character in Garhwal Himalaya within the altitudinal gradient varying from 1400-2600 m above msl. Singh (1999) investigated species diversity, vegetation structure and plant community composition of Great Himalayan National Park. Rawat and Pant (1999) investigated structure of chir pine community along two aspects and four elevational zones in Garhwal Himalaya. The findings indicated that the chir pine prefers sunny slopes with xeric conditions and is a dominant species in such drier south facing slopes.

Prakash and Uniyal (1999) also studied the structure of forest vegetation along an altitudinal gradient (2550-3600 m) in the Valley of Flowers and its adjoining area using 25 quadrates of 10 x10 m for trees and 5 x 5 m for shrubs. Based upon the IVI values, three major vegetation types, i.e., Himalayan moist upper temperate forest (2550-3000 m), sub-alpine fir forest (3000-3250 m) and sub-alpine birch forest (3300-3600 m) were identified. During investigations, average tree density was found to increase with the altitude whereas,

the average basal area of tree species showed a decreasing trend with the increase in altitude. Rawat and Bhainsora (1999) studied the structure and composition of forests across the Shivalik of Doon valley and also of outer Himalaya in Dehra Dun district covering western fringe of Rajaji National Park by using stratified random plots. Aspects like Richness of woody species, Importance Value Index (IVI) of trees and regeneration of sal (*Shorea robusta*) besides the climax species of the region were compared and discussed at great length.

Srinivas and Yadava (1999) had undertaken phytosociological studies at four oak forest with various levels of disturbance (site I low, site II and III moderate and site IV high) in Manipur, North-East India. The dominant species at all the sites was *Quercus serrata*, with *Q. dealbata* as co-dominant. Correlation analysis was carried out between the occurrences of the different tree/woody species and exhibits positive correlations among them in four forest sites. Phytosociological studies (Varghese and Menon, 1999) conducted in the Agasthyamalai region of Kerala, at 100-500 m altitude. Random sampling was done using census quadrat technique. In the 0.1 ha are sampled (ten 10X10 m quadrats) 18 species were recorded belonging to >12 families. The Myristica swamp forest had a comparatively low stand density 9520 trees/ha), maturity index value (18.33) and species density (18 species/0.1ha). It showed medium diversity (2.50), an absence of higher frequency classes and a high concentration of dominance (0.09). On the basis of dominance, the forest is identified as of the *Gymnacranthera farquhariana*, *Myristica fatua* var. *Mangifera indica*, *Knema attenuata* type.

The studies on phytodiversity of Kumbhalgarh Wildlife Sanctuary in Pali and Udaipur District of Rajasthan conducted and twelve important forest community types are distinguished, and notes on the occurrence and conservation of rare and threatened plants in the sanctuary (Pandey and Singh, 2000). Phytosociological analysis of sand mines of Solan district, Himachal Pradesh (Panwar *et al.* 2000) revealed that mining had caused loss of biodiversity in those areas and many of the economically important plant species have been eroded and replaced by uneconomical and unwanted species.

Costa *et al.* (2001) carried out phytosociological and floristic inventories, with the use of 100 quadrates of 1 m<sup>2</sup>, in order to determine the structural characteristics of vegetation of the oceanic dunes of Crispin, Marapanin Municipality, Para State, and Northern Brazil. A phytosociological survey on the woody and ground vegetation was conducted (Tomar *et al.* 2001) in the abundant Jhum fallows in the upper Shipra watershed

in Meghalaya. Results revealed the presence of 34 species of woody perennials belonging to 29 families and 35 species of ground vegetation belonging to 22 families comprising the fallow lands. The highest IVI was found in *Pinus kesiya* (81.5) and lowest in *Emblia officinalis* (1.02). IVI for ground vegetation were highest for *Lantana camera* (45.7) and lowest for *Inula cappalum* (1.02).

The phytosociological study was conducted on the vegetation structure of woody plant species along mountain flank of a montane forest in Narainbagar, Chamoli District in Garhwal Himalayas, Uttarakhand, India (Rawat, 2001). The flank was surveyed for floristic composition, distribution pattern, species diversity and dominance at each stratum of the woody vegetation. Plant diversity assessment in relation to the disturbances in mid-elevation forests (1300-2000 m above msl) of Nainital (Khera *et al.* 2001). During the study, higher number of trees and shrubs were recorded on the western aspect which was experiencing low erosion and great anthropogenic pressure. The tree density was recorded high at the hilltop of eastern aspect and on the hill slopes of western aspects. They observed that the presence of *Coriaria nepalensis* Wall, a non-leguminous nitrogen fixing species, in all the sites, may help in the restoration of soil and in conservation of original Pine-Oak forests.

Various qualitative parameters along the gradient and regeneration forests of Uttarkashi were earlier detailed by Pande (2002) who finally recorded higher density, Total Basal Area (TBA) and density values for north-east aspect. Similarly, Pande *et al.* (2001) studied the effect of plant species diversity and other parameters on vegetation analysis in moist temperate forest of Kedarnath Forest Division by dividing the whole area into eight sub-sites as per the aspect and altitude ranging from 1800-2800 m above msl. Pandey *et al.* (2002) described plant species diversity, various parameters of vegetation analysis and resource amongst various plant species, in a moist temperate Western Himalayan forest ecosystem located in district Chamoli, Garhwal Himalaya. For this, whole of the area was divided into eight sub-sites depending upon the altitude ranging from 1800-2820 m above msl. Negi (2002) carried out studies on diversity of Woody species of Sangla Valley (HP) by using quadrature method and found that a total of seventeen tree species and nine shrub species were the dominant woody elements.

Arunachalam (2002) analyzed the species composition and diversity in two different forest types, viz., wet evergreen and dry deciduous tropical forests of Western Ghats in India. Singh *et al.* (2002) analyzed the phytosociology of *Solanum surattense* and observed that about 55 species were associated with these plants in the selected study site of

Ganganagar district, Rajasthan. Ilorkar and Khatri (2003) conducted the phytosociological study of Navegaon National Park and measured different phytosociological attributes like density, basal area, Importance Value Index (IVI), nature of vegetation, distribution pattern and resource utilization of woody vegetation.

Pandit and Raviya (2003) studied the composition and structure of the five sites in Rana Barda (Porbandar district). In each site frequency, density, relative dominance, IVI, coefficient of variation and relative growth index were worked out. The characteristic species in the area were *Acacia senegal*, *Lantana camara* and *Premna herbacea*. Verma *et al.* (2003a) studied all the relevant details of phytodiversity including chemical properties of soil under the *Betula utilis* D. Don forest in Gramphu- a Cold Region of Lahaul–Spiti, Himachal Pradesh. The study revealed that the number of species comprising ground flora were (38) within the forest area when compared to their number outside the forest (14). Similar studies were also conducted by Verma *et al.* (2003b) in Man Lunga valley (north-east aspect) and Khamengar valley (southern aspect), falling in Pin Valley National Park.

Samant and Joshi (2004) gave comprehensive information on site and habitat characteristics, community diversity and distribution pattern, vegetation composition (species richness, richness of native, endemic and economically important species) and structural pattern of woody species. Further, communities have been prioritized based on their conservation value of Nanda Devi Biosphere Reserve, Western Himalaya. Bhatt *et al.* (2004) reported community structure and diversity of a moist mixed temperate forest of Notha-Churikhhal, situated in Pauri district of Garhwal Himalaya on the altitude ranging from 1700-2300 m above msl. The values of density and basal cover for different species in the study area ranged from 10 to 490 plants/ ha and 0.36 to 126.48 m<sup>2</sup>/ ha in different sites, respectively.

Srivastava (2004) gave an overview of the state-of-the-art, forest (sal, mixed, riparian, deciduous and miscellaneous forests) and vegetation type (grasslands, aquatic vegetation), floristic composition, endemic species and ethnobotanical studies in Uttar Pradesh, India. The status and conservation of algae, fungi, lichens, bryophytes (liverworts) and pteridophytes in the state are discussed. Reassessment of the phytodiversity of Gujarat state was conducted and described the quantified representation of the richness and diversity of the flora; and the different threatened and rare plants including means of conservation (Meena and Pandey, 2004).

The studies on phytodiversity was conducted in Bethuadahari sanctuary, Nadia, West Bengal and revealed that the vegetation of the area comprises 300 species which includes three species of Cycadaceae (gymnosperms) and six species of Pteridophytes (Chakraborty *et al.* 2004). Anita (2005) studied the effect of *Lantana camara* on floristic diversity in chir pine forests of Himachal Pradesh and revealed that *Lantana camara* invasion reduce the number of herbaceous plant species in study sites, change the distribution pattern of the species. Most of the species have contiguous distribution followed by random, only a few species have regular distribution pattern in the control sites as compared to the invaded site.

Kumar *et al.* (2005) analyzed quantitative study of herbaceous vegetation on elevation ranging from 1900-2400 m above msl in the temperate region of Garhwal Himalaya. Floristic composition, diversity, dominance and distribution pattern of herbaceous species were studied in three different stands, viz., undisturbed (UD), mildly disturbed (MD) and highly disturbed (HD), during three different prominent seasons (winter, summer and rainy) in the temperate forest along disturbance gradients. Mishra *et al.* (2005) conducted studies on species diversity in Bhitarkanika Mangrove ecosystem in Orissa, India and concluded that the Bhitarkanika forest block contains highest number of tree species followed by Dagmal, Kakranasi and Thakurdia blocks. Bhitarkanika and Dagmal are part of core area of Bhitarkanika wildlife sanctuary.

Kharkwal *et al.* (2005) conducted ecological studies in the central Himalayan regions of India and concluded that the distribution and species richness pattern in this region largely depends on the altitude and climatic variables like rainfall, temperature. Galav *et al.* (2005) carried out study to determine the effect of climatic variation on the phytosociological parameters of grassland communities of Southern Aravalli hills, Rajasthan, India. Verma *et al.* (2005) conducted study to assess the plant diversity around Renuka lake of Renuka wildlife sanctuary of Himachal Pradesh. A total of 109 species including regeneration of 15 trees and shrub species were recorded from the area. The distribution of all the plant species except two was contiguous and index of dominance was recorded as 0.021, whereas, index of diversity was 5.976.

Verma *et al.* (2006) conducted studies on plant diversity in alpine pasture of Shikari Devi Wild Life Sanctuary of District Mandi, Himachal Pradesh. Sharma *et al.* (2006) carried out phytosociological studies of tree species and physicochemical properties of soil in traditional Agroforestry of Chhattisgarh (Bilaspur and Raipur Districts), India, which demonstrated that the distribution of tree species was contagious and random. Tree species

such as *Acacia nilotica*, *Albizia procera* and *Butea monosperma* were found to be most successfully grown. Samant and Shreekar (2006) studied the diversity, distribution pattern and conservation status of the plant species used for treating liver diseases/ ailments in the Indian Himalayan region. They reported 34 species are native, 3 are endemic and 15 near endemic, 7 species are categorized as critically endangered as per IUCN criteria.

Phytosociological study was carried out (Sahu *et al.* 2007) in tropical dry deciduous forest of Boudh District, Eastern Ghats of Orissa, India and inventoried a total of 187 species (trees 91, shrub 10, climbers 12 and herb 74) within a four hectare sampled area. The predominant species are *Shorea robusta*, *Madhuca indica*, *Buchanania lanzan*, *Cleistanthus collinus* and *Diospyros melanoxylon*. Study area shows species rarity (Those represented by < 2 individuals) of 18 per cent. The Shannon-Weiner diversity index is 4.51; with Simpson's value 0.92 infer that tropical dry deciduous forests are also species diverse systems. Mean stand density was 591/ha and mean basal area was 25.50 m<sup>2</sup>/ ha stand density and species richness have consistently decreased with increasing girth class of tree species. Girth class having <30 cm gbh contributed to about 68.13 per cent of species richness.

Species diversity and community structure of ferns and fern allies were studied in Tarai forest, which are characterized by tropical deciduous forests, in the Balmikinagar, District West Champaran of Bihar and Kusumi forest, District Gorakhpur of Uttar Pradesh, India situated adjacent to India-Nepal border (Alka Kumari and Tripathi, 2007). These forests consist approximately 45 fern species belonging to 16 families in which maximum species are of the family Selaginellaceae (63%) followed by Adiantaceae (38%) and Thelypteridaceae (31%). *Selaginella* had the maximum number of species while *Dryopteris cochleata* was found to be the most dominant. Viraj *et al.* (2007) conducted a survey of Sangla valley of district Kinnaur in Himachal Pradesh. A total of 26 threatened plant species, belonging to 16 families and 22 genera of which 5 critically endangered, 7 endangered and 14 vulnerable plant species were recorded as per IUCN classification. Samant *et al.* (2007) identified a total of 643 species of medicinal plants and are classified according to nativeness, endemism, and rarity and prioritized for cultivation.

The investigation was undertaken to characterize the floristic composition, vegetation diversity and distribution pattern of medicinal and aromatic plants (Dutt *et al.* 2007) at different altitudinal zones of Sangla valley in Himachal Pradesh. The study revealed that the important value index (IVI) of different species varies from site to site. Majority of herb species exhibited contiguous distribution pattern, followed by random

distribution pattern. Whereas, most of the shrub species showed random distribution pattern followed by the contiguous distribution pattern. Viraj and Dutt (2008a) conducted studies on diversity and distribution pattern of high altitude medicinal and aromatic plants of Sangla valley in Himachal Pradesh. The Population ecology of the Himalayan Yew (*Taxus baccata* subsp. *wallichiana*) was studied (Shreekar and Samant, 2008) in Khokhan Wildlife Sanctuary of North Western Himalaya for conservation management by sampling six forest communities of the wildlife sanctuary.

Verma *et al.* (2008) recorded 75 species of plant, comprising of 7 grasses, 4 sedges, 4 leguminous forbs and 60 non-leguminous forbs from the Talra Wildlife Sanctuary of district Shimla, Himachal Pradesh. The distribution of all the plant species was contiguous. Index of dominance was 0.036 and index of diversity 5.386. The Phytosociological study in natural forests of Hastinapur has been conducted (Khurana and Kalpana, 2008) and the species richness, biodiversity index and total number of plants of three forests sites were measured.

The investigation was undertaken to study the structural parameters of woody elements in Sangla valley of district Kinnaur, Himachal Pradesh. Dominant, co-dominant and associated species in each transect were worked out in accordance to their IVI values (Bawa, *et al.*2009).

Phenology is generally described as an art of observing the phases of the life cycle or the activities of the organism as they occurred through the year. The study deals with the floristic diversity and phenological behavior of the woody elements in Dodra Kwar forest range in Himachal Pradesh (Bawa, *et al.*2011).

The investigation done in Sangla valley revealed that variation in different phenophases of the vegetation during the same and different growing seasons was due to variation in climatic conditions, altitudinal variation, aspect, genetic alterations and original behavior of different plant species. The study is helpful in knowing the abrupt changes that occur in different plant communities in different habitats (Bawa *et al.*, 2011).

The composition of forest vegetation along an altitudinal gradient (400-525 m and 525-650 m) in Simbalwara wildlife sanctuary was studied (Verma *et al.* 2009). The forest is composed of 53 species of trees, 32 of shrubs and 175 of herbs. The distribution pattern of plant species was random and contiguous at both the altitudes.

Tripathi and Singh (2009) studied species diversity, structure and concentration of dominance of woody plants at various strata of natural and plantation forests within the

Katerniaghat Wildlife Sanctuary, north India. The tree densities were higher in plantation as compared to natural forests. The vegetation composition and diversity was studied in the reclaimed mines in Sirmour district of Himachal Pradesh (Saxena and Soni, 2010). A chronosequence of four reclaimed sites and an adjoining stands of natural forest were selected and periodical phytosociological studies undertaken.

Rohit and Sharma (2010) conducted ecological studies and revealed the dominance, diversity and species richness of tree species along an altitudinal gradient of Mandakini catchment of Garhwal Himalaya. The study revealed that diversity/ha and total basal area values of the selected stands ranged between 2084 to 600 trees/ha and 55.44- 6-.36 m<sup>2</sup>/ha, respectively. The ecology of medicinal plants were carried out and observed that (Ram *et al.* 2010) the most frequent medicinal herb was *Artemisia nilagerica* while large number of medicinal herbs was rarely distributed in these forests. It was concluded that the natural distribution and their associations would be important for growing and covering the medicinal herbs in the Uttarakhand Himalaya.

The study was conducted to estimate the floristic diversity and vegetation types of Rawa district in Madhya Pradesh (Shukla *et al.* 2010). The floristic analysis of data revealed that the family Poaceae shows maximum diversity represented by 101 species, followed by Fabaceae with 65 spp., Cyperaceae with 37 spp., Asteraceae with 36 spp., Euphorbiaceae 31 spp. etc. A brief account of area, climatic conditions, vegetation types, floristic analysis and brief note on economic plants, invasive and threatened taxa have been discussed.

Srivastava and Banerjee (2010) identified three monitoring locations were selected in the vicinity of industrial estate and data were collected to compute species richness, Evenness, Importance Value Index (IVI), Shannon-Wiener diversity Index and Simpson's Index of biodiversity. The Simpson's Index of biodiversity varied at a range 0.28 to 0.41, signifies the presence of less biodiversity. Species Evenness, a measure of relative abundance of the different species was at a range of 0.36 to 0.46. Verma and Kapoor (2010) carried out assessment of floristic diversity in Pooh valley of cold desert of district Kinnaur, Himachal Pradesh and reported that the distribution pattern of most of the plant species was contiguous. The index of diversity for herb species was reported 3.89, 3.86 and 3.81 for 2700-3200m, 3200-3700m and 3700-4200m elevation ranges, respectively. The study was undertaken to understand the community behavior of *Nardostachys jatamansi* in three density classes (Vasistha *et al.* 2011) viz., maximum, moderate and minimum in sub alpine and alpine areas of Yamunotri region of Uttarkashi district in Uttarakhand.

A study was conducted by Verma and Kapoor (2011a) to understand the plant diversity along an altitudinal gradient with elevations varying from 3000 m to 5000 m above msl in Ropa- Giavung valley falling in cold desert area of Pooch sub division of district Kinnaur, Himachal Pradesh during 2008. The dominant families were Asteraceae, Polygonaceae, Rosaceae and Ranunculaceae. On the basis of Importance Value Index (IVI), *Ephedra gerardiana*, *Artemisia brevifolia*, *Bistorta affinis* and *Potentilla argrophylla* were the dominant herbs dotting different elevational ranges and distribution pattern of plant species was mostly contiguous in all the altitudes. Index of similarity for herb species between different altitudes was low indicating more dissimilarity of species between different altitudes.

Verma and Kapoor (2011b) conducted study to assess the plant at elevation varying from 300 m to 4500 m above msl in Murti Pang Valley of Rakchham Chitkul Wildlife Sanctuary of District Kinnaur, Himachal Pradesh. A total number of 131 plant species belonging to 46 families and 91 genera was collected. The dominant families were Asteraceae, Rosaceae, Polygonaceae, Lamiaceae and Ranunculaceae. The dominant tree species was recorded as *Populus ciliata* and *Juniperus polycarpus*, whereas among the shrub species, *Berberis jaeschkeana* and *Juniperus indica* were dominant at 3300-3700m and 3700-4100m above msl, respectively. The herb species *Sibbaldia cuneata*, *Thymus linearis* and *Heracleum lanatum* were recorded as dominant at 300-3700m, 3700-4100m and 4100-4500m above msl, respectively. Index of diversity for herb was 4.02, 3.78 and 3.67 for 3300-3700m, 3700-4100m and 4100-4500m above msl, respectively. A study was conducted (Verma and Kapoor, 2012) to understand the plant diversity along an altitudinal gradient elevation varying from 2400-2625m above msl in alpine areas of Dainkund in Kalatop Khajjiar Wildlife Sanctuary in District, Himachal Pradesh. The total number of shrub and herb species was recorded 10 and 53, respectively. The dominant shrub and herb was recorded as *Viburnum erubescens* and *Erigeron multiradiatus* respectively. The richness index for shrub and herb species was recorded 1.463 and 7.148, respectively.

Pant and Samant (2012) conducted the studies on diversity and regeneration status of tree species in Khokhan Wildlife Sanctuary of Kullu district, Himachal Pradesh. Rawat and Chandra (2012) carried out tree layer vegetational analysis in temperate forest of Uttarakhand and recorded the maximum species richness was at moist habitat, while minimum at stream bank habitat and ridge habitat. *Lyonia ovalifolia*, *Quercus leucotricophora*, *Rhododendron arboreum* and *Myrica esculenta* was the dominant tree

species. Species diversity was maximum on moist habitat. The present study concludes that the distribution and species richness pattern in this region largely depend on the altitude and climatic variables like rainfall and temperature.

The investigations were carried out by Mishra *et al.* (2012) to record the annual variation in phytosociological status and population dynamics of herbaceous flora of Anapara region in Sonebhadra district of U.P. The phytosociological aspects, viz., Relative Frequency, Relative Density, Relative Dominance as well as the Importance Value Index (IVI) of three representative genera namely *Vernonia*, *Tridax* and *Parthenium* of family Asteraceae were studied thoroughly for three successive years. Banarjee *et al.* (2012) documented biodiversity of the two fenced area of Dhanolti reserve forest of Mussoorie forest division with the view of long term ecological monitoring of biodiversity with inventory of its floral and faunal diversity.

Bisht and Sharma (2014) collected 169 plant species from the communities of Bharsar and adjoining area of Pauri Garhwal District, Uttarakhand, India. Among which 40 species of vegetables, 19 species of forest and agroforestry, 24 species of ornamental flower, 71 species of lesser known medicinal plants and 15 species of agricultural crops which were economically important as they were used by the people frequently for various purposes. Negi and Subramani (2002) documented the genetic resources of wild edible plant and traditional recipes in Kinnaur district of Himachal Pradesh, India. Their study revealed that the herbs contributed the highest proportion of the edible species (57) followed by trees (32), shrubs (26) and climber (1). Fruits (50) are the highly consumed plant parts, followed by leaves (33), seeds (23), bulbs (6), resin/gum (6), roots (5), flowers (4), shoots (4), bark (2) and tubers (2), respectively.

## **2.1 ETHNOBOTANICAL STUDIES**

The role of traditional and folk medicines is well known and plays a vital role in the treatment of various human ailments. For many centuries the aborigines had a traditionally self managed system of folk medicine mainly based on herbal remedies. Modern medical facilities could not reach as yet in the remote and far flung areas. Ethnic people have deep belief in the traditional system of native folklore-medicine for remedies and rely exclusively on herbal cures.

The plant remedies of primitive societies, handed down by word of mouth from generation to generation, gradually became part of the knowledge of ancient civilizations.

They were described in ancient books, on Egyptian Papyri, on Babylonian clay tablets and on temple walls. Plant drugs were written in China during 5000 years ago. The first God of healing was Emperor Shen Nung, who, according to legend, tried out the medicinal value of hundreds of herbs. He is supposed to have described 250 plants in the first Chinese herbal, written about 2700 B. C. This work became the foundation of all latter Chinese works on plants. The most famous of this later work is the Great Herbal, the Pen-Ts'ao of KangMu published in 1596 during the Ming Dynastry. All the plant of China was collected in this fifty-two-volume work. Over a thousand plants were listed, with their history, the prescribed dosage and the methods of preparation. Some of these herbal remedies are being used in China today, along with the most modern twentieth-century medicines (Selsam, 1959). The Greeks learned much from the ancient writing in Egypt and Babylonia. Hippocrates, called as the father of medicine, described the use of many plant drugs in the fifth century, B.C. Aristotle's pupil, Theophrastus, wrote, about 300 B.C., an Inquiry into Plants. These book sums up the knowledge of plants gained up to that time and the section on medicine lists 500 plants.

The superstitions in the sixteenth century were called the Doctrine of Signatures. According to this, every plant showed some sign of its intended use. If a plant had leaves shaped like the lobes of the liver, it was undoubtedly meant for diseases of the liver. If it had heart shaped leaves, it was surely beneficial to the heart. Yellow plants must be for the cure of yellow diseases like jaundice. *Saxifraga* species, which grew among broken rocks and crumble them, would crumble the stones in a man's kidney. We still have remains of the Doctrine of Signatures in the common names of many plants like heartsease, liver leaf, etc. The first book about medicinal plants actually written in America was the Aztec Herbal of 1552. The author was an Aztec Indian Doctor, Martin de la Cruz, who was studying at the college of Santa Cruz in Mexico. The book was translated into latin by a fellow Aztec, Juannes Badianus. The curative value of hundreds of native Mexican plants was pictured and described in this beautiful manuscript.

The Rigveda believed to have been written about 5000 B.C. and regarded as first authentic record of human civilization, mentioning many plants for their beneficial effects. The systematic study of Indian vegetable drugs was carried out in early nineteenth century. Probably the botanical observations of selected plants are the first step in such a direction. The *Catalogue of Indian Medicinal Plants and Drugs* was followed by the *Bengal Dispensary* and *Pharmacopoeia of O'Shaughnessy* (1841) where in the properties and uses

of the medicinal plants were mentioned. The *Pharmacopoeia of India* was published for more understanding about the indigenous medicinal plants. Some important drugs of India from this work were incorporated in *British Pharmacopoeia*. The *Translation of Sanskrit Materia Medica* and the *Materia Medica of Madras* brought a good account of drugs used by the then Hindu physicians. The *Vegetable Materia Medica* of Western India was also a good contribution to indigenous drugs work conducted by different people (1890-93) as *Pharmacographia India* were practically the *Compendium of Indigenous Medicinal Plants*.

Later on encyclopedia work (1889-1890) *The Economic Products of India* was completed and this catered information on vegetable drugs. *The Indigenous Drugs of India* (1896), *Indian Medicinal Plants* (1958), *Indian Meteria Medica* (1954) and *The Wealth of India* (1948-74, 1994) are the note-worthy publications in this field of study (Pal and Jain, 1998). Western Himalayas being an emporium of medicinal plants holds great references to ethno-botanical studies. There is a rich wealth of information on the identity and distribution of different plant species of the region in the form of regional floras, reports of botanical expeditions floras, monographic accounts of families, genera and similar other publications. Different workers have carried out such studies in Himachal Pradesh (Shabnam, 1954).

Chauhan (1974) reported the use of *Ainsliea aptera* for curing acute gastritis by the Gujjars, Gaddies and Vaidis residing in the remote parts of Himachal Pradesh. Uniyal and Chauhan (1979) reported 30 Indian medicinal plants used in Tibetan medicines at Tibetan Medicinal Centre, Mecleod-Ganj, Dharamshala, district Kangra. Murty and Sharma (1984) reported the use of some plants as narcotic by the tribals of Orissa. Among the list are included *Anthocephalus chinensis*, *Ardisia solanacea*, *Musa paradisiaca*, *Holarrhena antidysentrica*, *Clerodendron indicum*, etc. Similarly, Ommachan and Maish (1991) enumerated 233 flowering plants from tribal dominated district of Madhya Pradesh and brought out valuable information regarding the local use of plants. Among the plants used for specific purposes included *Rauvolfia serpentina* for blood pressure, *Barleria prinitis* for whooping cough and tuberculosis, *Smilax zeylanica* for venereal diseases and *Jatropha curcas* for cancer.

Hosagaudhar and Henry (1993) reported the traditional use of plants for inducing sterility and increasing fertility in women, by the tribes of the Rangana Betta in Mysore. They reported that the roots of *Adiantum lunulatum* and *Nephrolepis cordifolia* are used in cases of permanent sterility in women. The stem bark of *Elaeocarpus tuberculatus* and

*Schliechera oleosa* is used as an abortifacient and that of *Ficus* species to promote fertility in women. Aminudin (1996) highlighted the use of locally available plant wealth by the tribals of Paudi Bhuinya of Bonar hills in district Sundargarh, for day to day use. Some important plant uses included *Ardisia solanacea* in bodyache, *Baliospermum montanum* in indigestion, *Desmodium velutinum* in diarrhoea, *Murraya paniculata* in fracture.

Chauhan (1997) documented the ecological and ethno-botanical studies on the flora of Spiti. Out of 477, identified species, 74 were categorized as medicinal and aromatic plants, 104 plant species with ethno-botanical importance were recorded. Similarly, Sharma (1998) did ethno-botanical studies of Gaddies- A tribal community in district Kangra of Himachal Pradesh. He collected 161 species belonging to 124 genera and 54 families. The ethno-botanical study was carried out by Chauhan and Chauhan (1988) among Paharis inhabiting the trans Giri area of Sirmour district in Himachal Pradesh. Kumar and Pullaiah (1998) revealed first hand information gathered on 50 ethno-medicinal plants traditionally used by Chenchu, Yanadi, Suga and Yerukala tribes of Prakasam of Andhra Pradesh for the treatment of various diseases and disorders.

Bhatt *et al.* (1999) described 54 ethno-medicinal plants, which were used by tribals and rural people of Jhuni and adjoining villages near Pindari glacier of Bageshwar district. Chaurasia *et al.* (1999) conducted an ethno-medico-botanical survey of Nubra Valley of Ladakh and documented 36 plant species of ethnomedicinal properties along with botanical name, local name, family, locality, altitude, brief notes and specific uses. Yonzone and Yonzone (1999) listed the ethno-botanical uses of 18 plants for food, medicine, paper, pesticides and other purposes, among the 18 tribal communities in Darjeeling Himalayas. Awasthi and Goel (1999) ethnobotanical studies were carried out among members of the Onges tribe. A brief account of geography of Little Andaman Island is presented. Seventy one plant species used for various purposes in day to day life (medicinal, food, fuel, fish poison, building materials etc.) are listed in alphabetical order of Latin name, with family and common names, part(s) used, mode of application and voucher number.

Poll (1999) carried out study on medicinal plants in area of Mayan culture, such as Guatemala, has been significant since ancient times. They found that many habitants of rural area depended greatly on the use of medicinal plants to treat diseases and disorders. Based on the results of ethnobotanical studies 10 common species of medicinal plants with hypoglycaemic effect were described. Sharma and Rana (1999) enlisted the ethno-botanical, Ayurvedic and pharmacological uses of 27 plant species used in rural areas in Himachal

hills, Himachal Pradesh. Singh (1999) gave a brief ethno-botanical account of 109 plant species belonging to 41 families and 86 genera found in Kullu district of North western Himalayas.

Natarajan *et al.* (2000) did ethno-pharmacological study from Kullu district and reported that local women in hamlets of Banjar Taluka, Kullu district, used 34 plant species. Singh and Kaushal (2000) gathered information on the traditional use of 14 medicinal plants, which are utilized in Veterinary medicine by the Gaddies of Kangra valley for preparing powder, paste, aqueous extract, decoction, etc., for treating the sick animals. Verma (2000) carried out ethno-botanical study and collected 250 species of ethno-botanical importance under 213 genera and 80 families from different locations of Kunihar forest division of Himachal Pradesh.

Khanna and Ramesh (2000) gave an account of ethno-medicinal uses of 50 plant species known among the Gujjar tribes of Saharanpur district of Uttar Pradesh. Comparison of their uses with those mentioned in the concerned literature indicated that 22 ethno-medicinal uses of plants were not reported earlier. Silori and Rana (2000) described the indigenous knowledge on medicinal plants in Narayan Sarovar Sanctuary in the arid district Kachchh of Gujarat State. They enlisted 34 medicinal plants and their uses to cure a range of diseases. Of these, 27 species had multiple use efficiencies for treating more than one disease individually or in combination with other medicinal plants.

Rajendran *et al.* (2001) did an ethno-botanical survey for collection of plant samples, which were used as ethno-medicinal by Valaya tribals of Seithur hills of Virudunagar district forest division. The survey revealed the uses of 36 plant species belonging to 33 genera and 24 families of flowering plants. Similarly, Singh *et al.* (2001) collected a total of 39 aromatic plant species from far- flung areas and higher passes of Ladakh and Lahaul and Spiti along with their various local uses. Viswanathan *et al.* (2001) gave an account of 56 ethno-medicines used in 49 preparations by the Kanis or Kanikkars in the Kalakkad-Mundanthurai Tiger Reserve of Tamil Nadu, India. The ethno-medicinal data include botanical name of the plant, family, locality, tribal names and medicinal use of voucher specimens.

Nautiyal *et al.* (2001) conducted a study on indigenous knowledge system of some tribes in Bhagirathi valley's of Garhwal Himalayas and concluded that Bhotiya communities use over 220 wild plant species, either as whole plant or as their parts (including roots, tubers, leaves, stem and bark) of these 80 per cent were used for medicine,

directly or indirectly. Negi and Subramani (2002) carried out an ethnobotanical survey of the tribal village Chhitkul, district Kinnaur, Himachal Pradesh, which resulted in the recording of 17 plant species of medicinal importance, 25 of edible and agricultural value, 14 of cultural religious importance and 22 species of fuel, fodder and timber values. Punjani (2002) revealed the information on 63 plant species from 60 genera and 36 angiosperms families used for the therapy of various ailments by the tribals of Danta Taluka, Banaskantha district of Gujarat State.

An ethnobotanical survey conducted in the Ayyanar Koil reserve forest of Tamil Nadu, India, revealed 43 plants with different medicinal properties were tabulated. Of these 14 plants were used for treatment of fevers including malarial fevers and also to treat cuts and wounds. Similarly, about 12 species were used for treating bronchial asthma and acute coughs, respectively (Rajendran *et al.* 2003). The Ethnobotanical studies were conducted in Melpattu Reserve forest, Javvadu Hills of Eastern Ghats, Tamil Nadu, India to document the floristic composition and population in the area. A total of 63 species were enumerated. Each species is provided with a brief description, frequency of occurrence, habitat followed by information on medicinal uses (Ravi and Sankar 2003). An ethnobotanical survey of the Iggede-speaking area of Nigeria indicated that over 30 taxa of plants were used in traditional medicines, a total of 31 prescriptions for different kinds of ailments or therapeutic indications were noted (Igoli *et al.* 2003).

Pakia and Cooke (2003) carried out the ethnobotanical studies on medicinal plants uses of three Midzichenda tribes and found that a significant proportion (56%) of all plant species used were employed for the basic health care system and magical rituals while other medicinal plants were used only on the basis of mythical beliefs within the society. Out of 5856 flowering plants recorded in Nepal, 690 species are identified as medicinal plants. A vast majority of rural people in Nepal still practice traditional knowledge and depend on medicinal plants for primary health care. Collection and trade of medicinal and aromatic plants has also been the source of their income (Sharma *et al.* 2004). Medicinal plants of commercial value are in a state of threat due to deforestation and over harvesting. For this reason conservation, management and sustainable utilization of medicinal plants is necessary for Nepal.

Singh and Pundir (2004) collected some information on the ethnomedicinal plants used by the tribal people of Jaunsar-Bawar and also listed their botanical name, family, English name, vernacular name, habit and habitat, flowering and fruiting season and their

ethno-medicinal uses. Singh and Pundir (2004) conducted the studies on indigenous knowledge and conservation practices of biological resources among the tribal society. Similarly, Gonzalez *et al.* (2004) conducted a study on traditional therapeutic use of 84 species belonging to 38 families of medicinal plants with the aim to resecure and preserve a part of the traditional culture in Galicia and Spain.

Chatterjee (2004) conducted a study on the ethnobotanical resources of India, their utilization patterns in the tribal dominated areas in general and in the North-Eastern Himalayan region in particular. He concluded that tribe of North Eastern region uses more herb species, whereas Western Indian tribes would prefer more tree and shrubby species. Bhattacharya and Krishna (2004) gave the significance and potential of medicinal plants for rural women and child health care. The trend and the existing use of the major species of medicinal value for the cure of women and children diseases were described. Bondya and Sharma (2004) conducted ethnobotanical studies on plants used for the treatment of diabetes in the Bharagora Block of Jharkhand, India and concluded that 11 ethnomedicinal plants used in the treatment of diabetes along with their local names and mode of preparation and administration.

Singh and Chauhan (2005) also recorded the plant habit, plant characteristics, plant part used of 43 plant species belonging to 25 families and also their local use in curing different diseases in Lahaul valley. Pandey and Verma (2005) study revealed marvellous aspect of ethnobotany, 'remedy through plant wreath' has been explored out from the aboriginals of sub-himalayan Tarai region of Uttar Pradesh, India. The study provides an enumeration of 16 plants with their pharmacognostic features and uses in a novel way with clinical confirmations in some cases. Sharma and Lal (2005) gave the indigenous therapeutic application and other traditional uses of 9 plant species that are used by natives of Himachal Pradesh, India. The information provided includes scientific name, family name, vernacular name, distribution and ethnobotanical use along with the common used are recorded from relevant literature.

Rajiv and Vijendra (2005) enumerated some medicinal plants used for common diseases by traditional healers Central India. Khumbongmayum *et al.* (2005) ethnobotanical studies carried out in the four sacred groves of Manipur (India) revealed therapeutic applications of 120 plant species representing 106 genera and 57 families. Tree species contributed the maximum having 42% while herbs recorded 33 per cent of the total medicinal plants. These plants are used for a wide range of common ailments such as skin

disorders, ulcer, rheumatism and bronchitis. Leaves are the major plant parts used for the preparations of medicine by the medicine-men (Maibas). Most of the plant parts are harvested from the wild. It has been observed that the species that are scarce locally in the forest due to various developmental activities, deforestation and over-exploitation are abundant in the sacred groves.

The use of plants by the native people of the Saurashtra region of Gujarat, India for the cure of diarrhoea is described uses of 162 plant species and along with their local names and other information (Jadeja *et al.* 2005). An ethnobotanical study (Begum *et al.* 2005) revealed that 44 species of 31 families are being used by the local people of Dheri/Julagram Malakand Agency (Pakistan). These plants were invariably used as crude drugs for treating various diseases. Local name and disease treated is recorded. The information collected shows that the people mostly use allopathic medicines. The ethnobotanical knowledge about the use of medicinal plants rests mainly with the elders.

Exploration trips (Reddy *et al.* 2005a) were undertaken for ethnobotanical studies and germplasm collection of the traditional Ayurvedic medicinal plants. medicinal plant species belonging to 21 families have been enumerated, highlighting local medicinal uses practiced by local tribals and villagers since ages. Similarly Reddy *et al.* (2005b) conducted ethnobotanical studies in the Eastern Ghats region of Andhra Pradesh, India, covering Chittoor, Cuddapah, East Godavari, Guntur, Khammam, Krishna, Kurnool, West Godavari and Visakhapatnam districts and the tribal populations of Chenchus, Erukalas, Koyas, Konda Reddis, Lambdas (Sugalis), Nukadoras, Valmikas and Yanadis. The studies brought to light the ethnic uses of 21 epiphytic and terrestrial orchids.

The study on weeds as medicinal plants used by the traditional healers in Bhojpur district of Bihar, India, for treating ailments and also discussed the medicinal and other useful weed species with their name and its medicinal uses. Information on other general economic importance of medicinal weeds is also described (Rai and Pandey, 2005). The investigation were carried out to enumeration of plants with medicinal values, which are used by the Valaiyans, an ethnic group, residing in and around Piranmalai Hills, Tamil Nadu, South India (Sandhya *et al.* 2005). The study elucidates a rich and unique profile of Phytodiversity of the area surveyed, with 63 species of medicinal plants belonging to 59 genera and 38 families.

Viraj and Dutt (2007) carried out survey in the Sangla valley of tribal district Kinnaur in Himachal Pradesh and collected information on plants of religious beliefs. A result of interaction with the local people the information on 8 plant species belonging to 7 genera from 7 families was collected. Chauhan *et al.* (2007) gave the information on 241 multipurpose plant species found in Kullu valley of Himachal Pradesh along with their botanical name, local name along with uses. Kumar *et al.* (2008) conducted the studies on ethno-medicinal values of plant species used by Sahariya tribe of Lalitpur district in Bundelkhand region and revealed 29 plant species that are used for treatment of various day to day diseases.

The ethnobotanical studies have been carried out among the tribes of Sangla valley of district Kinnaur in Himachal Pradesh (Viraj and Dutt, 2008b). As a result of interaction with the local people the traditional information on plant species were recorded and are presented along with their botanical name, local name and their local uses. Balakrishanan *et al.* (2009) conducted ethnobotanical studies among villagers from Dharapuram Taluk, Tamil Nadu and reported that thirty one formulations incorporating 31 plant species as being used for treatment of female reproductive disorders. Gupta *et al.* (2010) conducted ethnobotanical survey in villages of Deoband tehsil of Saharanpur district of Uttar Pradesh. During the study 74 plant species from 69 genera belonging to 42 families were found of ethno-medicinal value. The plant species are enumerated in alphabetical order with families and local names, followed by their ethno-medicinal uses.

The investigation was attempt for the documentation of MFP's (Ranjeet and Joshi, 2010) used by local of the Govind Wildlife sanctuary and National Park of Uttarakhand. The study revealed that the 173 plant species belonging to different families were used for various purposes by the local people. Reddy *et al.* (2011) an ethnobotanical survey was carried out among the ethnic groups of Yerukala, Yanadi and Sugali tribals inhabited in Sheshachala hill range of Kadapa district, Andhra Pradesh, Indian. A total of 60 plant species belonging to 33 families of ethnobotanical interest upon enquiry from these tribal informants between the ages of 50-82 years were reported. The study shows a high degree novelty in the use of plants among the tribal people reflecting the revival of interest in traditional medicine. Sawan *et al.* (2011) studied the ethnobotanical shrubs used by the Golatappar fresh waterswamp forest of Dehradun, Uttarakhand. The investigation revealed medicinal properties of 24 species belonging to 23 genera under 16 families. The taxa with ethno-medicinal uses are arranged alphabetically with botanical name, local name, family

and fruiting/flowering period and their uses. Avasthe *et al.* (2012) studied the ethnobotanical edible plant biodiversity of Lepcha tribes in Sikkim.

Santvan *et al.* (2012) carried out the studies on status and uses of tree flora of Darlaghat Wildlife Sanctuary, Solan (H.P.) used for various purposes which include house construction, furniture, agricultural implements, fuel, etc. Kumari *et al.* (2012) studied the non timber forest products used for mother and child health care in tribal and non tribal communities located in Kinnaur, Lahaul, Bharmour and Pangi (tribal area) Shilai, Churah, Parvati valley and Chhauhara (non tribal but remote area) in Himachal Pradesh revealed that 9 species are used as tonic by the expecting mothers. Rana *et al.* (2012) carried out studied on extraction, utilization pattern and prioritization of Fuel resources for conservation in Manali Wildlife Sanctuary, Northwestern Himalaya. They reported 15 plants belonging to 10 families from the area which are used to extract fibre and used in traditional practices. An ethno botanical survey was carried out by Shaheen *et al.* (2014) in Kashmir Himalayas. The study revealed that 39 plants species belonging to 20 families, being used for various cosmetic purposes.

Bajpai *et al.* (2015) documented 204 tree species belonging to 143 genera and 50 families of medicinally important species of trees used by Tharu tribe in the Himalayan Terai region of India. Joshi *et al.* (2016) presented a review over Ethnopharmacology, Volatile Phytochemistry and biological activities of Himalayan aromatic medicinal plants. They summarized 116 aromatic plant species distributed over 26 families. Joshi and Pande (2016) highlighted the indigenous practices prevalent among Bhotia tribe of Kumaun of Uttarakhand for prenatal and postnatal care in women. They observed that 15 plant species of 13 families were used by tribe for curing women health related problem.

## *Chapter-3*

# **MATERIALS AND METHODS**

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The present investigation entered “**Phytosociological and Ethnobotanical Studies in Shilli Wildlife Sanctuary in District Solan, Himachal Pradesh**” was conducted during 2016-18 in Shilli Wildlife Sanctuary which falls in Solan district of Himachal Pradesh. The general description of the site under investigation has been detailed under the following heads/sub-heads:

### **3.1 GENERAL DISCRIPTION OF THE STUDY AREA**

The study was undertaken in the compartment 7, 8, 9 and 10 of the Shilli Forest, which is the protected forest of the Solan Forest Division. Data collected were used to calculate Frequency, Density and Basal area and further the data was analyzed using statistical tables and tools. Vegetational analysis is the best way to study species composition and vegetation structure in one ecosystem and IVI was calculated in vegetation analysis.

#### **3.1.1 Location and Extent**

Geographically, this sanctuary is situated between 30°54'15” to 30°54'41” latitude, 70°07'45” to 77°09'13” longitude. This is the smallest sanctuary in Himachal Pradesh covering an area of 2.13 sq. km located in district Solan. It was earlier a protected forest and was notified as a sanctuary in the year 1963 under notification nm Ft.43-51/50-VI dated 30.07.1963. On March 27, 1974, it was renotified under notification number 5-11/70-SF. Earlier it was a part of Solan Forest division, but later on was transferred to Shimla Wildlife Division under Chail Wildlife Range.

#### **3.1.2 Geology and Terrain**

Shilli Wildlife Sanctuary is well defined by hill ranges. The altitude gradually ranges from 1200 to 1800 m above mean sea level. The soil in this region where Ban oak exists is deep and consists thick moulds. In pine forest also, the soil is sandy and deep.

#### **3.1.3 Climate**

The sanctuary unfolds four seasons. The winter generally advances over from November to March. The period from April to June is summer and rainy season generally

extends from July to August. September and October exhibits autumn. The temperature range of the Shilli Wildlife Sanctuary -3°C to 33°C.

#### 3.1.4 Water availability

There are **two perennial streams** named as Bhalo and Shilli ka Nala. Feeding channels of these streams are seasonal water sources. Six ponds of Conifer Research Centre and Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni (Solan) at Research Centre Shilli are also the water sources for human as well as animal consumption. Tanks at Bajhrol, Malaun and Shilli also fulfill the needs of local inhabitants.

### 3.2 FLORA

Reconnaissance survey was taken up initially to record and find out floristically opulent as well as various types of vegetation was undertaken in the entire study area during first year of the study. Informal discussions on particular issue pertaining to the same were also held with concerned staff of the Forest and Wildlife Departments and also with the local people as well. After building this unofficial and fundamental information, a detailed plan was developed for botanizing the area by regular field collection trips in special location with rich floral wealth, covering microhabitats, various types of vegetation in different areas in different altitudes. Each area was visited three times, i.e., during April to June for data collecting flora during spring and pre-monsoon, during July to September to enumerate the monsoon flora and during October to November to cover plants of autumn season. During survey, relevant details of the data concerning to the habitat, microhabitat characteristics and phenological period of each of the species were collected. Photographs of the important plants in their natural habitats, some distinct vegetation types were also taken as a part of the documentation and presented in the thesis as colored plates.

The flora of the area is distributed into three stories, which are as follows:

- Upper storey: *Cedrus deodora*, *Quercus leucotrichophora*, *Pinus roxburghii*, *Rhododendron arboretum* and exotic pines (Introduced) *Pinus banksiana*, *Pinus palustris*, *Pinus taeda*, etc.
- Middle storey: *Rhododendron arboretum* and *Pyrus pashia*.
- Ground cover: *Rubus ellipticus*, *Rosa moschata*, *Sarcocoea saligna*, *Daphne cannabina* and various Ferns.

### **3.3 FAUNAL BIODIVERSITY AND ANALYTICAL FRAME OF WORK**

As far as animals are concerned the sanctuary area is habited by carnivores namely- *Panthera pardus* is present. Herbivores are Barking deer, Ghorl, Hare, Porcupine Langoor etc. The Omnivore is Fox. At least 139 bird species have been reported in the site. (Naim Akhtar pers. Comm.. 2003), including five species of pheasants namely cheer (*Catreus wallichii*), Koklass (*Pucrasia macrolopha*), Kaleej (*Lophura leucomelanos*), Peafowl (*Pavo cristatus*), and Red Junglefowl (*Gallus gallus*). While Cheer Pheasant occur only in grassland, Kaleej and Koklass occur in oak forest. In the late 1970s, Gaston and Singh (1980) and Gaston *et al.* (1981) estimated 40 to 60 pairs, while in March 1983, Gaston *et al.* (1992) estimated a minimum of 32 pairs.

### **3.4 TRADITIONAL RIGHTS**

Local people have traditional rights of habitation, viz., grazing, collection of timber, firewood and other minor forest produce, fodder extraction rights. Rights also exist in relation to burial grounds, religious yatra and religious monuments. In core zone of nearly 100 hectares the forest area is free from these rights, where only rights of way (passage) are allowed.

### **3.5 OTHER BIOTIC FACTORS AFFECTING HABITAT**

Forest fire and hail storms are known to occur in this Sanctuary. During 1984-85, 1364 hectares area was affected by forest fires. There appears to be a severe shortage of water in the sanctuary, though, in some places water holes have been dug. Drought was reported to affect the sanctuary area in 1979-80. One of the major problems of the sanctuary is the fast growing weeds like *Lantana camara*, which has even affected the cultivated lands.

### **3.6 METHODOLOGY**

This chapter details the methodology adopted for the fields survey, data collection and analysis of the information collected as per the requirements of the study.

The present investigations were undertaken for following headings:

1. To conduct phytosociological studies in different altitudinal zones of Shilli Wildlife Sanctuary.
2. To identify the species of ethnobotanical importance.

**1. PHYTOSOCIOLOGY:** Is the branch dealing with plant communities, their composition and development, and the relationship between the species within them.

### **Selection of Study Sites**

As the sanctuary lies at an altitude between 1200 to 1800 m amsl., the study area was divided into three different altitudinal zones, i.e., Zones I: 1200-1400 m; Zone II: 1400-1600 m and Zone III: 1600-1800 m above amsl. Sites were selected on each and every accessible aspect between 1200m to 1800m asml. The habitats were identified based on the physical characters and dominance of the vegetation.

Plant species growing together have mutual relation among themselves and also with the surroundings. From habitat population of plant communities varies and this helps in finding out the type of plant community (Lugo, 1978).

Shaheen *et al.* (2014) Vegetation diversity, distribution and species endemism were studied in high altitude (>3300m) Himalayan plateau in Northern Pakistan. Species diversity and richness were negatively; whereas, evenness was positively correlated with slope steepness and moisture content. Grazing was considered a threat to endemic species.

A complete list of the species present on each plot is considered an almost absolute requirement (Du reitz, 1921) for the working out of sociology of growing species. The study of phytosociology helps deeper insights into the structure composition of the vegetation.

Huttle (2000) studied the forest of the temperature region and said there is a gap of knowledge and research needs. It is still unclear whether all these requirements can be filled economically and in agreement with the concept of ecological sustainability.

It is considered that at initial stage of succession diversity increases while at the closing stage it decreases (Margalef , 1968; Whittaher; 1969).

In order to express the dominance and ecological success of any species with a single value, concept of Important Value Index has been developed. This index utilizes three characteristics, viz, Relative Basal Area, Relative Density, and Relative frequency (Mishra, 1968).

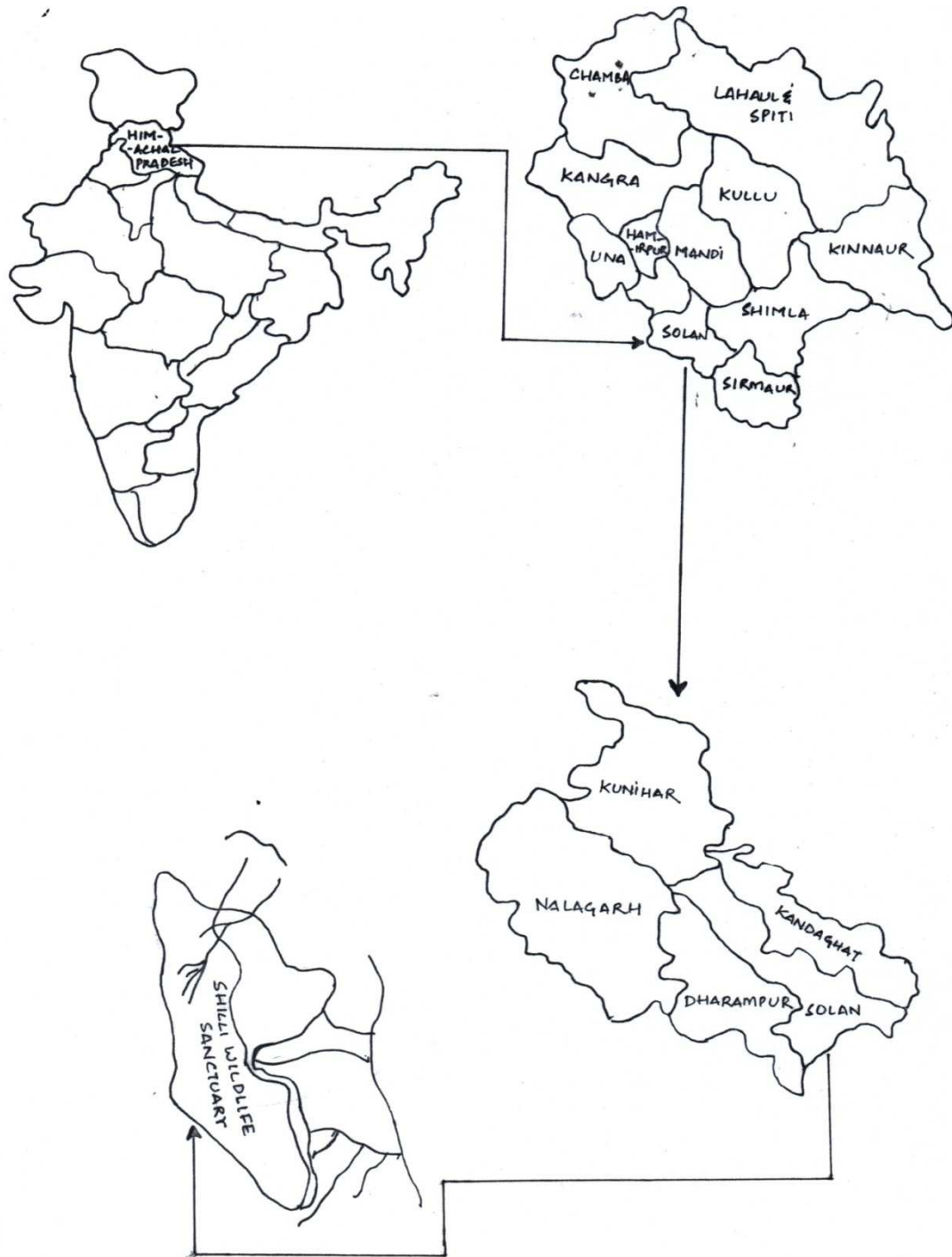
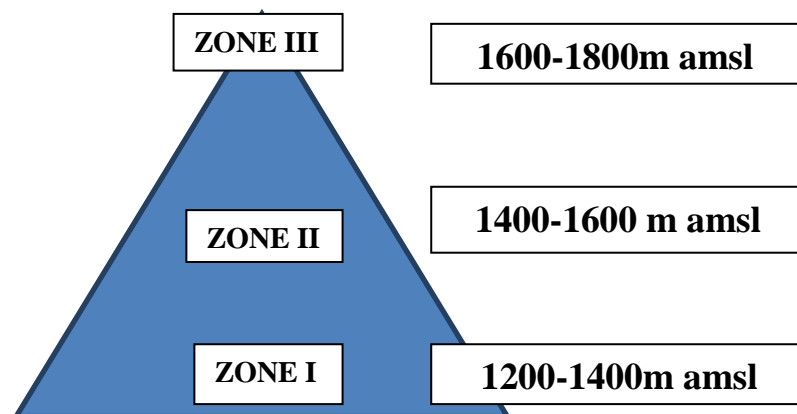


FIG-1: LOCATION OF SHILLI WILDLIFE SANCTUARY, SOLAN, HIMACHAL PRADESH



**Fig 2: Different altitudinal Zones of Shilli Wildlife Sanctuary**

**Quantitative Analysis:**

There were six quadrats in each sub-zone=9×6=54. Fifty four quadrats of 30m × 30m (900 sq m) size determined by Species area curved method were randomly but systematically laid to study Tree species. In each quadrat, a sub-quadrat of 5m × 5m (25 sq m) size for Shrubs and 2m × 2m for Herbs/regeneration study respectively, were observed.

<b>Zone III</b>	LEFT (L) Z <sub>3L</sub> (6 Quadrats)	MIDDLE (M) Z <sub>3M</sub> (6 Quadrats)	RIGHT (R) Z <sub>3R</sub> (6 Quadrats)
<b>Zone II</b>	Z <sub>2L</sub> (6 Quadrats)	Z <sub>2M</sub> (6 Quadrats)	Z <sub>2R</sub> (6 Quadrats)
<b>Zone I</b>	Z <sub>1L</sub> (6 Quadrats)	Z <sub>1M</sub> (6 Quadrats)	Z <sub>1R</sub> (6 Quadrats)

Where, Z= Zone, L=Left, M=Middle, R=Right

**Species Area Curve Method:**

The species area curve describes the relationship between the area of habitat, or of part of a habitat and the number of species found within the area. To study the status of plant diversity and natural regeneration of Shilli Wildlife Sanctuary, at each population community analysis was carried out during majority of the plants were at the peak of their growth.

For the ecological analysis of data Curtis and McIntosh (1950); Grieg Smith (1957); Kersaw (1973); Mueller-Dombois and Ellenberge (1974); Singh and Singh (1992); Dhar *et al.* (1997); Samant *et al.* (2002a and b); Samant and Joshi (2004) and Joshi and Samant (2004) have been followed. Communities were identified based on the Importance Value Index (IVI). The IVI was calculated as sum of relative frequency, relative density and relative

basal area. The abundance data of different sites were pooled to get community averages in terms of Density, Total Basal Area and IVIs.

**Density:** Density quantifies the strength of the species in the community and therefore, considered as one of the prime important character in determining community structure.

$$\text{Density} = \frac{\text{Total number of individuals of a species}}{\text{Total number of quadrat studied}}$$

**Frequency:** Frequency of an individual species denotes its spatial pattern, importance as also the evenness of spatial distribution in community. For comparison of different vegetation units frequency is expressed in terms of various species in a community

$$\text{Frequency} = \frac{\text{No. of quadrats in which species occur}}{\text{Total number of quadrat studied}}$$

**Percent Frequency:** It indicator of number of samples in the given species occurs and thus expresses the distribution of various species in a community.

$$\text{Frequency} = \frac{\text{Number of sampling unit in which species occurred}}{\text{Total number of quadrat studied}}$$

$$\text{Percent Frequency} = \frac{\text{Number of sampling unit in which species occurred}}{\text{Number of sampling units studied}} \times 100$$

**Abundance (A):**

$$\text{Abundance} = \frac{\text{Number of individuals of a species}}{\text{Number of sampling units of occurrence}}$$

**Basal Area/Dominance:** This is regarded as an index of dominance of a species. Higher basal area of a species indicates greater dominance. The average basal area and the relative basal area were calculated from the average diameter of the stem at breast height (diameter at breast height-DBH) for trees.

$$\text{Basal area} = \pi d^2 / 4$$

Where, d= Diameter

**Importance Value Index (IVI):**

A total picture of the ecological status of a species with respect to a community structure can be obtained by summing up the relative density, relative frequency and relative dominance as Importance Value Index (Curtis, 1959).

**Importance Value Index**= Relative Density + Relative Frequency + Relative Dominance

**Species Diversity:** A number of different measures of species diversity have been proposed. This exercise explores two methods namely; the Simpson Index and the Shannon-Weiner Index.

**Simpson Index:** Simpson Index of dominance was calculated using the Simpson formula (Simpson, 1949).

$$C = \sum_{i=1}^s (N_i / N)^2$$

Where, C= Simpson's Index of Dominance;

$N_i$ = Total number of  $i^{\text{th}}$  species

**Shannon Index:** The species diversity was calculated using Shannon-Weiner Index (Shannon and Weiner, 1963) as follows:

$$H = - \sum (N_i/N) \times \ln (N_i/N)$$

Where, H= Shannon Weiner Index

N= Total number of individual of all species

$N_i$ = Total number of individuals of  $i^{\text{th}}$  species

Total number of angiosperms, gymnosperms, ferns, lichens has been counted recorded and these have been suitably arranged species wise on the basis of genera, belonging to different families as per the method described by Alka Kumari and Tripathi, 2007.

Occurrence and presence of the timber yielding species in three altitudinal zones of Shilli Wildlife Sanctuary, fodder yielding species in all zones, fibers and flosses, tans and dyes, gums and resins, fuelwood species, bee flora species have been recorded according to the method explained by Sahu *et al.*, 2007.

Occurrence and presence of the species used for tantra mantra (Black Magic), occurrence of the insecticidal species, ferns and lichens used have been recorded therein and documented and classified on the basis of their families and presented in the table giving their scientific/botanical name and common name as per the method explained by Dutt *et al.*, 2007; and all the species through the help of local guide and arranged therein. Specimen sample of few species have been identified matching with herbarium species maintained here at Nauni campus and with the use of botanical plant descriptions as laid out in the book of Taxonomy text book of Dendrology and also methodology and analytical frame of work adopted by Verma *et al.*, 2012.

Presence and Occurrence of species, viz., timber, fodder, fibre, tans and dyes have been suitably arranged and their per cent share in percentage is called/considered plant community. As a whole of hundred percentage, inventory of exotic plants present in the Shilli Wildlife Sanctuary is also documented, locating them in the occurrence in the scattered patches and presented with proper identification and enlisted with their common name and identified with the help of botanical keys and their morphological features and inventory generated. Overall in all the zones per cent constitution is also marked for species group namely angiosperms, gymnosperms and ferns in total woody and non woody species as per analytical framework adopted and described by Bawa *et al.*, 2011.

Occurrence and presence of gymnosperms have been also recorded, belonging to different families and presented in the table with their scientific names and common names. Overall total numbers of species observed from the study has been documented and presented as timber species, fodder species, fibre and flosses, tans and dyes, gymnosperms, fuelwood species, bee flora, tantra mantras, insecticides according to the method as per suggested by Srivastava and Banerjee, 2010.

Different life forms of ethanobotanical plants found in total has been depicted in the table with their botanical name, local name, family, uses and explained therein with ethnobotanical use of each species.

A range of ethobotanical information gathered including plant's local name, official parts used and use/ mode of their utilization of ethnobotanical important plants have been generated as per detailed methodology suggested by Rohit and Sharma, 2010 and Shukla *et al.*, 2010.

**2. ETHNOBOTANICAL STUDIES:** It is the study of region's plant and their practical uses through the Indigenous Traditional Knowledge (ITK) of local culture and people.

The ethnobotanical study was conducted in five villages in surrounding of Shilli Wildlife Sanctuary namely

- Shilli
- Malaun
- Bhajrol
- Bhajlog and
- Phaskana

The villages were regularly visited from April 2017 to October 2017 and also during 2018. The information regarding the usage of medicinal plants, religious belief, aromatic, timber, fuel wood, fodder, etc., available in the study area was collected by using a questionnaire survey and semi structured interviews and discussions with key informants, i.e., knowledgeable elders, religious leaders, herbal healers and local vaid, family elders (both, male and female). A range of ethnobotanical information including plant local names, uses, official part of the plants used and mode of utilization was covered. Some social facts like age, gender, education were also recorded after the interview. Out of 70 householders, 50 houses were selected randomly starting from one corner of the village. A total of 50 informants in which 30 men and 20 women were interviewed. The interview was focused on the basic questions of the uses of local plants. Typical questions were asked, like which local plant they are aware of and what usage of those plants were, to assure that the information was unbiased, possible efforts were made to avoid the presence of the other people during the course of investigation.

The information regarding the usage of medicinal plants, wild edible, aromatic, timber, fuel wood, fodder, etc., available in the study area was collected by using a questionnaire survey, semi structured interviews and discussions with key informants. A range of ethnobotanical information including plant local names, uses, official parts used, and mode of utilization were covered. Information generated on the basis of eight basic questions about their awareness and response of the people from nearly five villages (male and female) as mentioned has been presented in the Table 30 with the response of the questions in two options i.e. yes or no and average value of positive response is taken into consideration and accordingly presented in an average of all response in percentage as per method suggested by Sharma *et al*, 1989.



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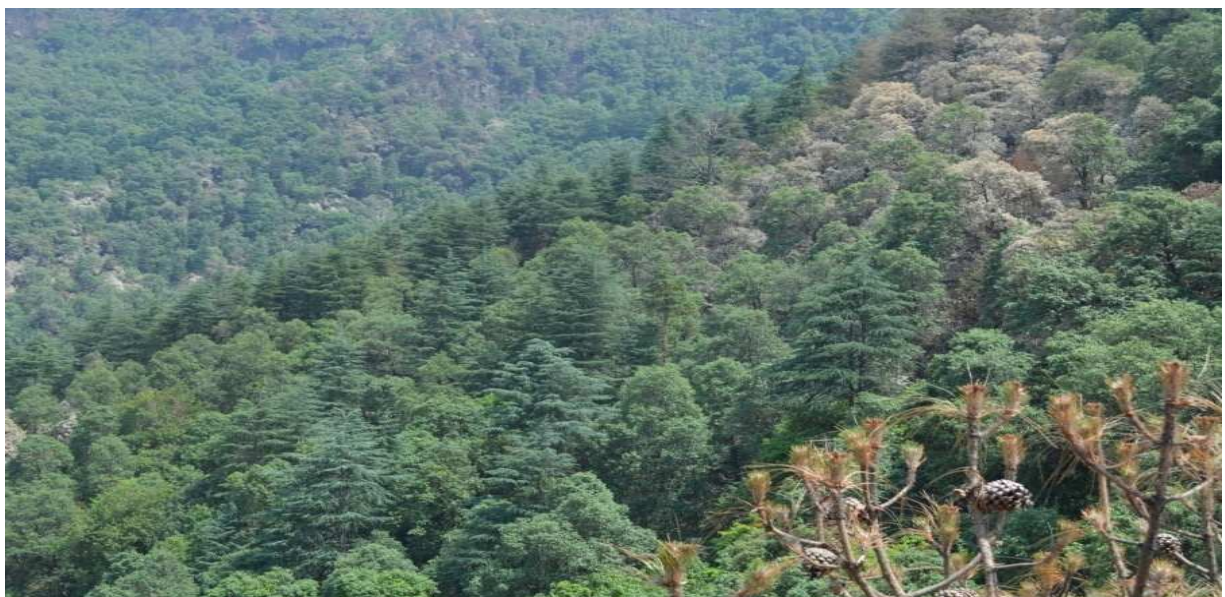
**Plate 1: Field office of Department of Tree Improvement and Genetic Resources, College of Forestry, UHF at Shilli Wildlife Sanctuary- Area under study**



**Zone I- 1200-1400 m amsl)**



**Zone II- 1400-1600 m amsl)**



**Zone III- 1600-1800 m amsl)**

**Plate 2: Different zones of Shilli Wildlife Sanctuary- Solan**

## *Chapter-4*

# **RESULTS AND DISCUSSION**

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Vegetation structure and functions in relation to the environment form the basis for complete understanding of dynamics of an ecosystem. Vegetation has always been described as the most conspicuous and characteristic aspect of the landscape. The totality of factors like climate, biotic, edaphic physiographic, generally determine complexity at any place and at any stage of its environment. The results of the present investigation entitled “**Phytosociological and Ethnobotanical Studies in Shilli Wildlife Sanctuary, District Solan, Himachal Pradesh**” are presented in the following segments/headings:

- 1. Phytosociology**
- 2. Ethnobotanical studies**

### **Species present in the study area (Shilli Wildlife Sanctuary)**

Table 1 explains complete enumeration of list of species present in the study area, i.e., Shilli Wildlife Sanctuary. Name of each species identified on the basis of morphological identification features with its common name and family to which the species belongs and inventory of the species present therein are documented and generated. Before the focus on two broad objectives under namely, Phytosociology and Ethnobotanical studies systematically in different three altitudinal zones (1200-1800 m amsl). The sanctuary has a wide range/ account of woody and non-woody species. In total, there are 301 species present and found to occur, properly identified reveals that Shilli Wildlife Sanctuary is quite rich as far as forest genetic resources are concerned being smallest wildlife sanctuary. Three hundred and one species includes various families in the study area are Asteraceae, Papilionaceae and Verbenaceae. The families Rosaceae and Acanthaceae are less dominant ones among 301 present in the study area. This is complete inventory of 301 species in three altitudinal zones of the sanctuary between 1200-1800 m above mean sea level, present over there.

**Table 1: List of species present in the Study area (Shilli Wildlife Sanctuary)**

Sr. No.	Name of Species	Common Name	Family
1	<i>Achania grandiflora</i> Linn.	Wax Mallow	Malvaceae
2	<i>Achyranthes bidentate</i> Bl.	Puth-kanda	Amaranthaceae
3	<i>Adhatoda</i> app.	Badi- Basuti	Acanthaceae
4	<i>Adiantum capillus- veneris</i> Linn.	Hansraj	Filicinaceae
5	<i>Adiantum edgeworthii</i> Hook.	Dumtuli	Filicinaceae
6	<i>Aechmananthera tomentosa</i> Nees	Nile-ka-phool	Acanthaceae
7	<i>Aerua scandens</i> Wall.	Areua	Amaranthaceae
8	<i>Ageratum conyzoides</i> Linn.	Nila-phulnu	Asteraceae
9	<i>Agrotis verticillata</i> Vill.	Agrotis	Graminae
10	<i>Ainslia eaaptera</i> DC.	Karvi- buti	Asteraceae
11	<i>Ajuga bracteosa</i> Wall.	Neel-kanthi	Verbenaceae
12	<i>Albizia lebbeck</i> L.	Siris, Sirsa	Mimosaceae
13	<i>Albizia odoratissima</i> Benth.	Klaisiris	Mimosaceae
14	<i>Alternanthera Sessilis</i> R. Br.	Jalajambo	Amaranthaceae
15	<i>Amaranthus hybridus</i> Linn.	JangliChulai	Amaranthaceae
16	<i>Anaphalis busua</i> DC.	Dharadi	Asteraceae
17	<i>Androsa cerotundifolia</i> Hard W.	Golpati - phul	Primulaceae
18	<i>Apluda aristata</i> Hack	JharuGhas	Graminae
19	<i>Arabis alpina</i> linn.	Alpine rockcress	Brassicaceae
20	<i>Arabisam amplexicaulis</i> Edgew	Arabis	Brassicaceae
21	<i>Arachhne cordifolia</i> Muell.	Kukuli	Euphorbiaceae
22	<i>Arisaema flavum</i> Schott.	Sampkimaki	Araceae
23	<i>Arisaema intermedium</i> R.Br.	Sampkimaki	Araceae
24	<i>Artemisia roxburghiana</i> Wallex.	Chairmera	Asteraceae
25	<i>Asparagus adscendens</i> Roxb.	Shatavari	Liliaceae
26	<i>Asplenium delhousiae</i> Hook.	Asplenium	Filicinaceae
27	<i>Aster molliumscululs</i> Wallex.	Wild aster	Asteraceae
28	<i>Aster thomsonii</i> C.B. Clarke	Wild aster	Asteraceae
29	<i>Athyrium schimperi</i> Moug. Ex Fee	Athurium	Filicinaceae
30	<i>Atylosia</i> spp.	Jungli- sem	Papilionaceae
31	<i>Avena fatua</i> Linn.	Janglijavi, Wild oat	Graminae
32	<i>Bahunia variegata</i> Linn.	Kanchan	Caesalpiniaceae
33	<i>Barleria cristata</i> Linn.	Tendrelu	Acanthaceae
34	<i>Begonia picta</i> Smith	Lundiara	Begoniceae
35	<i>Berberis aristata</i> DC.	Kashmal, Dharuhaldi, Daruharidr	Berberidaceae
36	<i>Berberis lyceum</i> Royle	Kashmal	Berberidaceae
37	<i>Berchemia floribunda</i> Wall.	Kaulali, Amili	Rhamnaceae
38	<i>Bergenia cilliata</i> (Haw)	Pthar chat	Saxifragaceae
39	<i>Bidens tripartite</i> Linn.	Chor- pushpi	Asteraceae
40	<i>Bidens walichii</i> DC.	Bur	Asteraceae
41	<i>Blavinvillea latifolia</i> DC.	Chota- Surajmukhi	Asteraceae
42	<i>Boenninghausenia albiflora</i> Reichenb.	Pissambar- buti	Rutaceae
43	<i>Bombax ceiba</i> Linn.	Semal,Simal	Bombacaceae
44	<i>Bromus patulus</i> Mert & Koch	Bromus	Graminae
45	<i>Buddleia paniculata</i> Wall.	Neemba	Loganiaceae
46	<i>Bupleurum falcatum</i> Linn.	Sicle leaved hare's ear	Apiaceae

47	<i>Bupleurum tenue</i> Don.	Bupleurum	Apiaceae
48	<i>Callistemon lanceolatus</i> DC.	Bottle brush	Myrtaceae
49	<i>Campanula colorata</i> Wall.	Bell flower	Campanulaceae
50	<i>Cannabis sativa</i> Linn.	Bhang	Cannabinaceae
51	<i>Capsella bursa-pastoris</i> Medik	Shepherdi's purse	Brassicaceae
52	<i>Carissa carandas</i> Linn.	Karonda ,Garna	Apocynaceae
53	<i>Caryopteris odorata</i> (D.Don)	Chingari, Karne	Verbenaceae
54	<i>Cassia dimidiata</i> Baker.	Cassia	Caesalpiniaceae
55	<i>Cedrus deodara</i> Louden	Deodar, Diar	Pinaceae
56	<i>Celtis australis</i> Linn.	Khirak	Ulmaceae
57	<i>Centella asiatica</i> (Linn.) Urban	Brahmi	Hydrocotylaceae
58	<i>Centratherum anthelminticum</i> (L.)	Kali- jiri	Asteraceae
59	<i>Cheilanthes lbomarginata</i> Clarke	Barun	Filicinaceae
60	<i>Chinopodium album</i> Linn.	Banthu	Chenopodiaceae
61	<i>Chiritapumila</i> Don.	Chirita	Gesneriaceae
62	<i>Cissam pelospaireira</i> Linn.	Batendu, Patendu	Menispermaceae
63	<i>Clematis buchaniana</i> DC	Kauni-bel, Kauni -bali	Ranunculaceae
64	<i>Clematis montana</i> Buch -Ham	Kaunia- bali	Ranunculaceae
65	<i>Clematis nutans</i> Royle	Nuk- Chhikni, Kanguli, Kauni	Ranunculaceae
66	<i>Clerodendrum philippinum</i> Schauer	Langai	Verbenaceae
67	<i>Clinopodium umbrosum</i> K.Koch	Clinopodium	Verbenaceae
68	<i>Cnicus argyranthus</i> DC.	Liya, Cheul	Asteraceae
69	<i>Commelina paludosa</i> Blume	Knachara	Commelinaceae
70	<i>Conzyza stricta</i> Wild.	Conzyza	Asteraceae
71	<i>Conzyza viscidula</i> Wall.	Conzyza	Asteraceae
72	<i>Coria nepalensis</i> wall.	Masuri, Mesrei	Coriariaceae
73	<i>Cornus macrophylla</i> Wall.	Hale, Khagsha	Cornaceae
74	<i>Cotinus coggygia</i> Scop	Tunga, Tungla	Anacardiaceae
75	<i>Cotoneaster microphylla</i> Wall.	Pasarni	Rosaceae
76	<i>Crepis japonica</i> Benth.	Crepis	Asteraceae
77	<i>Crotalaria sessiliflora</i> Linn.	Chhun- Chhunu	Papilionaceae
78	<i>Crotalaria albida</i> Heyne	Thakara, Kidney Bean	Papilionaceae
79	<i>Crotalaria hirsute</i> Willd.	Chhun- Chhunu	Papilionaceae
80	<i>Cupressus tortulosa</i> D.Don.	Morpankhi	Cupressaceae
81	<i>Cuscuta reflexa</i> Roxb.	Amar- bel	Cuscutaceae
82	<i>Cynodon dactylon</i> Pers.	Dub grass	Graminae
83	<i>Cynoglossum denticulatum</i> G. don	Kuri, Hatheki	Boraginaceae
84	<i>Cynoglossum micranthum</i> Desf.	Kuri	Boraginaceae
85	<i>Cyperus rotundus</i> Linn.	Moth, Nagarmotha	Cyperaceae
86	<i>Daphne cannabina</i> Wall.	Shivji ka phool	Thymeliaceae
87	<i>Debregeassia hypoleuca</i> Wedd.	Siaru	Urticaceae
88	<i>Delphinium nudatum</i> Wall	Main,Nirbisi	Ranunculaceae
89	<i>Desmodium concinnum</i> DC	Bhatula	Papilionaceae
90	<i>Desmodium floribundum</i> G. Don.	Martoi	Papilionaceae
91	<i>Desmodium laxiflorum</i> DC.	Chimbattai	Papilionaceae
92	<i>Desmodium podocarpum</i> DC.	Martoi	Papilionaceae
93	<i>Desmodium tiliaefolium</i> G. Don	Matoi	Papilionaceae
94	<i>Deutzia staminea</i> Br.	Ghugtai	Philadelphaceae
95	<i>Dicliptera bupleuroides</i> Nees	Bauna	Acanthaceae

96	<i>Digitalis lanata</i> Ehrh.	Tilpushpi, wooly foxglove	Scrophulariaceae
97	<i>Dioscorea bulbifera</i> Linn.	Ratalu	Droscoreaceae
98	<i>Dioscorea deltoidea</i> Wall.	Potato Yam	Droscoreaceae
99	<i>Dodonea Viscosa</i> Jacq.	Ghisanni, Mendru	Sapindaceae
100	<i>Echinops nivens</i> Wall.	Unt- Katara	Asteraceae
101	<i>Ehretia accuminata</i> R. Br.	Puna, Punan	Cordiaceae
102	<i>Elaeagnus umbellata</i> Thumb.	Giyayin	Elaeagnaceae
103	<i>Erigeron annus</i> Linn.	Maredi	Asteraceae
104	<i>Erigeron linifoluns</i> Willd.	Phulnu	Asteraceae
105	<i>Eucalyptus globulus</i> Labill.	Safeda	Myrtaceae
106	<i>Euonymus tingens</i> Wall.	Bhambeli, Skiosh, Barphali	Celastraceae
107	<i>Eupatorium reevesii</i> Wall.	Hiyodori	Asteraceae
108	<i>Euphorbia helioscopia</i> Linn.	Hirruseeah	Euphorbiaceae
109	<i>Euphorbia hypricifolia</i>	Euphorbia	Euphorbiaceae
110	<i>Fagopyrum esculentum</i> Moench.	Buck-Wheat	Polygonaceae
111	<i>Ficus faveolata</i> Wall.	Chipku bel	Urticaceae
112	<i>Ficus palmate</i> Forsk	Fig	Urticaceae
113	<i>Ficus roxburghii</i> Wall.	Tor, toriamble	Urticaceae
114	<i>Fimritylis squarrosa</i> Vahl.	Knabo	Cyperaceae
115	<i>Fragaria indica</i> Andr.	Akha	Rosaceae
116	<i>Fragaria vesca</i> Linn.	Wild strawberry	Rosaceae
117	<i>Galinsoga parviflora</i> Cav.	Piuplughas	Asteraceae
118	<i>Galium aparine</i> Linn.	Goose grass	Rubiaceae
119	<i>Galium rotundifolium</i> Linn.	Safed manjith	Rubiaceae
120	<i>Gerbera gossypina</i> (R.) Beaw.	Kapas	Asteraceae
121	<i>Gernium divaricatum</i> Ehrh. Beitr	gernium	Geraniaceae
122	<i>Gernium nepalese</i> Sweet	Bhanda, Nepalese Crane's bill	Geraniaceae
123	<i>Gnaphalium affine</i> L.	Dhardi	Asteraceae
124	<i>Gnaphilumluteo – album</i> Linn.	BadiDhareli	Asteraceae
125	<i>Grewia optiva</i>	Beul	Tiliaceae
126	<i>Habenaria edgeworthii</i> Hook.	Ridhi	Orchidaceae
127	<i>Habenaria pectinata</i> Don.	Ridhi-Vridhi	Orchidaceae
128	<i>Halenia elliptica</i> D. Don	False chirata	Gentianaceae
129	<i>Hedera helix</i> Linn.	Mithiari	Araliaceae
130	<i>Hedychium acuminatum</i> Wall.	Jangli-haldi	Zingiberaceae
131	<i>Hemiphragma heterophylla</i> Wallich	Naash Jhaar	Scrophulariaceae
132	<i>Hygrophila spinose</i> T. Andres	Kntili	Acanthaceae
133	<i>Hypericum Cernuum</i> Roxb.	Piunli, Aluba	Hypericaceae
134	<i>Impatiens amphorata</i>	Binchi	Balsaminaceae
135	<i>Imperarta cyllindrica</i> Blume	Cagon glass	Graminae
136	<i>Indigofera gerardiana</i> Wall.	Kathi	Papilionaceae
137	<i>Indigofera hebeptala</i> Benth.	Choti- kathhi	Papilionaceae
138	<i>Indigofera pulchella</i> Roxb.	Sakina	Papilionaceae
139	<i>Inula cappa</i> DC	Poshkar	Asteraceae
140	<i>Ipomea purpurea</i> Rath.	Ghodhi	Convolvulaceae
141	<i>Jasminum dispernum</i> Wall.	Chameli	Oleaceae
142	<i>Jasminum humile</i> Linn.	Pili- chameli	Oleaceae
143	<i>Juglans regia</i> Linn.	Akhrot	Juglandaceae
144	<i>Justicia adhatoda</i> Linn.	Basuti	Acanthaceae

145	<i>Justicia simplex</i> Don.	Basuti	Acanthaceae
146	<i>Lamium album</i> Linn.	White dead nettle	Verbenaceae
147	<i>Lantana Camara</i> Linn.	Phul- lakri	Verbenaceae
148	<i>Lathyrus aphaca</i> Linn.	Jabgli-matar	Papilionaceae
149	<i>Latuca macrorhiza</i> Hook	Dudli	Asteraceae
150	<i>Lavendula sylvestris</i>	Graden lavender	Verbenaceae
151	<i>Lecanthuspeduncularis</i> (Royle) Wedd.	Lecathus	Urticaceae
152	<i>Lepidium latifolium</i> L.	Jangli Halo	Brassicaceae
153	<i>Lepidium rudrale</i> Linn.	Narrow leaved pepper	Brassicaceae
154	<i>Leptodermis lanceolata</i> Wall.	Padara	Rubiaceae
155	<i>Lespedeza gerardiana</i> Grah.	Tinpati	Papilionaceae
156	<i>Leucaena leucocephala</i> L.	Subabul	Papilionaceae
157	<i>Leucas lanatana</i> Benth.	Bukhar-davai	Verbenaceae
158	<i>Liatsea chinensis</i> Lamk.	Chandna	Lauraceae
159	<i>Lindera pulcherrima</i> Benth & Hook.	Dadila	Lauraceae
160	<i>Lonicera japonica</i> Thumb.	Japanese honey suckle	Caprifoliaceae
161	<i>Lonicera quinquelocularis</i> Hardw.	Himalayan Honeysuckle	Caprifoliaceae
162	<i>Lotus corniculata</i> L.	Pila phool	Papilionaceae
163	<i>Machilus duthiei</i> King	KawalaBhojo	Lauraceae
164	<i>Machilus odoratissima</i> Nees.	Kawala	Lauraceae
165	<i>Malvastrum tricuspidatum</i> (Art.)	Kangi	Malvaceae
166	<i>Malaxus wallichii</i> Linn.	Rishbhak	Orchidaceae
167	<i>Malva verticillata</i> Linn.	Khubasi, Sonchala	Malvaceae
168	<i>Machilus duthiei</i>	Bay Tree	Lauraceae
169	<i>Medicago lupulina</i> Linn.	Hop clove	Papilionaceae
170	<i>Melia azedarch</i> Linn.	Mahaneem	Meliaceae
171	<i>Mentha arvensis</i> Linn.	Pudina , Field mint	Verbenaceae
172	<i>Meriandra strobilifera</i> Benth.	Murtae, Buthi	Verbenaceae
173	<i>Micomeria bifora</i> Benth.	Indian wild thyme	Verbenaceae
174	<i>Mimosa rubicaulis</i> Lam.	Alay	Mimosaceae
175	<i>Mirabilis Jalapa</i> Linn.	Gulabas	Nyctaginaceae
176	<i>Mollugo stricta</i> Linn.	Erect carpetweed	Molluginaceae
177	<i>Morus alba</i> Linn.	Toot	Moraceae
178	<i>Myrica esculenta</i> Buch-Ham.	Kaphal, Bay-berry	Myricaceae
179	<i>Myrsine Africana</i> Linn.	Bnawan, jhunjhia	Myrsinaceae
180	<i>Nasturium montanum</i> Wall.	Brahmi- Sag	Brassicaceae
181	<i>Nasturium officinale</i> R.Br.	Chhuchha, Chhu	Brassicaceae
182	<i>Nepeta spicata</i> Benth.	Billiotan	Verbenaceae
183	<i>Nicandra physaloides</i> Garein.	Noshadar	Solanaceae
184	<i>Nicotiana tabacum</i> Linn.	Tamakhu	Solanaceae
185	<i>Ocimum sanctum</i> Linn.	Tulsi, Sacred basil	Verbenaceae
186	<i>Oenothera rosea</i> Ait.	Rose evening primrose	Onagraceae
187	<i>Ophiopogon intermedius</i> Don.	Ophiopogon	Haemodoraceae
188	<i>Origanum vulgare</i> Linn.	Ghah-dali, Wild marjoram	Verbenaceae
189	<i>Osbeckia stellata</i>	Starry osbeckia	Melastomataceae
190	<i>Osyris quadripartite</i> Salz ex. Decne	Ban-chai	Santalaceae
191	<i>Oxalis corniculata</i> Linn.	Tinpatia, Amrul	Oxalidaceae
192	<i>Oxalis latifolia</i> H.B & K	khatua	Oxalidaceae
193	<i>Pahseolus mungo</i> L.	Moong	Papilionaceae

194	<i>Panicum plicatum Lamk.</i>	Cheenaghass	Graminae
195	<i>Parmelia parlata (Muds.) Ach.</i>	Chharila , Stone Flowers	(Lichen)
196	<i>Paspalum longiflorum Retz.</i>	Kodraghas	Graminae
197	<i>Pennisetum orientale Rich</i>	Bajraghas	Graminae
198	<i>Phyllanthus parvifolius Buch- Ham.</i>	Jaramla	Euphorbiaceae
199	<i>Physalis minima Linn.</i>	Ras berry	Solanaceae
200	<i>Picea smithiana Wall.</i>	Spruce, Tosh	Pinaceae
201	<i>Pilea scripta Wedd.</i>	Pilea	Urticaceae
202	<i>Pimpinella diversifolia DC.</i>	Junglisomf	Apiaceae
203	<i>Pinus gerardiana Wall.</i>	Chilgoza	Pinaceae
204	<i>Pinus patula Schl. &amp; Cham.</i>	Jelecote Pine	Pinaceae
205	<i>Pinus roxburghii Roxb.</i>	Chir	Pinaceae
206	<i>Pistacia integerrima Stewari</i>	Kkkar- singi	Anacardiaceae
207	<i>Plantago major</i>	Luhiriya	Plantaginaceae
208	<i>Plantago rugelii Dacne.</i>	Silk Plant	Plantaginaceae
209	<i>Plantago tibetica Hook f &amp;Thoms</i>	JangliIsabgoal	Plantaginaceae
210	<i>Plectranthus coesta Buch-Ham</i>	Coesta	Verbenaceae
211	<i>Plectranthus striatus Benth.</i>	Crested flower	Verbenaceae
212	<i>Plntago lanceolata Linn.</i>	Baltanga, Ripple grass	Plantaginaceae
213	<i>Polygala abyssincia R. Br.</i>	Guju	Polygalaceae
214	<i>Polygala arillata Wall.</i>	Yellow milk- wort	Polygalaceae
215	<i>Polygonum alatum Buch-Ham.</i>	Gidar-pipli	Polygonaceae
216	<i>Polygonum Capitatum Buch- Ham.</i>	Marshpepper	Polygonaceae
217	<i>Polygonum hydropiper Linn.</i>	Jalmirch	Polygonaceae
218	<i>Polystrichum discretum D.Don</i>	Polystrictum	Filicinaceae
219	<i>Polystrichum squarresumD.Don</i>	Polystrictum	
220	<i>Portulaca oleracea Linn.</i>	Khursa, Common Purslane	Potulacaceae
221	<i>Potentilla nepalensis Hook.</i>	Bajradanti	Rosaceae
222	<i>Prinephrium penangianum (Hook)</i>	Prine	Filicinaceae
223	<i>Prinsepia utilis Royle</i>	Bhekhal	Rosaceae
224	<i>Prunus cerasoides D.Don</i>	Pajja	Rosaceae
225	<i>Pteris cretica Linn.</i>	Barne	Filicinaceae
226	<i>Punica granatum Linn.</i>	Daru	Punicaceae
227	<i>Pyrrosia stricita (Kuntze) Holttum</i>	Pyrosssia	Filicinaceae
228	<i>Pyrus pashia Buch- Ham</i>	Kainth, Mahal	Rosaceae
229	<i>Quercus leucotrichophora Linn.</i>	Ban oak	Fagaceae
230	<i>Randia tetrasperma (Roxb.)</i>	Pindalu, Gharri	Rubiaceae
231	<i>Ranunculus hirtellus Royle</i>	Minkli	Ranunculaceae
232	<i>Ranunculus laetus Wall</i>	Minkli	Ranunculaceae
233	<i>Reinwardtia indica Dum</i>	Basant, Basanti, Piuli	Linaceae
234	<i>Rhamnus triqueter wall.</i>	Galeju, Gaunta	Rhamnaceae
235	<i>Rhamnus virgatus Roxb.</i>	Pjai, Chato	Rhamnaceae
236	<i>Rhododendron arboreum Smith.</i>	Burans , Bras	Ericaceae
237	<i>Rhussemialata Murray</i>	Tekri, Titri	Anacardiaceae
238	<i>Rhynchosia minima DC.</i>	Gnattavare	Papilionaceae
239	<i>Ricinus communis Linn.</i>	Erand, Arandi	Euphorbiaceae
240	<i>Robdosia rugose Wall.</i>	Jharu, Chhichhri	Verbenaceae
241	<i>Rosa moschata Mill.</i>	Gulabri	Rosaceae
242	<i>Rosmarinus officinalis Linn.</i>	Rosemary	Verbenaceae

243	<i>Royle elegans</i> Wall.	Patkarru	Verbenaceae
244	<i>Rubia cordifolia</i> Linn.	Manjith, Indian madder	Rubiaceae
245	<i>Rubus ellipticus</i> Smith.	Akha	Rosaceae
246	<i>Rubus lasiocarpus</i> Smith.	Kala akha	Rosaceae
247	<i>Rubus paniculatus</i> Smith.	Kala- akha	Rosaceae
248	<i>Rumex hastatus</i> Don.	Khathi-mithi	Polygonaceae
249	<i>Rumex nepalaensis</i> Spreng	Morlo, Jungli-palak	Polygonaceae
250	<i>Sagerotia oppositifolia</i> Brongn.	Gonta, Manchi	Rhamnaceae
251	<i>Salix tetrasperma</i> Roxb.	Beuns , Indian willow	Saliaceae
252	<i>Salvia coccinea</i> Linn.	Mousmi Salvia	Verbenaceae
253	<i>Salvia lanata</i> Roxb.	Thunth	Verbenaceae
254	<i>Salvia moorcroftiana</i> Wall.	Thuth, Gurugumma	Verbenaceae
255	<i>Sanicula Europaea</i> Linn.	Sanicle	Apiaceae
256	<i>Sapium sebiferum</i> Roxb.	Pahari Shisham	Euphorbiaceae
257	<i>Sarcococca pruniformis</i> Lindl.	Tiliari	Euphorbiaceae
258	<i>Scutella riaangulosa</i> Benth.	Scutella	Verbenaceae
259	<i>Sedum rosulatum</i> Edgew	Phulu	Crassulaceae
260	<i>Senecio nudicaulis</i> Buch – ham.	Neelkanthi	Asteraceae
261	<i>Smilax aspera</i> Linn.	Barag-bel	Liliaceae
262	<i>Smilax parvifolia</i> Wall.	Brag-bel	Liliaceae
263	<i>Smilax vaginata</i> Decne	Barag-bel	Liliaceae
264	<i>Solanum khasianum</i> Clarke	Ban - bhindi	Solanaceae
265	<i>Solanum Pseudocapsicum</i> Linn.	Gol - mirch	Solanaceae
266	<i>Solanum sissymbriifolium</i> Lam.	Safed kantkari	Solanaceae
267	<i>Solanum tuberosum</i> Linn.	Alu, potato	Solanaceae
268	<i>Sonchus arvensis</i> Linn.	Dudhli	Asteraceae
269	<i>Sonchus asper</i> Vill.	Dudhli, Didhi	Asteraceae
270	<i>Sonchus oleraceus</i> Linn.	Dudhli, Sowthistle	Asteraceae
271	<i>Stellaria decumbens</i> Edgew.	Chick- weed	Caryophyllaceae
272	<i>Stellaria longissima</i> Wall.	Longleaf starwort	Caryophyllaceae
273	<i>Strobilanthes artropurpureus</i> Nees	Kashmir acanthus	Acanthaceae
274	<i>Tagetes minuta</i> Linn.	Gatatkari	Asteraceae
275	<i>Taraxacum officinale</i> Wigg.	Bitterwort	Asteraceae
276	<i>Taxodium mucronatum</i> Tenore	Taxodium	Toxodiaceae
277	<i>Thalictrum Foliolosum</i> DC	Mamira, Pinjari, Mamiri, Piliari	Ranunculaceae
278	<i>Thuja orientale</i> Linn.	Morpankhi	Cupressaceae
279	<i>Toona ciliata</i> M.J.Roem.	Toon, Red cedar	Meliaceae
280	<i>Trifolium repens</i> Linn.	White Clover	Papilionaceae
281	<i>Trium fectarhomboidea</i> Jacq.	Chikti, Burweed	Tiliaceae
282	<i>Uraria hamosa</i> Wall.	Prishniparni	Papilionaceae
283	<i>Valeriana jatamansi</i> Jones	Mushkbala	Valerianaceae
284	<i>Verbascum Thapsus</i> Linn.	Giddar- tambaku	Scrophulariaceae
285	<i>Verbena Bonariensis</i> L.	Verbena	Verbenaceae
286	<i>Verbena officinalis</i> Linn.	Vervain	Verbenaceae
287	<i>Viburnum cotinifolium</i> Don.	Bhutnoi	Caprifoliaceae
288	<i>Vicatia conifolia</i> DC.	Cone leaf vicatia	Apiaceae
289	<i>Viciahirsuta</i> L.	Munmana	Papilionaceae
290	<i>Viciatenera</i> Grah.	Ankra	Papilionaceae
291	<i>Vinca major</i> Linn.	Sadabahar, Green periwinkle	Apocynaceae

292	<i>Viola canescens</i> Wall.	Banfsha, Banaksha	Violaceae
293	<i>Viola Serpens</i> Wall.	Banafsha, Banaksha	Violaceae
294	<i>Viscum album</i> Linn.	Banda, Mistletoe	Loranthaceae
295	<i>Vitex negundo</i> Linn.	Bana, Sambhalu	Verbenaceae
296	<i>Vitishim alayana</i> Brandis	JungliAngoor	Vitaceae
297	<i>Woodfordia fruticosa</i> (L) Kurz.	Dhabi, Dhai	Lythraceae
298	<i>Xylosma longifolium</i> Clos.	Sialu, Drendu, Katari	Bixaceae
299	<i>Zanthoxylum armatum</i> DC.	Timar, Dramar	Rutaceae
300	<i>Zehneriaum bellata</i> Thwaites	Jangli-kakri	Cucurbitaceae
301	<i>Zizyphus mauritiana</i> Lamk.	Beri	Rhamnaceae

## PHYTOSOCIOLOGY

Plant species growing together have mutual relation among themselves and also with the surroundings. From habitat to habitat population of plant communities varies and this helps in finding out the type of plant community (Lugo, 1978). Shaheen *et al.* (2014).Vegetation diversity, distribution and species endemism were studied in high altitude (>3300 m) Himalayan plateau in Northern Pakistan. Species diversity and richness were negatively whereas evenness was positively correlated with slope steepness and moisture content. Grazing was considered a threat to endemic species.

A complete list of the species present on each plot is considered an almost absolute requirement (Du Reitz, 1921) for the working out of sociology of growing species. The study of phytosociology helps a deeper insight into the structure composition of the vegetation. Huttel (2000) studied the forest of the temperate region and said there is a gap of knowledge and research needs. It is still unclear whether all these requirements can be filled economically and in agreement with the concept of ecological sustainability. It is considered that at initial stages of succession diversity increases while at the closing stages it decreases (Margalef, 1968; Whittaker, 1969).

Phytosociological studies were conducted across three altitudinal zones (Lower base, Mid hill and Hill top) of the Shilli Wildlife Sanctuary in District solan, Himachal Pradesh.

Prakash and Uniyal (1999) also studied the structure of forest vegetation along an altitudinal gradient (2550-3600 m) in the Valley of Flowers and its adjoining area using 25 quadrates of 10 x10 m for trees and 5 x 5 m for shrubs. Based upon the IVI values, three major vegetation types, i.e., Himalayan moist upper temperate forest (2550-3000 m), sub-alpine fir forest (3000-3250 m) and sub-alpine birch forest (3300-3600 m) were identified.

## Zone I: (1200-1400m amsl)

### Tree Species

Tree species were highly diversified in the altitudinal Zone-I (1200-1400m). Among the various tree species recorded in this area, *Pinus roxburghii* was the dominant tree species having maximum density (350 trees /ha) and IVI (47.06) followed by *Bombax ceiba* (IVI 41.68) and *Toona ciliata* (IVI 29.19). The highest value of frequency and abundance was recorded for *Pinus roxburghii* (40%) and *Bombax ceiba*, respectively. The abundance to frequency ratio indicates that distribution of all the species was contiguous (Table 2).

**Table 2: Phytosociological attributes of dominant tree species in Shilli Wildlife Sanctuary at Zone I (1200-1400 m amsl)**

Sr. No.	Name of the tree species	Density (D)	Frequency (F)	A/F	IVI
1.	<i>Albizia lebbek</i>	120	30	0.375	19.43
2.	<i>Bombax ceiba</i>	180	40	0.244	41.68
3.	<i>Callistemon lanceolatus</i>	200	30	0.112	15.90
4.	<i>Eucalyptus globulus</i>	120	30	0.211	16.45
5.	<i>Juglans regia</i>	280	20	0.400	20.68
6.	<i>Lindera pulcherrima</i>	180	20	0.162	07.81
7.	<i>Machilus duthiei</i>	100	20	0.162	10.90
8.	<i>Melia azedrach</i>	150	30	0.169	16.02
9.	<i>Morus alba</i>	250	30	0.692	20.86
10.	<i>Phaseolus mungo</i>	50	20	0.200	10.48
11.	<i>Pinus roxburghii</i>	350	40	0.500	47.06
12.	<i>Prunus cerasoides</i>	130	20	0.261	21.10
13.	<i>Sapium sebiferum</i>	200	20	0.125	19.42
14.	<i>Toona ciliata</i>	280	20	0.202	29.19
<b>Total</b>					<b>297.98</b>

Where, D = Density (/ha); F = Frequency (%); A = Abundance (%); IVI = Importance Value Index

### Shrub species

Shrub species were highly diversified in the altitudinal Zone-I. Among the various Shrub species recorded in this area, *Zanthoxylum armatum* was the dominant shrub species having maximum density (500 shrubs /ha) and IVI (39.67) followed by *Jasminum humile* (IVI 42.64). The highest frequency was recorded in two of the species, i.e., *Dodonaea viscosa* (50) and *Jasminum humile* (50). In total, there were 19 shrub species recorded in lower base altitudinal zone (Table 3).

**Table 3: Phytosociological attributes of dominant shrub species in Shilli Wildlife Sanctuary at Zone I (1200-1400 m amsl)**

Sr. No.	Name of the species	Density (D)	Frequency (F)	A/F	IVI
1.	<i>Achania grandiflora</i>	250	30	0.234	4.32
2.	<i>Aechmanthera tomentosa</i>	350	20	0.124	7.69
3.	<i>Berberis aristata</i>	200	40	0.165	1.90
4.	<i>Berberis lyceum</i>	150	20	0.100	3.71
5.	<i>Berchemia floribunda</i>	250	20	0.300	13.67
6.	<i>Carrisa carandos</i>	300	20	0.296	21.69
7.	<i>Dodonaea viscosa</i>	400	50	0.089	17.64
8.	<i>Hedera helix</i>	350	20	0.342	06.96
9.	<i>Hypercium cernuum</i>	220	20	0.120	2.21
10.	<i>Jasminum humile</i>	450	50	0.100	42.64
11.	<i>Justicia adhatoda</i>	250	30	0.200	10.91
12.	<i>Prinsepia utilis</i>	500	40	0.100	18.62
13.	<i>Rhamnus triqueter</i>	300	20	0.269	05.67
14.	<i>Rhamnus virgatus</i>	250	20	0.200	23.25
15.	<i>Rosa moschata</i>	350	30	0.296	18.69
16.	<i>Rubus ellipticus</i>	300	20	0.239	15.26
17.	<i>Sarcococca pruniformis</i>	300	20	0.126	23.40
18.	<i>Vitex negundo</i>	150	30	0.250	18.00
19.	<i>Zanthoxylum armatum</i>	500	40	1.500	39.67
20.	<i>Zizyphus mauritiana</i>	300	30	0.262	03.96
<b>Total</b>					<b>299.86</b>

Where, D = Density (/ha); F = Frequency (%); A = Abundance (%); IVI = Importance Value Index

### Herb species

In lower base altitudinal Zone, a total of 38 species were recorded. In this Zone, among the various herb species recorded in this area, *Cynoglossum denticulatum* was the dominant herb species having density (1100 herbs /ha) and having IVI (22.92) followed by *Centella asiatica* having density (850 herbs /ha) with IVI (20.64). Highest frequency was recorded in two of the species in this zone namely *Phaseolus mungo* (40) and *Cnicus argyracanthus* (40). Overall 38 herb species have been recorded in lower base zone, having altitudinal range of 1200-1400 m amsl (Table 4).

**Table 4: Phytosociological attributes of dominant herb species in Shilli Wildlife Sanctuary at Zone I (1200-1400 m amsl)**

Sr. No	Name of the species	Density (D)	Frequency (F)	A/F	IVI
1.	<i>Agrostis verticillata</i>	250	10	0.067	04.49
2.	<i>Alternanthera sessilis</i>	500	20	0.233	05.29
3.	<i>Amaranthus hybridus</i>	400	15	0.371	11.24
4.	<i>Bromus patulus</i>	600	20	0.163	08.60
5.	<i>Centella asiatica</i>	850	25	0.075	20.64
6.	<i>Cnicus argyranthus</i>	700	40	0.371	06.20
7.	<i>Crepis japonica</i>	500	25	0.267	11.20
8.	<i>Cynodon dactylon</i>	750	25	0.233	06.89
9.	<i>Cynoglossum denticulatum</i>	1100	15	0.175	22.92
10.	<i>Dicliptera bupleuroides</i>	150	5	0.267	06.20
11.	<i>Erigeron annuus</i>	350	20	0.111	02.30
12.	<i>Euphorbia hypericifolia</i>	250	10	0.075	09.20
13.	<i>Habenaria pectinata</i>	350	15	0.1	08.29
14.	<i>Hemiphragma heterophylla</i>	200	10	0.233	04.19
15.	<i>Ipomea purpurea</i>	200	10	0.1	09.20
16.	<i>Lamium album</i>	300	15	0.111	06.29
17.	<i>Leucas lanata</i>	400	20	0.2	06.21
18.	<i>Nasturtium officinale</i>	250	20	0.075	10.20
19.	<i>Nicandra physaloides</i>	350	15	0.163	12.20
20.	<i>Nicotiana tabacum</i>	400	20	0.067	11.21
21.	<i>Ocimum sanctum</i>	500	25	0.075	07.65
22.	<i>Origanum vulgare</i>	300	15	0.075	09.90
23.	<i>Oxalis corniculata</i>	600	30	0.067	06.29
24.	<i>Panicum plicatum</i>	350	15	0.371	03.20
25.	<i>Pennisetum orientale</i>	200	10	0.267	04.40
26.	<i>Phaseolus mungo</i>	300	40	0.163	07.40
27.	<i>Plectranthus coesta</i>	200	10	0.1	06.20
28.	<i>Polygonum hydropiper</i>	600	20	0.267	10.24
29.	<i>Portulaca oleracea</i>	400	20	0.1	04.62
30.	<i>Rhynchosia minina</i>	250	20	0.233	04.96
31.	<i>Rumex hastatus</i>	700	25	0.111	06.92
32.	<i>Rumex nepalensis</i>	400	20	0.2	08.20
33.	<i>Salvia coccinea</i>	400	15	0.067	06.95
34.	<i>Scutellaria angulosa</i>	350	15	0.163	08.20
35.	<i>Sonchus arvensis</i>	200	15	0.2	04.60
36.	<i>Sonchus oleraceus</i>	100	20	0.075	06.29
37.	<i>Verbascum thapsus</i>	300	15	0.371	04.49
38.	<i>Viola serpens</i>	550	25	0.075	05.62
<b>Total</b>					<b>299.09</b>

Where, D = Density (/ha); F = Frequency (%); A = Abundance(%); IVI = Importance Value Index

## Zone II: 1400-1600 m amsl

### Tree species

Tree species were highly diversified in the altitudinal Zone-II (1400-1600m). Among the various tree species recorded in this area, *Quercus leucotricophora* was the dominant tree species having maximum density (400 trees /ha) and IVI (25.06) followed by *Rhododendron arboreum* having density 380. The species holding second highest IVI is *Salix tetrasperma* (20.39). The highest value of frequency was recorded for *Quercus leucotricophora* (100), respectively (Table 5). In total 22 tree species recorded in Zone II i.e. 1400-1600 m amsl).

**Table 5: Phytosociological attributes of dominant tree species in Shilli Wildlife Sanctuary at Zone II (1400-1600 m amsl)**

Sr. No.	Name of the species	Density (D)	Frequency(F)	A/F	IVI
1.	<i>Albizzia odoratissima</i>	50	20	0.261	08.20
2.	<i>Bauhinia variegata</i>	130	30	0.375	09.43
3.	<i>Cedrus deodara</i>	170	60	0.400	18.68
4.	<i>Celtis australis</i>	80	20	0.125	16.41
5.	<i>Cupressus torulosa</i>	60	20	0.222	18.20
6.	<i>Euonymus tingens</i>	60	20	0.202	14.30
7.	<i>Ficus palmata</i>	20	10	0.692	10.86
8.	<i>Grewia optiva</i>	50	20	0.169	10.24
9.	<i>Machilus duthiei</i>	80	20	0.250	09.32
10.	<i>Picea smithiana</i>	70	10	0.244	20.62
11.	<i>Pinus gerardiana</i>	50	20	0.244	19.68
12.	<i>Pinus patula</i>	30	20	0.169	10.29
13.	<i>Pistacia integerrima</i>	70	10	0.162	09.80
14.	<i>Pyrus pashia</i>	80	10	0.211	10.20
15.	<i>Quercus leucotricophora</i>	400	100	0.202	25.06
16.	<i>Rhododendron arboreum</i>	380	60	0.112	08.90
17.	<i>Rhus semialata</i>	60	20	0.200	10.20
18.	<i>Salix tetrasperma</i>	20	10	0.500	20.39
19.	<i>Taxodium mucronatus</i>	40	20	0.179	10.65
20.	<i>Thuja orientalis</i>	30	10	0.182	10.80
21.	<i>Viscum album</i>	50	10	0.162	09.81
22.	<i>Xylosona longifolium</i>	80	30	0.244	11.20
<b>Total</b>					<b>293.24</b>

Where, D = Density (/ha); F = Frequency (%); A = Abundance (%); IVI = Importance Value Index

### Shrub species

In total, 48 shrub species were present in the altitudinal Zone-II (Table 6). As the Table illustrates, among the various shrub species recorded in this area, *Woodfordia fruticosa* was the dominant Shrub species having maximum density (600 shrubs ha-1) having IVI (13.71) followed by two of the shrub species having density (400 shrubs ha-1) of *Punica granatum* and *Rosmarinus officinalis*. The highest IVI has been recorded in *Rosmarinus officinalis* IVI (15.26) followed by *Woodfordia fruticosa* IVI (13.71).

**Table 6: Phytosociological attributes of dominant shrub species in Shilli Wildlife Sanctuary at Zone II (1400-1600 m amsl)**

Sr. No.	Name of the species	Density (D)	Frequency (F)	A/F	IVI
1.	<i>Acchmanthera tomentosa</i>	150	10	0.342	03.96
2.	<i>Adhatoda</i> species	250	20	0.239	03.26
3.	<i>Arachne cordifolia</i>	200	10	0.300	04.62
4.	<i>Berberis aristata</i>	200	20	0.165	06.90
5.	<i>Berberis lycium</i>	150	10	0.100	03.71
6.	<i>Caryopteris odorata</i>	250	30	0.200	03.96
7.	<i>Coriaria nepalensis</i>	250	30	0.240	10.25
8.	<i>Cotinus coggygia</i>	200	20	0.269	05.67
9.	<i>Cotoneaster microphylla</i>	300	10	0.126	02.30
10.	<i>Daphne cannabina</i>	350	40	0.120	03.21
11.	<i>Debregeassia hypoleuca</i>	150	20	0.262	03.96
12.	<i>Desmodium concinnum</i>	100	20	0.162	03.96
13.	<i>Desmodium floribundum</i>	200	10	0.089	08.20
14.	<i>Desmodium podocarpum</i>	250	30	0.100	06.90
15.	<i>Desmodium tiliaefolium</i>	100	10	0.296	02.90
16.	<i>Deutzia staminea</i>	150	10	0.135	04.90
17.	<i>Elaeagnus umbellata</i>	250	30	0.234	04.32
18.	<i>Ficus foveolata</i>	250	20	0.089	05.64
19.	<i>Hygrophila spinosa</i>	150	10	0.100	11.26
20.	<i>Hypericum cernuum</i>	250	20	0.120	04.21
21.	<i>Indigofera hebeptala</i>	300	10	0.239	06.42
22.	<i>Indigofera pulchella</i>	200	20	0.342	06.96
23.	<i>Inula cappa</i>	300	30	0.262	03.96
24.	<i>Jasminum dispernum</i>	250	30	0.100	10.26
25.	<i>Lantana camara</i>	200	40	0.124	02.69
26.	<i>Leptodermis lanceolata</i>	150	10	0.269	05.67
27.	<i>Lonicera japonica</i>	300	10	0.234	04.32
28.	<i>Lonicera quinquelocularis</i>	250	20	1.400	10.67
29.	<i>Malvastrum tricuspidatum</i>	100	10	0.234	04.32
30.	<i>Meriandra strobilifera</i>	150	10	0.126	09.26
31.	<i>Mimosa rubicaulis</i>	200	30	0.296	03.90
32.	<i>Myrsine africana</i>	350	40	0.089	03.42
33.	<i>Osyris quadripartite</i>	300	20	1.500	09.62
34.	<i>Punica granatum</i>	400	40	0.120	12.21
35.	<i>Randia tetrasperma</i>	250	10	0.200	05.62
36.	<i>Reinwardtia indica</i>	150	10	1.500	10.67
37.	<i>Ricinus communis</i>	100	30	0.200	04.20
38.	<i>Rosa moschata</i>	250	30	0.210	06.40
39.	<i>Rosmarinus officinalis</i>	400	50	0.100	15.26
40.	<i>Roylea elegans</i>	250	20	0.165	05.01
41.	<i>Rubus lasiocarpus</i>	200	40	0.124	05.69
42.	<i>Sacocca pruniformis</i>	100	20	0.269	03.20
43.	<i>Solanum tuberosum</i>	350	40	0.296	04.24
44.	<i>Strobilanthes atropurpureus</i>	200	20	0.296	04.20
45.	<i>Uraria hamosa</i>	100	20	0.180	05.20
46.	<i>Viburnum contifolium</i>	200	20	0.300	09.27
47.	<i>Woodfordia fruticosa</i>	600	50	0.100	13.71
48.	<i>Zanthoxylum armatum</i>	100	20	0.300	04.67
<b>Total</b>					<b>295.11</b>

Where, D = Density (/ha); F = Frequency (%); A = Abundance (%); IVI = Importance Value Index

## Herb species

In Zone II, a total of 101 species were recorded. In this Zone, among the various herb species recorded in this area, *Rubia cordifolia* and *Digitalis lanata* was the dominant herb species having density (1100 herbs/ha) and having IVI (03.85). Highest frequency was recorded in two of the species in this zone namely *Valeriana jatamansi* (40) and *Lepidium latifolium* (40). This altitudinal Zone has the highest diversity of herb species amongst all the altitudinal zones of Shilli Wildlife Sanctuary (Table 7).

**Table 7: Phytosociological attributes of dominant herbaceous species in Shilli Wildlife Sanctuary at Zone II (1400-1600 m amsl)**

Sr. No.	Name of the species	Density(D)	Frequency (F)	A/F	IVI
1.	<i>Achyranthes bidentata</i>	350	20	0.067	02.20
2.	<i>Ageratum conyzoides</i>	400	20	0.233	03.46
3.	<i>Ajuga bracteosa</i>	150	25	0.075	02.12
4.	<i>Androsace rotundifolia</i>	250	20	0.267	02.01
5.	<i>Arabis alpine</i>	600	30	0.067	02.20
6.	<i>Artemisia roxburghiana</i>	350	40	0.371	02.11
7.	<i>Aster molliusculus</i>	200	25	0.267	02.25
8.	<i>Aster thomsonii</i>	300	20	0.111	02.14
9.	<i>Atylosia sp.</i>	150	5	0.267	02.45
10.	<i>Avena fatua</i>	300	15	0.067	03.21
11.	<i>Barleria cristata</i>	400	25	0.233	02.89
12.	<i>Begonia picta</i>	600	10	0.067	02.78
13.	<i>Bergenia ciliata</i>	400	20	0.2	03.87
14.	<i>Bidens tripartite</i>	150	15	0.2	02.66
15.	<i>Bidens walichii</i>	300	20	0.075	02.11
16.	<i>Bupleurum falcatum</i>	250	25	0.233	02.56
17.	<i>Campanula colorata</i>	300	15	0.710	03.12
18.	<i>Cassia dimidiata</i>	400	15	0.371	02.25
19.	<i>Centratherum anthelminticum</i>	400	15	0.175	02.13
20.	<i>Chinopodium album</i>	200	15	0.63	02.25
21.	<i>Chirita pumila</i>	200	20	0.163	02.15
22.	<i>Conyza viscidula</i>	300	20	0.067	02.13
23.	<i>Conyza stricta</i>	500	10	0.1	03.25
24.	<i>Crotalaria hirsuta</i>	300	15	0.111	02.45
25.	<i>Crotalaria sessiliflora</i>	400	20	0.2	03.21
26.	<i>Cuscuta reflexa</i>	350	10	0.075	02.58
27.	<i>Cynoglossum micranthum</i>	500	20	0.200	02.32
28.	<i>Cyperus rotundus</i>	400	15	0.163	03.42
29.	<i>Delphinium denudatum</i>	250	20	0.075	02.11
30.	<i>Digitalis lanata</i>	1100	10	0.670	03.85
31.	<i>Dioscorea bulbifera</i>	300	15	0.075	03.11
32.	<i>Echinops nivens</i>	200	15	0.173	02.14
33.	<i>Erigeron linifolus</i>	400	10	0.233	02.78
34.	<i>Eupatorium reevesii</i>	350	15	0.371	02.14
35.	<i>Fragaria vesca</i>	700	25	0.111	03.25
36.	<i>Galinsoga parviflora</i>	500	5	0.267	02.58
37.	<i>Gallium aparine</i>	200	25	0.075	02.14
38.	<i>Gallium rotundifolium</i>	100	20	0.1	02.54
39.	<i>Geranium divaricatum</i>	200	10	0.233	03.32
40.	<i>Gerbera gossypina</i>	400	15	0.111	02.57
41.	<i>Gnaohalium luteo-album</i>	700	25	0.750	03.54
42.	<i>Gnaphalium affine</i>	600	20	0.200	02.22

43.	<i>Habenaria edgeworthii</i>	400	15	0.111	03.25
44.	<i>Halenia elliptica</i>	700	25	0.111	02.12
45.	<i>Hedychium acuminatum</i>	150	10	0.100	03.58
46.	<i>Impatiens amphorata</i>	300	15	0.371	02.25
47.	<i>Justicia simplex</i>	350	15	0.371	03.35
48.	<i>Lactuca macrorrhiza</i>	400	15	0.075	03.25
49.	<i>Lathyrus aphaca</i>	500	25	0.075	02.44
50.	<i>Lavendula sylvestris</i>	300	20	0.100	02.54
51.	<i>Lecanthus peduncularis</i>	1000	15	0.371	02.17
52.	<i>Lepidium latifolium</i>	300	40	0.163	03.25
53.	<i>Lepidium rudrale</i>	250	20	0.233	02.25
54.	<i>Lotus corniculata</i>	300	15	0.075	03.89
55.	<i>Malaxus walichii</i>	350	20	0.200	02.78
56.	<i>Malva verticillata</i>	200	10	0.1	02.38
57.	<i>Medicago lupulina</i>	200	10	0.1	03.21
58.	<i>Mentha arvensis</i>	400	30	0.067	02.14
59.	<i>Micromeria biflora</i>	500	30	0.163	02.24
60.	<i>Mirabilis jalapa</i>	500	10	0.100	03.87
61.	<i>Mollugo stricta</i>	300	20	0.163	03.45
62.	<i>Nasturtium officinale</i>	700	40	0.371	03.21
63.	<i>Nepeta spicata</i>	250	20	0.233	02.31
64.	<i>Oenothera rosea</i>	550	25	0.075	03.21
65.	<i>Ophiopogen intermedius</i>	200	25	0.075	02.47
66.	<i>Oxalis corniculata</i>	350	15	0.163	02.44
67.	<i>Physalis minima</i>	100	15	0.100	03.25
68.	<i>Pilea scripta</i>	200	5	0.267	02.31
69.	<i>Pimpinella diversifolia</i>	700	15	0.371	02.25
70.	<i>Plantago lanceolata</i>	300	15	0.200	03.65
71.	<i>Plantago rugelii</i>	250	20	0.075	02.34
72.	<i>Plantago tibetica</i>	700	15	0.175	03.24
73.	<i>Plectranthus coesta</i>	550	30	0.71	02.44
74.	<i>Polygala abyssinica</i>	350	20	0.111	03.47
75.	<i>Polygala arillata</i>	200	15	0.2	02.22
76.	<i>Polygonum capitatum</i>	100	10	0.233	03.54
77.	<i>Potentilla nepalensis</i>	600	20	0.267	02.14
78.	<i>Ranunculus hirtellus</i>	550	25	0.075	03.12
79.	<i>Ranunculus laetus</i>	400	20	0.1	02.14
80.	<i>Rubia cordifolia</i>	1100	30	0.067	03.21
81.	<i>Salvia lanata</i>	400	25	0.267	02.21
82.	<i>Salvia moorcroftiana</i>	600	20	0.111	02.85
83.	<i>Sanchus oleraceus</i>	400	15	0.163	03.25
84.	<i>Sanicula europa</i>	500	10	0.267	02.41
85.	<i>Sedum rosulatum</i>	250	10	0.075	02.45
86.	<i>Senecia nudicaulis</i>	250	10	0.100	03.85
87.	<i>Solanum nigrum</i>	200	25	0.075	02.44
88.	<i>Sonchus asper</i>	550	15	0.070	02.85
89.	<i>Stellaria decumbens</i>	100	20	0.075	03.85
90.	<i>Sterllaria longissima</i>	900	15	0.175	02.89
91.	<i>Taraxacum officinale</i>	600	20	0.233	02.77
92.	<i>Trifolium repens</i>	400	15	0.067	03.44
93.	<i>Triumfetta rhomboidea</i>	400	20	0.067	02.78
94.	<i>Valeriana jatamansi</i>	200	40	0.163	02.89
95.	<i>Verbena bonariensis</i>	300	20	0.75	03.45
96.	<i>Verbena officinalis</i>	200	10	0.267	02.77
97.	<i>Vicatia conifolia</i>	350	20	0.075	02.45
98.	<i>Vicia hirsuta</i>	350	15	0.163	03.22
99.	<i>Vicia tenera</i>	500	20	0.233	02.78
100.	<i>Viola canescens</i>	500	25	0.267	02.47
101.	<i>Zehneria umbellata</i>	400	15	0.1	03.89
<b>Total</b>					<b>279.90</b>

Where, D = Density (/ha); F = Frequency (%); A = Abundance (%); IVI = Importance Value Index

### Zone III- 1600-1800 m and above

#### Tree species

Tree species were found very less in the altitudinal Zone-III (1600-1800m) due to the highest distance from mean sea level. Among the tree species recorded in this area, *Cedrus deodara* was the dominant tree species having maximum density (500 trees ha<sup>-1</sup>) and IVI (112.96). The species holding second highest IVI is *Myrica esculentea* (94.42). The highest value of frequency was recorded for *Cedrus deodara* (100) respectively (Table 8).

**Table 8: Phytosociological attributes of dominant tree species in Shilli Wildlife Sanctuary at Zone III (1600-1800 m amsl)**

Sr. No.	Name of the species	Density(D)	Frequency(F)	A/F	IVI
1.	<i>Cedrus deodara</i>	500	100	1.621	112.96
2.	<i>Cornus macrophylla</i>	100	40	0.729	92.61
3.	<i>Myrica esculentea</i>	200	50	0.981	94.42
<b>Total</b>					<b>299.99</b>

Where, D = Density (ha<sup>-1</sup>); F = Frequency (%); A = Abundance (%); IVI = Importance Value Index

#### Herb species

In hill top altitudinal Zone, total of only 8 species were recorded. In this Zone, among the various herb species recorded in this area, *Geranium nepalense* was the dominant herb species having density (1100 herbs /ha) and having IVI (42.69). Highest frequency was recorded in two of the species in this zone namely *Anaphalis busua* (35). The A/F ratio is also highly diversified in this Zone of Shilli Wildlife Sanctuary (Table 9).

**Table 9: Phytosociological attributes of dominant herb species in Shilli Wildlife Sanctuary in Zone III (1600-1800 m amsl)**

Sr. No.	Name of the species	Density(D)	Frequency(F)	A/F	IVI
1.	<i>Ainsliacea aptera</i>	700	20	0.262	37.69
2.	<i>Anaphalis busua</i>	1000	35	0.320	40.29
3.	<i>Blainvillea latifolia</i>	550	10	0.241	34.67
4.	<i>Dioscorea bulbifera</i>	375	15	0.121	34.63
5.	<i>Geranium nepalense</i>	1100	25	0.269	42.69
6.	<i>Lotus corniculata</i>	500	20	0.142	28.24
7.	<i>Malaxus walichii</i>	1000	25	0.421	42.23
8.	<i>Plantago major</i>	600	20	0.292	39.20
<b>Total</b>					<b>299.64</b>

Where, D = Density (ha<sup>-1</sup>); F = Frequency (%); A = Abundance (%); IVI = Importance Value Index

These values of density are within the earlier values reported by various authors like Rawat and Singh (2006); Pant and Samant (2007); Semwal *et al.* (2010), Gairola *et al.* (2011); Raturi (2012) and Bhat (2012). Pant and Samant (2007) reported shrub density ranging from 704 to 11,056/ha. , Rawat and Singh (2006) reported shrub density ranging from 809.09 to 2966.67/ha. The results suggests that in both of the valley tree density increases with increasing altitude in the order of upper zone>mid zone>lower Zone but density of shrubs showed decreasing trend with the increase in elevation. Such trends were also reported by Rawat and Singh (2006).

Chen *et al.* (2008) argued that density of any species in a given stand or forest type depends largely upon environmental condition and the area covered by each individual stem. They also reported that shrubs species are contagiously distributed in all forest sites. Also the distribution of species is largely regulated by altitude and physiographic factors (Sharma *et al.*, 2009), edaphic conditions, slope, aspect and moisture regime (Adhikari *et al.*, 2009). Perhaps variation in micro-environment in each experimental site resulted in change in their growth behaviour of vegetation as reported by Srivastava *et al.* (2005) that the community characters differ with aspect, slope and altitude even in the same vegetation type. The altitude and aspect play a key role in determining the temperature regime and atmospheric pressure of every site. Within one altitude the co-factors like topography, aspect, inclination of slope and soil type affects the vegetation composition influence the vegetation.

### **Species Diversity of Trees, Shrubs and Herbs**

Table 10 depicts that the vegetational index of altitudinal Zone I, which is in the range of 1200-1400 m is categorized into four categories, i.e., species richness (S), Shannon index (H'), Simpson index (Ds) and Evenness index (E). The Table illustrates that the species richness is prior in herbs, i.e., 49, secondary in shrubs, i.e., 26 and then shrubs which is 16. The Shannon Index (H') also shows the same order of arrangement. Firstly the highest Shannon Index is in herbs, the in shrubs and lastly in trees 3.12, 2.76 and 2.69, respectively. The Simpson index (Ds) is calculated as firstly the trees with the value of 0.73, secondly the herbs with the value of 0.11 and finally the shrubs with value of 0.06. The evenness index is in the order of that the shrubs are in the ratio of 0.84, herbs in the ratio of 0.80 and trees in 0.97. The data in Table 10 also describes the indices which are vegetationally occurred in the sanctuary. These values of diversity index are well within those reported earlier by various workers in different parts of Western Himalaya in general and Uttarakhand Himalaya in range like 0.91 to 3.0 by Pandey (2001) and Sharma *et al.*(2009), Raturi 2012 (0.78-3.45).

Species richness ranged from 1.88 to 0.88 for trees and 1.62 to 1.48 for shrubs. These studies provide a support to the earlier investigations that species richness increases from high elevation to low elevations (Kumar and Thakur, 2008) (Table 10).

**Table 10: Species diversity of trees, shrubs and herbs in Shilli Wildlife Sanctuary in Zone I (1200-1400m amsl)**

Plant Category	ZONE I (1200-1400 m)			
	S	H'	Ds	E
Trees	16	2.69	0.73	0.97
Shrubs	26	2.76	0.06	0.84
Herbs	49	3.12	0.11	0.80

Where, Species Richness (S), Shannon's Index (H'), Simpson Index (Ds), Evenness (E)

**Vegetation indices i.e. Shannon's Index (H'), Species Richness (S), Simpson Index (Ds), Evenness (E) of trees, shrubs and herbs**

Data in Table 11 of Zone II that ranges from 1400-1600 m has the set of arrangement as the species richness (S) is highest in herbs (168), followed by shrubs and trees (51 and 31) respectively. Furthermore, the Shannon Index (H') shows, difference in the values depicted as 3.19 in herbs, 3.20 in shrubs and 2.58 in trees. Moreover, Simpson index (Ds) shows the vived range in the values of trees, herbs and shrubs that are 0.15, 0.07 and 0.03 respectively. Lastly, Evenness in the plant category is represented as shrubs being at the highest value of 0.93, followed by herbs and trees at 0.81 and 0.75 respectively. This table shows highly diversified classes of values for different aspects for different plant categories (Table 11).

**Table11: Species diversity of trees, shrubs and herbs in Shilli Wildlife Sanctuary in Zone II (1400-1600m amsl)**

Plant Category	ZONE II (1400-1600 m)			
	S	H'	Ds	E
Trees	31	2.58	0.15	0.75
Shrubs	51	3.20	0.03	0.93
Herbs	168	3.19	0.07	0.81

Where, Species Richness (S), Shannon's Index (H'), Simpson Index (Ds), Evenness (E)

**Vegetation indices i.e. Shannon's Index (H'), Species Richness (S), Simpson Index (Ds), Evenness (E) of trees, shrubs and herbs in Shilli Wildlife Sanctuary**

Table 12 depicts that the vegetational index of altitudinal zone III, which is in the range of 1600-1800 m that the species richness is high in herbs (221), secondary in shrubs with 47 and then shrubs (21). The Shannon index (H') shows the order that firstly the highest

Shannon index is in herbs (3.40), then in shrubs (3.00) and lastly in trees (2.13). The Simpson index (Ds) is calculated as, the trees with the value of 0.22, followed by herbs with the value of 0.03 and finally the shrubs with value of 0.01. The evenness index (E) is in the order of that the shrubs are in the ratio of 0.93, herbs in the ratio of 0.92 and trees in 0.69 (Table 12).

**Table12: Species diversity of trees, shrubs and herbs in Shilli Wildlife Sanctuary in Zone III (1600-1800m amsl)**

Plant Category	ZONE III (1600-1800 m)			
	S	H'	Ds	E
Trees	21	2.13	0.22	0.69
Shrubs	47	3.00	0.03	0.93
Herbs	221	3.40	0.01	0.92

Where, Species Richness (S), Shannon's Index (H'), Simpson Index (Ds), Evenness (E)

### Vegetational types in study area

Perusal of data in Table 13, it can be drawn that the species are categorized in to four categories, i.e., Angiosperms, Gymnosperms, ferns and lichens. In total, there are 301 species present in the sanctuary (enlisted in Table 1), belonging to 207 genera and 108 families. Species which comes under the category of angiosperms are 283 in numbers from 171 genera and 86 families. The gymnosperms have 08 species followed by 06 genera and 03 families. Thirdly, ferns have 10 species; however, the genera and families are of equal units i.e. 08. Lastly, the lichens have only 01 species present in the sanctuary followed by one genus and one family, respectively (Fig.3).

**Table 13: Vegetational types of Shilli Wildlife Sanctuary (Study Area)**

Sr. No.	Vegetational Distribution	Species	Genera	Families
1.	Angiosperms	283	171	86
2.	Gymnosperms	08	06	03
3.	Ferns	10	08	08
4.	Lichens	01	01	01
<b>Total</b>		<b>301</b>	<b>207</b>	<b>108</b>

### PRESENCE OF SPECIES IN SHILLI WILDLIFE SANCTUARY ACCORDING TO THEIR USE

Shilli Wildlife Sanctuary has a major account of species where many species are economically as well as non-economically important. It consist of major various species, which are very important aspect for the sanctuary. The species are characterized as follows, according to the occurrence and presence in all the three zones of Shilli wildlife sanctuary starting from the elevation of 1200-1800m above mean sea level.

## Timber Yielding Species

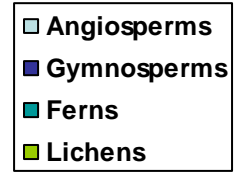
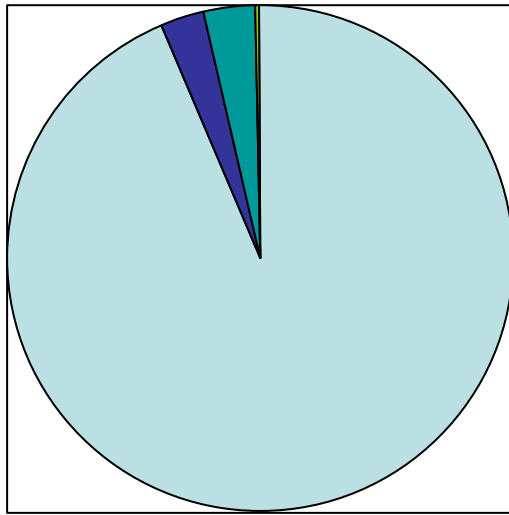
Table 14 illustrates the presence of 22 timber species present in the sanctuary. These species, which are high yielding timber species and can be classified as economically important species. As per the table, there are various species belonging to several families have been observed. There are 2 species belonging to the family Anacardiaceae, 1 species from Bombacaceae, 1 from Cannabaceae, 1 from Celastraceae, 2 from Cupressaceae, 2 of them are from Fabaceae, 1 belongs to the family Fagaceae, 1 from Juglandaceae, 1 from Lamiaceae, 3 belongs to Lauraceae, 2 from Meliaceae, 1 from Myrtaceae, 2 belongs to the family Pinaceae, 1 from Rutaceae and 1 from Salicaceae, respectively.

**Table 14: Timber yielding species in three altitudinal zones of Shilli Wildlife Sanctuary**

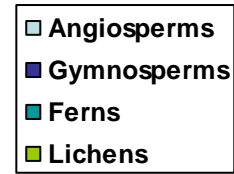
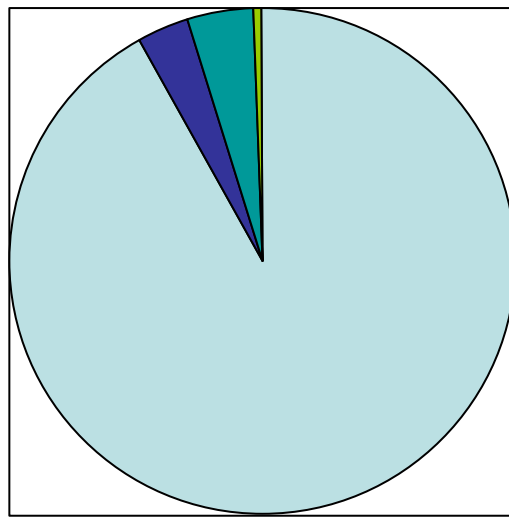
Sr. No.	Botanical Name	Common Name	Family
1.	<i>Albizia lebbeck</i>	Lebbeck tree	Fabaceae
2.	<i>Albizia odoratissima</i>	Black siris	Fabaceae
3.	<i>Bombax ceiba</i>	Cotton tree	Bombacaceae
4.	<i>Cedrus deodara</i>	Deodar	Pinaceae
5.	<i>Celtis australis</i>	Europeon nettle tree	Cannabaceae
6.	<i>Cupressus torulosa</i>	Himalayan cypress	Cupressaceae
7.	<i>Eucalyptus globulus</i>	Blue gum	Myrtaceae
8.	<i>Euonymus tingens</i>	Purple veined spindle tree	Celastraceae
9.	<i>Juglans regia</i>	English walnut	Juglandaceae
10.	<i>Lindera pulcherrima</i>	Spicewood	Lauraceae
11.	<i>Machilus duthiei</i>	Duthie's bay tree	Lauraceae
12.	<i>Machilus odoratissima</i>	Fragrant bay tree	Lauraceae
13.	<i>Mangifera indica</i>	Mango	Anacardiaceae
14.	<i>Melia azedrach</i>	Chinaberry	Meliaceae
15.	<i>Picea smithiana</i>	Indian spruce	Pinaceae
16.	<i>Pistacia integrumma</i>	Kakkar	Anacardiaceae
17.	<i>Quercus leucotricophora</i>	Ban oak	Fagaceae
18.	<i>Salix tetrasperma</i>	Indian willow	Salicaceae
19.	<i>Salvia lanata</i>	Salvia	Lamiaceae
20.	<i>Taxodium mucronatum</i>	Mexican cypress	Cupressaceae
21.	<i>Toona ciliata</i>	Red cedar	Meliaceae
22.	<i>Zanthoxylum armatum</i>	Prickly ash	Rutaceae

## Fodder Species

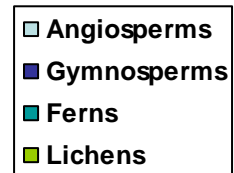
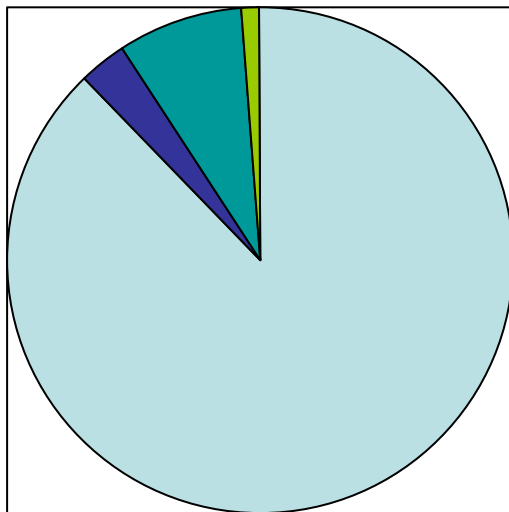
In total, there were 36 fodder species in the sanctuary, which are important on an account of fodder point of view. These are high demanding fodder species. The fodder species has a wide range of the various families from which all the species belongs.



**Species**



**Genera**



**Families**

**Fig. 3. Vegetational types of Shilli Wildlife Sanctuary, Solan**

Table 15 depicts that, there are maximum of the species belonging to the family Fabaceae, followed by Rosaceae, Poaceae, Moraceae and Berberidaceae, respectively.

**Table15: Fodder species in three altitudinal zones (1200-1800 m amsl) of Shilli Wildlife Sanctuary**

Sr. No.	Botanical Name	Common Name	Family
1.	<i>Achyranthus bidentata</i>	Ox knee	Amaranthaceae
2.	<i>Agrostis verticillata</i>	Common bent	Poaceae
3.	<i>Albizia lebbeck</i>	Lebbeck tree	Fabaceae
4.	<i>Albizia odoratissima</i>	Black siris	Fabaceae
5.	<i>Atylosia sp.</i>	Pigeon pea	Fabaceae
6.	<i>Bauhinia variegata</i>	Kachnar	Fabaceae
7.	<i>Berberis aristata</i>	Barberry	Berberidaceae
8.	<i>Berbens lycium</i>	Indian lycium	Berberidaceae
9.	<i>Bombax ceiba</i>	Cotton tree	Bombacaceae
10.	<i>Bromus patula</i>	Chinook brome	Poaceae
11.	<i>Buddle japoniculata</i>	Panicled butterfly bush	Scrophulariaceae
12.	<i>Celtis australis</i>	Europeon nettle tree	Cannabaceae
13.	<i>Commelina paludosa</i>	Swamp dayflower	Commenlinaceae
14.	<i>Coriaria nepalensis</i>	Masuri berry	Coriariaceae
15.	<i>Cuscuta reflexa</i>	Amar bel	Convolvulaceae
16.	<i>Cyprus rotundus</i>	Common nut sedge	Cyperaceae
17.	<i>Desmodium podocarpum</i>	Tic-trefoil	Fabaceae
18.	<i>Euonymous tingens</i>	Purple veined spindle tree	Celastraceae
19.	<i>Ficus palmata</i>	Anjiri	Moraceae
20.	<i>Grewia optiva</i>	Beul	Tiliaceae
21.	<i>Hedera helix</i>	English evy	Araliaceae
22.	<i>Indigofera bebepetala</i>	True indigo	Fabaceae
23.	<i>Indigofera puchella</i>	Indigo	Fabaceae
24.	<i>Lathyrus aphaca</i>	Yellow pea	Fabaceae
25.	<i>Lonicera quinquelocularis</i>	Translucent honeysuckle	Caprifoliaceae
26.	<i>Lotus comiculatus</i>	Bird's-foot trefoil	Fabaceae
27.	<i>Morus alba</i>	White mulberry	Moraceae
28.	<i>Punicum plicatum</i>	Pomegranate	Fabaceae
29.	<i>Prunus cerasoides</i>	Wild himalayan cherry	Rosaceae
30.	<i>Pyrus pashia</i>	Indian wild pear	Rosaceae
31.	<i>Rhynchosia minima</i>	Jumby-bean	Fabaceae
32.	<i>Rosa moschata</i>	Musk rose	Rosaceae
33.	<i>Salix tetrasperma</i>	Indian willow	Salicaceae
34.	<i>Salvia lanata</i>	Salvia	Lamiaceae
35.	<i>Trifolium repens</i>	White clover	Fabaceae
36.	<i>Ziziphus mauritiana</i>	Indian jujube	Rhamnaceae

## Fibre and Flosses

The sanctuary supports 4 species having high value for fibre and flosses, as depicted in Table 16, the species belonging to different families are as one belongs to Bombacaceae, one to Cannabaceae, one to Thymelaeaceae and one to Tiliaceae, respectively (Table 16).

**Table 16: Fibre and flosses species in three altitudinal zones of Shilli Wildlife Sanctuary**

Sr. No.	Botanical Name	Common Name	Family
1.	<i>Bombax ceiba</i>	Cotton tree	Bombacaceae
2.	<i>Cannabis sativa</i>	Bhaang	Cannabaceae
3.	<i>Daphne cannabina</i>	Indian paper plant	Thymelaeaceae
4.	<i>Grewia optiva</i>	Beul	Tiliaceae

## Tans and Dyes

Shilli Wildlife Sanctuary supports a wide range of species which are used as tans and dyes. Total 19 species have been recorded in the sanctuary having high important value for tans and dyes usage. As per Table 17, out of 19 species present under this category, 1 species belongs to the family Anacardiaceae, 2 from Berberidaceae, 1 from Coriariaceae, 6 belong to Fabaceae, 1 to Fagaceae, 1 from Juglandaceae, 2 from Lythraceae, 1 from Meliaceae, 1 from Myricaceae, 1 from Nyctanginaceae, 1 from Rubiaceae and 1 Sapindaceae, respectively. Fabaceae family has the wide range of species under the tans and dyes occurrence (Table 17).

**Table 17: Tans and dyes species in three altitudinal zones of Shilli Wildlife Sanctuary**

Sr. No.	Botanical Name	Common Name	Family
1.	<i>Albizia lebbek</i>	Lebbek tree	Fabaceae
2.	<i>Albizia odoratissima</i>	Black siris	Fabaceae
3.	<i>Bauhinia variegata</i>	Kachnar	Fabaceae
4.	<i>Berberis aristata</i>	Barberry	Berberidaceae
5.	<i>Berbens lycium</i>	Indian lycium	Berberidaceae
6.	<i>Coriaria nepalensis</i>	Masuri berry	Coriariaceae
7.	<i>Cotinus coggygria</i>	Smoke tree	Anacardiaceae
8.	<i>Dodonaea viscosa</i>	Hopbush	Sapindaceae
9.	<i>Indigofera bebepetala</i>	True indigo	Fabaceae
10.	<i>Indigofera puchella</i>	Indigo	Fabaceae
11.	<i>Indigofera gerardiana</i>	Himalayan indigo	Fabaceae
12.	<i>Juglans regia</i>	English walnut	Juglandaceae
13.	<i>Mirabilis jalapa</i>	Marvel-of-peru	Nyctanginaceae
14.	<i>Myrica esculenta</i>	Kaphal	Myricaceae
15.	<i>Punica granatum</i>	Pomegranate	Lythraceae
16.	<i>Quercus leucotricophora</i>	Ban oak	Fagaceae
17.	<i>Rubia cordifolia</i>	Madder	Rubiaceae
18.	<i>Toona ciliata</i>	Red cedar	Meliaceae
19.	<i>Woodfordia fruticosa</i>	Fire flame bush	Lythraceae

## Gums and Resins

Sanctuary has 2 species which are highly useful for the gums and resins purpose which including *Albizia lebbeck* and *Woodfordia futilcosa* belongs to the family Fabaceae and Lythraceae as per shown in the Table 18 given below:

**Table 18: Gums and resins species in three altitudinal zones (1200-1800 m amsl) of Shilli Wildlife Sanctuary**

Sr. No.	Botanical Name	Common Name	Family
1.	<i>Albizia lebbeck</i>	Lebbeck tree	Fabaceae
2.	<i>Woodfordia futilcosa</i>	Fire flame bush	Lythraceae

## Fuelwood species

Shilli wildlife sanctuary has a wide range of Fuelwood species. Table 18 elaborates the presence of 43 species present in the sanctuary amongst them the dominating family which are having maximum number of species are Fabaceae, Laminaceae, Lauraceae, Rosaceae, rest of the details of the species present in the sanctuary all shown and illustrated in the Table 19.

**Table 19: Fuelwood species in three altitudinal zones of Shilli Wildlife Sanctuary**

Sr. No.	Botanical Name	Common Name	Family
1.	<i>Albizia lebbeck</i>	Lebbeck tree	Fabaceae
2.	<i>Albizia odoratissima</i>	Siris	Fabaceae
3.	<i>Bombax ceiba</i>	Cotton tree	Bombacaceae
4.	<i>Buddleia paniculata</i>	Panicled butterfly bush	Scrophulariaceae
5.	<i>Carissa carandas</i>	Karanda	Apocynaceae
6.	<i>Caryopteris wallichiana</i>	Bluebeard	Laminaceae
7.	<i>Cedrus deodara</i>	deodar	Pinaceae
8.	<i>Celtis australis</i>	Europeon nettle tree	Cannabaceae
9.	<i>Coriaria nepalensis</i>	Masuri berry	Coriariaceae
10.	<i>Cotinus coggygria</i>	Smoke tree	Anacardiaceae
11.	<i>Cotoneaster microphylla</i>	Rockspray cotoneaster	Rosaceae
12.	<i>Cupressus torulosa</i>	Himalayan cypress	Cupressaceae
13.	<i>Dodonea viscosa</i>	Hopbush	Sapindaceae
14.	<i>Elaeagnus umbellata</i>	Autumn olive	Elaeagnaceae
15.	<i>Eucalyptus globulus</i>	Tasmanian blue gum	Myrtaceae
16.	<i>Euonymus tingens</i>	Purple veined spindle tree	Celastraceae
17.	<i>Ficus palmata</i>	Anjiri	Moraceae
18.	<i>Grewia optiva</i>	Beul	Tiliaceae
19.	<i>Indigo ferapuchella</i>	Indigo	Fabaceae
20.	<i>Juglans regia</i>	English walnut	Juglandaceae
21.	<i>Justicia adhatoda</i>	Malabar nut	Acanthaceae
22.	<i>Lanata camara</i>	West indianlatana	Verbenaceae
23.	<i>Leptodermis lanceolata</i>	Eflora of india	Rubiaceae
24.	<i>Lindera pulcherrima</i>	Spice bush	Lauraceae

25.	<i>Machilus duthei</i>	Duthei's bay tree	Lauraceae
26.	<i>Machilus odoratissima</i>	Fragrant bay tree	Lauraceae
27.	<i>Magifera indica</i>	Mango	Anacardiaceae
28.	<i>Melia azedrach</i>	Chinaberry	Meliaceae
29.	<i>Mimosa rubicaulis</i>	South india mimosa	Fabaceae
30.	<i>Myraca esculenta</i>	Bayberry	Myricaceae
31.	<i>Picea smithiana</i>	Indian spruce	Pinaceae
32.	<i>Princepia utilis</i>	Himalayan cherry prinsepia	Rosaceae
33.	<i>Prunus cerasoides</i>	Sour cherry	Rosaceae
34.	<i>Punica granatum</i>	pomegranate	Rosaceae
35.	<i>Pyrus pashia</i>	Himalayan pear	Rosaceae
36.	<i>Quercus leucotricophora</i>	Ban oak	Fagaceae
37.	<i>Rhododendron arboreum</i>	Rhododendron	Ericaceae
38.	<i>Salix tetrasperma</i>	Indian willow	Salicaceae
39.	<i>Toona ciliata</i>	Toon	Meliaceae
40.	<i>Vitex negundo</i>	Chinese chastetree	Laminaceae
41.	<i>Vitis himalayana</i>	Himalayan woodbine	Laminaceae
42.	<i>Woodfordia fruticosa</i>	Fire flame bush	Lythraceae
43.	<i>Zizyphus mauritiana</i>	Indian jujube	Rhamnaceae

### Bee-flora species

The sanctuary has a major account of bee flora. As per Table 20, species recorded in the sanctuary including the families, dominantly, 6 species belong to the family Rosaceae, 4 of Laminaceae, 4 of Fabaceae, and 3 species from Asteraceae. Among 45 numbers of species belonging to several families, Rosaceae holds the maximum account of species under the category of Bee-flora.

**Table 20: Bee-flora species in three altitudinal zones of Shilli Wildlife Sanctuary**

Sr. No.	Botanical Name	Common Name	Family
1.	<i>Albizia lebbeck</i>	Lebbeck tree	Fabaceae
2.	<i>Albizia odoratissima</i>	siris	Fabaceae
3.	<i>Atylosia sp.</i>	Atylosia	Fabaceae
4.	<i>Berberis aristata</i>	barberry	Berberidaceae
5.	<i>Bidens tripartita</i>	Leafy-bracted beggarticks	Asteraceae
6.	<i>Bombax ceiba</i>	Cotton tree	Bombacaceae
7.	<i>Canaabis sativa</i>	Bhaang	Cannabaceae
8.	<i>Carissa carandus</i>	Karanda	Apocynaceae
9.	<i>Caryopteris wallichiana</i>	Bluebeard	Menispermaceae
10.	<i>Cellistemon lenculatus</i>	Bottlebrush	Myrtaceae
11.	<i>Cissam pelospareira</i>	Velvet leaf	Merispermaceae
12.	<i>Clematis gourina</i>	Java clematis	Ranunculaceae
13.	<i>Clerodendrum philippinum</i>	Chinese glory bower	Laminaceae
14.	<i>Cnicus argyllacanthus</i>	Common thistle	Asteraceae
15.	<i>Elaeagnus umbellata</i>	Autumn olive	Elaeagnaceae
16.	<i>Eucalytus globulus</i>	Tasmanium blue gum	Myrtaceae
17.	<i>Grewia optiva</i>	Beul	Tiliaceae
18.	<i>Hypericum cernuum</i>	Hypercium	Hypericaceae

19.	<i>Justicia adhatoda</i>	Malabar nut	Acanthaceae
20.	<i>Leptodermis lenceolata</i>	Lanceleaf	Rubiaceae
21.	<i>Lonicera japonica</i>	Japnese honeysuckle	Caprifoliaceae
22.	<i>Lonicera quinquelocularis</i>	Translucent honeysuckle	Caprifoliaceae
23.	<i>Lotus comiculata</i>	Bird's-foot trefoil	Fabaceae
24.	<i>Malva rotundifolia</i>	Round leaf mallow	Malvaceae
25.	<i>Nicotiana tabacum</i>	Tobacco	Solanaceae
26.	<i>Ocimum santum</i>	Basil	Laminaceae
27.	<i>Oxalis corniculata</i>	Creeping woodsorrel	Oxalidaceae
28.	<i>Prunus cerasoides</i>	Wild himalayan cherry	Rosaceae
29.	<i>Punica granatum</i>	Pomegranate	Lythraceae
30.	<i>Pyrus pashia</i>	Himalayan pear	Rosaceae
31.	<i>Rhabdosia rugosa</i>	Japanese rose	Laminaceae
32.	<i>Rosa moschata</i>	Musk rose	Rosaceae
33.	<i>Rubus ellipticus</i>	Yellow himalayan raspberry	Rosaceae
34.	<i>Rubus lasiocarpus</i>	Blackberries	Rosaceae
35.	<i>Rubus paniculatus</i>	Raspberries	Rosaceae
36.	<i>Salvia moorcroftiana</i>	Savia	Laminaceae
37.	<i>Sepium sebiferum</i>	Chinese tallow tree	Euphorbiaceae
38.	<i>Sarcocca saligna</i>	Willow leaf sweet box	Buxaceae
39.	<i>Smilax rotundifolia</i>	Roundleaf greenbrier	Smilacaceae
40.	<i>Smilax vaginata</i>	Sasparilla	Smilacaceae
41.	<i>Tagetus minuta</i>	Southern cone marigold	Asteraceae
42.	<i>Thuja orientalis</i>	Chinese thuja	Cupressaceae
43.	<i>Vinca major</i>	Greater periwinkle	Apocynaceae
44.	<i>Viscum album</i>	Common mistletoe	Santalaceae
45.	<i>Zizyphus mauritiana</i>	Indian jujube	Rhamnaceae

### Tantra-Mantras species

As shown in the Table 21, the sanctuary includes total three numbers of species around the entire area which are botanically/scientifically named as *Achyranthus bidentata*, *Prinsepia utilis* and *Verbascum Thapsus* belongs to the family Amaranthaceae, Rosaceae and Scrophulariaceae. These species are widely used by the local people as per their spiritual belief.

**Table 21: Tantra-Mantras (Black magic) species in three altitudinal zones of Shilli Wildlife Sanctuary**

Sr. No.	Botanical Name	Common Name	Family
1.	<i>Achyranthus bidentata</i>	Ox knee	Amaranthaceae
2.	<i>Prinsepia utilis</i>	Himalayan cherry princepia	Rosaceae
3.	<i>Verbascum thapsus</i>	Common mullein	Scrophulariaceae

### Insecticidal species

The sanctuary is having one species of having insecticidal property which is botanically named as *Arachne cordifolia* belonging to the family Phyllanthaceae (Table 22).

**Table 22: Insecticidal species in three zones of Shilli Wildlife Sanctuary**

Sr. No.	Botanical Name	Common Name	Family
1.	<i>Arachne cordifolia</i>	Durlu	Phyllanthaceae

**Fern and Lichen species**

The sanctuary consists of a wide range of ferns and one lichen. As described in the Table 23, ten species of ferns are present in Shilli Wildlife sanctuary, Solan. All ferns belong to the family Filicinaceae and one lichen species attain the family Parmeliaceae.

**Table 23: Ferns and lichens species in three altitudinal zones of Shilli Wildlife Sanctuary**

<b>FERNS</b>			
Sr. No.	Botanical Name	Common Name	Family
1.	<i>Adiantum edgeworthii</i> Hook.	Dumtuli	Filicinaceae
2.	<i>Adiantum capillus- veneris</i> Linn.	Hansraj	Filicinaceae
3.	<i>Asplenium delhousiae</i> Hook.	spleenworts	Filicinaceae
4.	<i>Athyrium schimperi</i> Moug. Ex Fee	Athrium	Filicinaceae
5.	<i>Cheilanthes albomarginata</i> Clarke	Barun	Filicinaceae
6.	<i>Prinephrium penangianum</i> (Hook)	Prinephrium	Filicinaceae
7.	<i>Pyrosia astricita</i> (Kuntze) Holttum	Pyrosia	Filicinaceae
8.	<i>Pteris cretica</i> Linn.	Barne	Filicinaceae
9.	<i>Polystri chumdiscretum</i> D.Don	Polystrichum	Filicinaceae
10.	<i>Polystri chumsquarresum</i> D.Don	Polyscium	Filicinaceae
<b>LICHENS</b>			
1.	<i>Parmelia perlata</i> (Muds.) Ach.	Chharila , Stone Flowers	Parmeliaceae

**Percentage Share of Occurrence of Different Species:**

The per cent share of various occurring species present in the Shilli Wildlife Sanctuary is distributed and detailed in the Table 24. The presence of timber species in Shilli Wildlife Sanctuary is 7.30 percent; however, the fodder species has an account of 11.96 percent. The fibre species (01.32%), tans and dyes species are in the distribution of 06.31; whereas, gums and resins have the percentage share of 0.66%. The fuelwood and bee flora species holds the highest percentage account of share of 15.61 percent and 15.95 percent respectively. The species used for tantras and mantras are distributed in the percentage of 0.99%; moreover, species having insecticidal properties are in the share of 0.33%. The ferns and lichens are distributed as per the percentage of 03.32% and 0.33%, respectively. Overall share of all the species reach to a level of 62.13 percent (Fig.4).

**Table 24: Occurrence of different species categories present in Shilli Wildlife Sanctuary**

Sr. No.	Category	Share (%)
1.	Timber	7.30
2.	Fodder	11.96
3.	Fibre and Flosses	01.32
4.	Tans and Dyes	06.31
5.	Gums and Resins	0.66
6.	Fuelwood	15.61
7.	Beeflora	15.95
8.	Tantras-mantras	0.99
9.	Insecticides	0.33
10.	Ferns	03.32
11.	Lichens	0.33

### Inventory of Exotic Pines

The sanctuary is quite rich in wide plantation of exotic pines. Twenty four species have been found occurring and identified in different locations in scattered pattern of Shilli Wildlife Sanctuary. The species were introduced in the sanctuary during 1969-1972 by State Forest Department and the species are illustrated in the Table 25.

**Table 25: Inventory of exotic pines present in Shilli Wildlife Sanctuary**

Sr. No.	Botanical Name	Common Name	Family
1.	<i>Pinus banksiana</i>	Jack pine	Pinaceae
2.	<i>Pinus palustris</i>	Longleaf pine	Pinaceae
3.	<i>Pinus taeda</i>	Loblolly pine	Pinaceae
4.	<i>Pinus virginiana</i>	Virginia pine	Pinaceae
5.	<i>Pinus glabra</i>	Spruce pine	Pinaceae
6.	<i>Pinus rigida</i>	Pitch pine	Pinaceae
7.	<i>Pinus caribaea</i>	Caribbean pine	Pinaceae
8.	<i>Pinus radiata</i>	Monterey pine	Pinaceae
9.	<i>Pinus latifolia</i>	Lodgepole pine	Pinaceae
10.	<i>Pinus clausa</i>	Sand pine	Pinaceae
11.	<i>Pinus echinata</i>	Shortleaf pine	Pinaceae
12.	<i>Pinus pungens</i>	Table mountain	Pinaceae
13.	<i>Pinus ponderosa</i>	Ponderosa pine	Pinaceae
14.	<i>Pinus jeffreyi</i>	Jeffrey pine	Pinaceae
15.	<i>Pinus contorta</i>	Shore pine	Pinaceae
16.	<i>Pinus coulteri</i>	Coulter pine	Pinaceae
17.	<i>Pinus sabiniana</i>	California foothill pine	Pinaceae
18.	<i>Pinus attenuate</i>	Knobcone pine	Pinaceae
19.	<i>Pinus torreyana</i>	Torrey pine	Pinaceae
20.	<i>Pinus muricata</i>	Bishop pine	Pinaceae
21.	<i>Pinus patula</i>	Patula pine	Pinaceae
22.	<i>Pinus elliottii</i>	Slash pine	Pinaceae
23.	<i>Pinus greggii</i>	Gregg's pine	Pinaceae
24.	<i>Pinus wallichiana</i>	Himalayan white pine	Pinaceae

### Plant diversity of species

The sanctuary has a distribution of all three angiosperms, gymnosperms and ferns with the percent share of 92.79 per cent, 3.6 per cent and 3.26 per cent. The plant diversity shows that the sanctuary is quite rich in angiosperms presence. (Table 26, Fig. 5).

**Table 26: Plant diversity of total species found in Shilli Wildlife Sanctuary**

Sr. No.	Species	Per cent Constitution
1.	Angiosperms	92.79
2.	Gymnosperms	3.6
3.	Ferns	3.26

**Occurrence and Presence of Gymnosperms:**

As the Table 27 illustrates that sanctuary has a range of gymnosperms. In total eight species are highly present in the sanctuary and shows dominating nature among all the species. The gymnosperms present in the sanctuary belongs to the family of Pinaceae and Cupressaceae. The details of the species are as

**Table 27: Occurrence and presence of Gymnosperms in Shilli Wildlife Sanctuary**

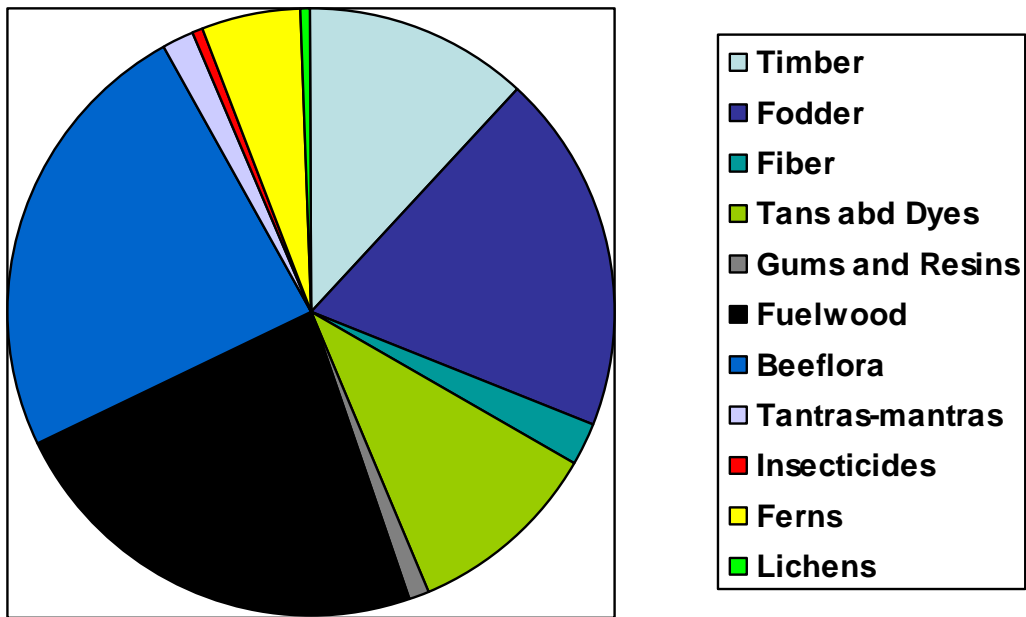
Sr. No.	Botanical Name	Common Name	Family
1.	<i>Cedrus deodara</i>	Deodar	Pinaceae
2.	<i>Pinus gerardiana</i>	Chilgoza	Pinaceae
3.	<i>Pinus patula</i>	Jelecote pine	Pinaceae
4.	<i>Pinus roxburghii</i>	Chir	Pinaceae
5.	<i>Picea smithiana</i>	Spruce	Pinaceae
6.	<i>Taxodium mucronatum</i>	Taxodium	Cupressaceae
7.	<i>Cupressus torulosa</i>	Morpankhi	Cupressaceae
8.	<i>Thuja orientalis</i>	Chinese thuja	Cupressaceae

**Economic importance wise species present in the study area**

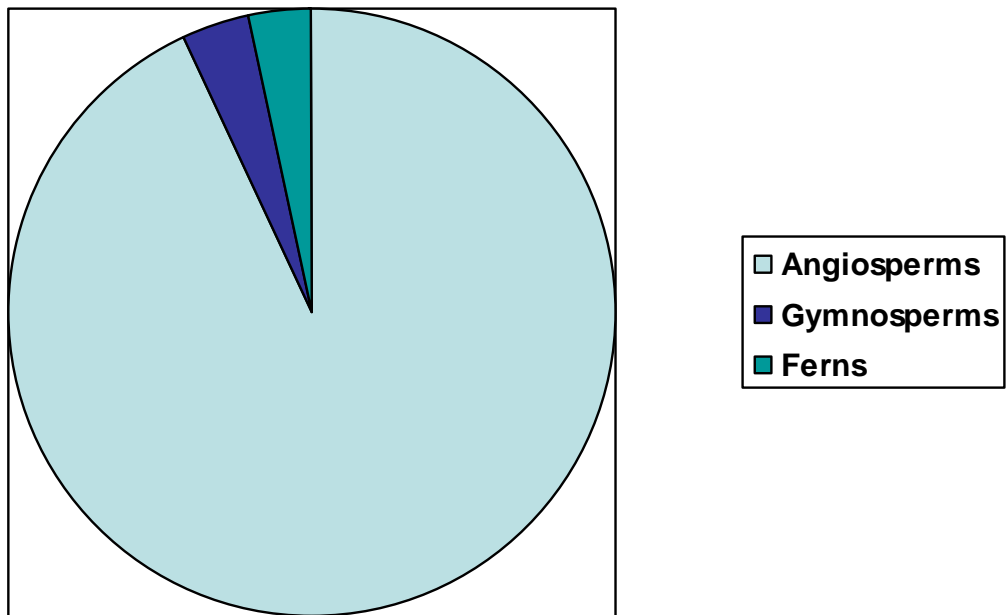
Table 28 elaborates, 9 types of group species have been recorded in Wildlife Sanctuary; which include, 22 species of timber, 36 species of fodder, 04 species of fibre and flosses, 19 species of tans and dyes, 2 species of gums and resins, 47 species of fuelwood, 42 species of bee flora, 3 species of tantras- mantras and 01 species of insecticides. Mainly, the sanctuary is rich in fuelwood, bee flora and fodder species. The sanctuary has major presence of timber as well (Fig. 6).

**Table 28: Economic importance/ Usage wise species present in the study area**

1.	Timber species	22
2.	Fodder species	36
3.	Fibre and flosses	04
4.	Tans and dyes	19
5.	Gums and resins	02
6.	Fuelwood	47
7.	Bee flora	42
8.	Tantras and mantras	03
9.	Insecticides	05
10.	Ferns	10
11.	Lichen	01



**Fig. 4. Occurrence of different species categories present in Shilli Wildlife Sanctuary.**



**Fig. 5. Plant diversity of total species found in Shilli Wildlife Sanctuary**

### **List of ethnobotanical plant with their botanical name, local name, part used and their uses in Shilli Wildlife Sanctuary**

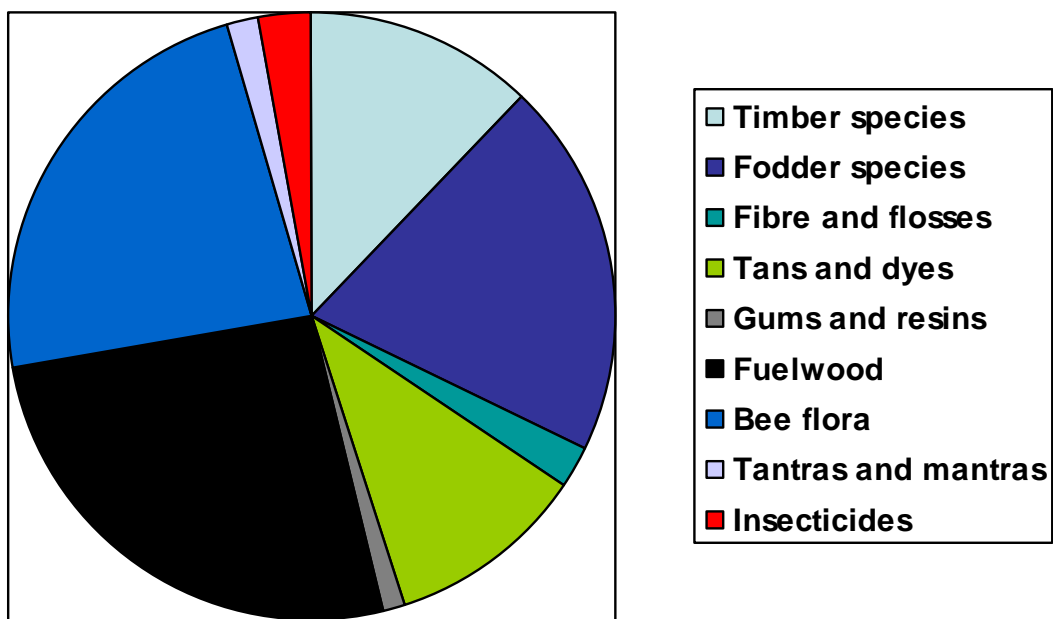
The Table 29 elaborates that there are 40 species present of ethnobotanical importance in Shilli Wildlife Sanctuary, Solan. The species including all trees, herbs and shrubs collectively in all the the three altitudinal zones of the sanctuary starting from 1200 m to 1800 m amsl elevation (Table 29). The study has been in concern with the investigation done previously by Chauhan (1997) documented the ecological and ethno-botanical studies on the flora of Spiti. Out of 477, identified species, 74 were categorized as medicinal and aromatic plants, 104 plant species with ethno-botanical importance were recorded. Similarly, Sharma (1998) did ethno-botanical studies of Gaddies- A tribal community in district Kangra of Himachal Pradesh. He collected 161 species belonging to 124 genera and 54 families. The ethno-botanical study was carried out by Chauhan and Chauhan (1988) among Paharis inhabiting the Trans Giri area of Sirmour district in Himachal Pradesh. Kumar and Pullaiah (1998) revealed first hand information gathered on 50 ethno-medicinal plants traditionally used by Chenchu, Yanadi, Suga and Yerukala tribes of Prakasam of Andhra Pradesh for the treatment of various diseases and disorders.

### **Vox populi of villagers living in the surrounding villages of Shilli Wildlife Sanctuary:**

Surrounding villagers were asked about the awareness of various concepts and responses of the people were observed which shows that 58 percent of the population living in the surrounding villages of the sanctuary goes in for open grazing of their domesticated animals. A total of 40 percent of villagers from five villages have been recorded for their dependence on wildlife sanctuary for various means. According to the survey, 20 percent of the villagers have other type of interaction are made by other type of farming community with the sanctuary; 76 percent admit that the sanctuary have the restriction of movement and extraction/ management; 26 percent of villagers attain their income from biotic and abiotic resources of the sanctuary; 74 percent of the villagers have experienced the man animal conflict for last three years as the wild animal species are highly present in the sanctuary. A total of 86 percent of the villagers collect medicinal plants from the sanctuary for various diseases and lastly none of the villagers have maintained the sacred groves in the area of the sanctuary as per their spiritual and religious belief (Table 30, Fig. 7 and 8).

**Table 29: Ethnobotanical plants and their usage occurring in Shilli Wildlife Sanctuary in three Zones (1200m-1800 m amsl)**

Sr. No.	Botanical name	Local name	Official Parts of the plant used	Ethanobotanical uses
1.	<i>Achyranthus bidentata</i>	Puthkanda	Entire plant	Used in asthma, used for treating waist pains.
2.	<i>Ajuga bracteosa</i>	Neel kanthi	Leaves	Juice of crushed leaves is used to cure the ear ache also used to cure diabetes.
3.	<i>Asparagus adscendens</i>	Safed musli	Roots	Roots are fed to milking cattles to enhance milk production.
4.	<i>Anaphalis busua</i>	Dharadi	Entire Plant	Plant is worshipped on "Durga ashtmi" and also mixed in hawan samaghri.
5.	<i>Bauhinia variegata</i>	Kachnar	Bark, flower	Bark is dried and powdered for decoction which is used gargling for relieving throat infection and flower buds are used to make pickles.
6.	<i>Berberis lycium</i>	Kashmal	Leaves, roots, fruits	Leaves are eaten everyday to cure painful urination; roots are applied to skin infection, fruits are edible, also used to make local wine.
7.	<i>Boenninghausenia albifolia</i>	Pissumar-mar-buti	Entire plant	The plant is kept under bed sheets to get rid of fleas.
8.	<i>Bombax ceiba</i>	Sheemal	Flosses and flower buds	Flosses covering the seeds are used for pillow stuffing and flower buds are used as vegetables.
9.	<i>Cannabis sativa</i>	Bhang	Seeds, leaves	Seeds are heated and eaten by local people to avoid cold and leaves are rubbed to reduce the swelling after insect bite.
10.	<i>Centella asiatica</i>	Brahmi	Leaves	Leaves are taken as such or dried leaf powder with ghee and honey taken in the morning for improving memory.
11.	<i>Cissampelos pariera</i>	Batendu, patindu	Roots	Used to cure tooth ache, used for curing dysentery in children due to heat.
12.	<i>Cotinus coggryia</i>	Tung	Bark	Used as 'Datun' tooth stick and its sap is applied on wounds for healing.
13.	<i>Cotoneaster microphylla</i>	Pasarni	Leaves	The paste of leaves is made and is applied to cure pasarni or brahma-sutra.
14.	<i>Cuscuta reflexa</i>	Akash- bel	Stem	Stem is crushed and the juice thus obtained is used to increase hair growth, also useful for rheumatic pains.
15.	<i>Delohinium denudatum</i>	Nirbishi	Roots	Roots cure 'kapha' and vata And for toothache as well. Also used as tonic.
16.	<i>Dioscorea bulbifera</i>	Ratalu	Tubers	Tubers are given to cattle to cure ghamaas i.e. stomach bleeding.
17.	<i>Dodonia viscosa</i>	Mehdru	Leaves	Leaf paste is applied on injured part for healing the wounds.
18.	<i>Ficus palmata</i>	Faigra	Entire plant	Milky juice of the plant is used expel out thorn from body part.
19.	<i>Galium aparine</i>	Safed-manjith	Entire plant	Plant is rubbed to cure warts on body.
20.	<i>Grewia optiva</i>	Beul	Leaves, bark	Leaves are used as fodder and bark is crushed and used for cleaning hairs and also used for making ropes.
21.	<i>Jasminum dispersum</i>	Chameli	Leaves	For acidity and gastric troubles and the green leaves are made into tablets mixed with gur and consumed with cold water.
22.	<i>Juglans regia</i>	Akhrot	Nuts, stem bark, leaves	Nuts are edible, the stem bark and leaves are used as datun.
23.	<i>Justicia adhatoda</i>	Basuti	Leaves	Leaves are put in grains during storage to protect against attack of store insects. Also used for prevent cough.
24.	<i>Litsea chinensis</i>	Medasaka	Bark	Bark of the plant is boiled with cow's urine and then applied on broken bones to cure fracture.
25.	<i>Meriandra stobilifera</i>	Murta	Leaves	Leaves are spread in cattle sheds to get rid of fleas.
26.	<i>Mentha arvensis</i>	Pudina	Leaf	Leaf juice is given to stop vomiting. Chatni prepared from the leaves to enhance appetite.
27.	<i>Nicotiana tabacum</i>	Tambaku	Leaves	Leaves are applied on the side of the face to avoid gum swelling.
28.	<i>Ocimum sanctum</i>	Tulsi	Entire plant	Plant is worshipped. Leaves are taken with honey to cure cough.
29.	<i>Pinus roxburghii</i>	Chir	Resin	Resin from the tree to cure cracks on the soles.
30.	<i>Punica granatum</i>	Daru	Fruit, seeds	Fruits rinds are dried and powdered and taken with cold water to relieve cough.
31.	<i>Princepia utilis</i>	Bhekhali	Stem	Hollow stems are used by children to play guns.
32.	<i>Prunus cerasoides</i>	Paja	Entire plant	Used in marriage ceremony.
33.	<i>Quecrus leucotricophora</i>	Ban	Tree holes	Black dye is extracted from the natural tree holes used as ink.
34.	<i>Rhododendron arboretum</i>	Bras, burans	Flowers	Flowers are used to make chatni. Sharbat is considered good for heart.
35.	<i>Rumex hastatus</i>	Khati-mithi	Entire plant	Used to clean silver ornaments.
36.	<i>Thalicttrum foliolosum</i>	Mamiri	Roots	Roots are burnt and used to make surma and eye problems.
37.	<i>Verbascum thapsus</i>	Gidar-tamaku	Flowers and roots	Plant is used for jadu tona. Also used for insect bite.
38.	<i>Viola serpens</i>	Banaksa	Entire plant	Decoction of plant is given in cough, cold and fever.
39.	<i>Vitex negundo</i>	Banna	Twigs and leaves	Used to cure toothache and headache.
40.	<i>Zanthoxylum alatum</i>	Tirmir	Young branches and fruits	Used as datum to strengthen gums and teeth.



**Fig. 6. Economic importance/ Usage wise species present in the study area.**

**Table 30: Vox Populi: Response of people from different villages of Shilli Wildlife Sanctuary**

Sr. No.	Concept of Awareness	V1		V2		V3		V4		V5		Positive Response (AVG of all responses)
	Questions	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	
1.	Open grazing in the Wildlife Sanctuary	7	3	6	4	8	2	5	5	3	7	58.00
2.	Dependence on the Wildlife Sanctuary	6	4	3	7	7	3	2	8	2	8	40.00
3.	Other type of interactions are made by the farming community with the Sanctuary	6	4	5	5	2	8	1	9	3	7	20.00
4.	Any restrictions of movements extraction/management due to Wildlife Sanctuary	9	1	8	2	7	3	6	4	8	2	76.00
5.	Any income from the biotic/abiotic resources of the Sanctuary	3	7	6	4	5	5	4	6	4	6	26.00
6.	Experienced any man-animal conflict for last three years	8	2	7	3	9	1	8	2	5	5	74.00
7.	Collect medicinal plants from the sanctuary	9	1	8	2	10	-	9	1	7	3	86.00
8.	Sacred grove is maintained in area	-	-	-	-	-	-	-	-	-	-	00.00

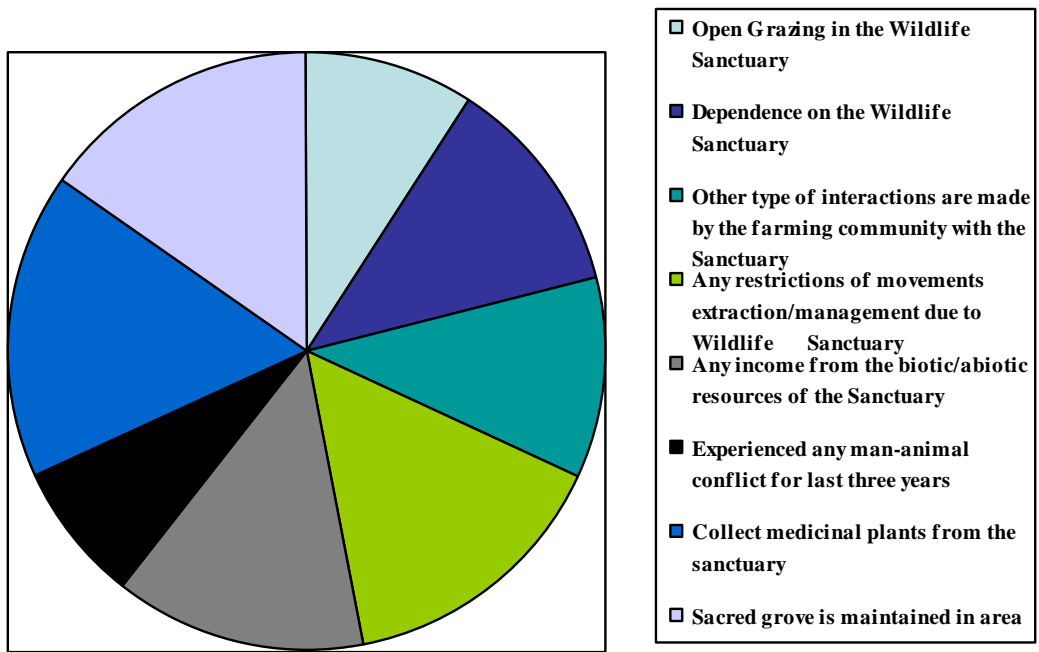
Where, V1: Shilli, V2: Malaun, V3: Bhajhrol, V4: Bhajhlog, V5: Phaskana

Each species is provided with a brief description, frequency of occurrence, habitat followed by information on medicinal uses (Ravi and Sankar 2003). An ethnobotanical survey of the Igede-speaking area of Nigeria indicated that over 30 taxa of plants were used in traditional medicines, a total of 31 prescriptions for different kinds of ailments or therapeutic indications were noted (Igoli *et al.* 2003).

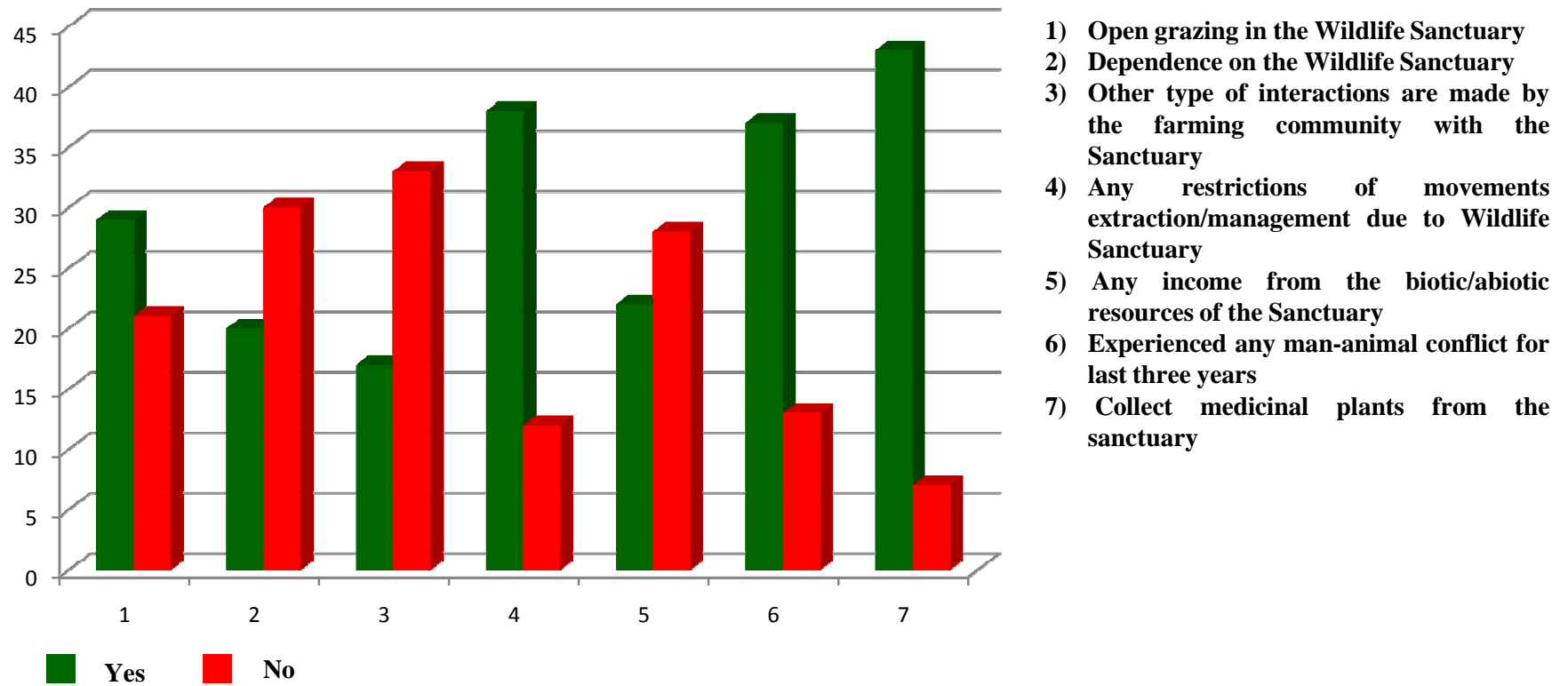
Results/findings in the present investigation are in line of confirmity with the findings on the research on topic 'Studies on Phytodiversity of Lippa-Asrang Wildlife Sanctuary in District Kinnaur, Himachal Pradesh' (Viraj Man, 2013).

The study investigated as 'Study on Dynamics of Plant Bioresources in Chail Wildlife Sanctuary of Himachal Pradesh' by Rakesh Kumar (2008) was also an important aspect under consideration in the present study in which phytosociological studies has been explained and the studies of phytosociological aspects w.e.f. density, frequency, etc., have been undertaken. The study on weeds as medicinal plants used by the traditional healers in Bhojpur district of Bihar, India, for treating ailments and also discussed the medicinal and other useful weed species with their name and its medicinal uses. Information on other general economic importance of medicinal weeds is also described (Rai and Pandey, 2005). The investigation were carried out to enumeration of plants with medicinal values, which are used by the Valaiyans, an ethnic group, residing in and around Piranmalai Hills, Tamil Nadu, South India (Sandhya *et al.* 2005). The study elucidates a rich and unique profile of Phytodiversity of the area surveyed, with 63 species of medicinal plants belonging to 59 genera and 38 families. This is the first report on phytosociological and ethnobotanical aspects of its own inventory and documentation of forest genetic resources and cannot be compared as such with the studies undertaken in different Wildlife Sanctuaries, National Parks, Protected Areas and Biosphere Reserves, etc. Similar studies have been conducted by Bawa *et al* (2009) on structural parameters of woody elements in Sangla valley of district Kinnaur, Himachal Pradesh. Further, Bawa *et al* (2011), has also undertaken ecological studies on floristic diversity and phenology of woody elements in Dodra Kwar Forest Range of Himachal Pradesh, where he reported that species diversity and richness were negatively correlated whereas evenness was positively correlated with slope, steepness and moist ecological niche.

Results/findings are also on the same line as far as species richness and diversity along an altitudinal gradient as reported by Sharma *et al* (2009). Another study was also



**Fig. 7. Vox Populi: Response of people from different villages of Shilli Wildlife Sanctuary**



**Fig. 8. Vox Populi: Positive and negative response of people from different villages of Shilli Wildlife Sanctuary**

conducted by Verma and Kapoor (2011b) conducted study to assess the plant at elevation varying from 300 m to 4500 m above msl in Murti Pang Valley of Rakchham Chitkul Wildlife Sanctuary of District Kinnaur, Himachal Pradesh. A total number of 131 plant species belonging to 46 families and 91 genera was collected. The dominant families were Asteraceae, Rosaceae, Polygonaceae, Lamiaceae and Ranunculaceae. The dominant tree species was recorded as *Populus ciliata* and *Juniperus polycarpos*, whereas among the shrub species, *Berberis jaeschkeana* and *Juniperus indica* were dominant at 3300-3700m and 3700-4100m above msl, respectively. The herb species *Sibbaldia cuneata*, *Thymus linearis* and *Heracleum lanatum* were recorded as dominant at 300-3700m, 3700-4100m and 4100-4500m above msl, respectively. Index of diversity for herb was 4.02, 3.78 and 3.67 for 3300-3700m, 3700-4100m and 4100-4500m above msl, respectively.

One more similar study was conducted by Srinivas and Yadava (1999) undertaken phytosociological studies at four oak forest with various levels of disturbance (site I low, site II and III moderate and site IV high) in Manipur, North-East India. The dominant species at all the sites was *Quercus serrata*, with *Q. dealbata* as co-dominant. Correlation analysis was carried out between the occurrences of the different tree/woody species and exhibits positive correlations among them in four forest sites.



**Plate 3. Sampling and field data collection in Shilli Wildlife Sanctuary, Solan**



**Plate 4. Sampling and field data collection with local guide in Shilli Wildlife Sanctuary during survey**



**Plate 5: Researcher visiting different villages surrounding Shilli Wildlife Sanctuary for interviewing the respondents**

## Chapter-5

# SUMMARY AND CONCLUSION

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The work on “**Phytosociological and Ethnobotanical Studies in Shilli Wildlife Sanctuary, District- Solan, Himachal Pradesh**” is summarized as below:

The present study was confined to three different altitudinal zones, i.e., lower base (1200-1400m), mid hill (1400-1600m), and hill top (1600-1800m) of Shilli Wildlife Sanctuary, which is located in Solan District of Himachal Pradesh. The areas of the sanctuary constitute of 2.13sq km and are the smallest sanctuary of Himachal Pradesh. The sanctuary is located between 30°54'15" to 30°54'41" North and longitude from 70°07'45" to 77° 09'13" East.

Executive summary of the research work on ecological parameters is as under, which is comprised to two broad objectives, i.e., phytosociological studies and identification of species of ethnobotanical importance.

In all the studied elevations of Shilli Wildlife Sanctuary, Solan, i.e., 1200-1400 m, 1400-1600 m and 1600-1800 m and above, 54 quadrats of 30 × 30 m size determined by species area curve method were randomly but systematically laid out to study tree species. In each quadrat, a sub quadrat of 5 × 5 m (25sqm) size of shrubs and 2 × 2 m (4 sq m) for herbs study were observed, respectively.

The vegetation data were quantitatively analyzed for density, percent frequency and Relative frequency, Relative density was determined following Phillips (1959), while Importance Value Index (IVI) was calculated following Curtis (1959).

Indices of similarity and dissimilarity were calculated. The species richness, species diversity (Shannon-Weaver, 1963), species dominance (Simpson, 1949) were also determined.

The sanctuary was distributed in three zones starting from lower zone, i.e., 1200-1400 m, mid hill i.e. 1400-1600 m and hill top 1600-1800 m.

In Zone I, i.e., 1200-1400 m of elevation, under the category of tree species, *Pinus roxburghii* was the dominant tree species having maximum density (350 trees ha<sup>-1</sup>) and IVI (47.06). The highest value of frequency and abundance was recorded for *Pinus roxburghii* (40%) and *Bombax ceiba* respectively. Whereas, among the various Shrub species recorded in this area, *Zanthoxylum armatum* was the dominant Shrub species having maximum density (500 shrubs ha<sup>-1</sup>) and IVI (39.67). The highest frequency was recorded in two of the species

i.e., *Dodonaea viscosa* (50) and *Jasminum humile* (50). In total, there were 19 shrub species recorded in lower base altitudinal zone. Among the various herb species recorded in this area, *Cynoglossum denticulatum* was the dominant herb species having density (1100 herbs ha<sup>-1</sup>) and having IVI (22.92). Highest frequency was recorded in two of the species in this zone namely *Phaseolus mungo* (40) and *Cnicus argyracanthus* (40).

In Zone II, i.e., mid hill that ranges from 1400-1600 m of elevation, among the various tree species recorded in this area, *Quercus leucotricophora* was the dominant tree species having maximum density (400 trees ha<sup>-1</sup>) and IVI (25.06). The highest value of frequency was recorded for *Quercus leucotricophora* (100) respectively. In case of shrub species, 48 shrub species were present in the altitudinal zone-II. The various shrub species recorded in this area, *Woodfordia fruticosa* was the dominant shrub species having maximum density (600 shrubs ha<sup>-1</sup>) having IVI (13.71). The highest IVI has been recorded in *Rosmarinus officinalis* IVI (15.26), respectively. The various herb species recorded in this area, *Rubia cordifolia* and *Digitalis lanata* was the dominant herb species having density (1100 herbs ha<sup>-1</sup>) and having IVI (03.85). Highest frequency was recorded in two of the species in this zone namely *Valeriana jatamansi* (40) and *Lepidium latifolium* (40). This altitudinal zone has the highest diversity of herb species amongst all the altitudinal zones of Shilli wildlife sanctuary.

In Zone III, that ranges from 1600-1800 m of elevation and said to be as hill top, tree species were found very less in this zone due to the highest distance from mean sea level. Among the tree species recorded in this area, *Cedrus deodara* was the dominant tree species having maximum density (500 trees ha<sup>-1</sup>) and IVI (112.96). The highest value of frequency was recorded for *Cedrus deodara* (100). In this zone, among the various herb species recorded in this area, *Geranium nepalense* was the dominant herb species having density (1100 herbs ha<sup>-1</sup>) and having IVI (42.69). Highest frequency was recorded in two of the species in this zone namely *Anaphalis busua* (35), respectively.

The vegetational analysis of the sanctuary includes angiosperms, gymnosperms, ferns and lichens. In total, there are 301 species present in the sanctuary, belonging to 207 genera and 108 families. Species which comes under the category of angiosperms are 283 in numbers from 171 genera and 86 families. The gymnosperms have 08 species followed by 06 genera and 03 families. Thirdly, ferns have 10 species; however, the genera and families are of equal units i.e. 08. Lastly, the lichens have only 01 species present in the sanctuary followed by 01 genera and 01 family, respectively.

The sanctuary is rich in all other aspects as well. Sanctuary has 22 timber yielding species belonging to different families. The dominant species among the timber species are Anacardiaceae, Cupressaceae and Lauraceae. Sanctuary is also rich in fodder species diversity. A total of 36 species useful for fodder purpose is present in Shilli Wildlife Sanctuary. Maximum no. of the species belonging to the family Fabaceae, followed by Rosaceae, Poaceae, Moraceae and Berberidaceae respectively.

The sanctuary is also consisting of fibre and flosses. Total four species present in Shilli Wildlife Sanctuary which are useful for fibre and flosses. Shilli Wildlife Sanctuary has a wide range of species useful for tans and dyes. Total 19 species have been recorded in the sanctuary having high important value for tans and dyes usage. Sanctuary has 2 species which are highly useful for the gums and resins purpose which including *Albizia lebbek* and *Woodfordia fucosa* belongs to the family Fabaceae and Lythraceae. Shilli Wildlife Sanctuary has a wide range of Fuelwood species. A total of 43 species present in the sanctuary amongst them the dominating family which are having maximum number of species are Fabaceae, Laminaceae, Lauraceae, Rosaceae, rest of the details of the species present in the sanctuary. The sanctuary has a major account of bee flora species. Species have been recorded in the sanctuary including the families, dominantly, 6 species belong to the family Rosaceae, Laminaceae includes 4 of the species, Fabaceae have 4, and Asteraceae have 3 of the species. The sanctuary has a major account of bee flora species. Species have been recorded in the sanctuary including the families, dominantly, 6 species belong to the family Rosaceae, Laminaceae includes 4 of the species, Fabaceae have 4, and Asteraceae have 3 of the species. The study area includes total three numbers of species around the entire area which are botanically/scientifically named as *Achyranthus bidentata*, *Prinsepia utilis* and *Verbascum Thapsus* belongs to the family Amaranthaceae, Rosaceae and Scrophulariaceae. These species are widely used by the local people as per their religious belief. The sanctuary is having one species of which is having insecticidal property which is botanically named as *Arachne cordifolia* belonging to the family Phyllanthaceae. The sanctuary consists of a wide range of ferns and one species of lichen.

The per cent share of various occurring species present in the Shilli Wildlife Sanctuary is distributed widely. The presence of timber species in Shilli Wildlife Sanctuary is 7.30 per cent; however, the fodder species has an account of 11.96 per cent. The fibre species has a percentage of 01.32. The tans and dyes species are in the distribution of 06.31 per cent;

whereas, gums and resins have the percentage share of 0.66 per cent. The fuelwood and bee flora species holds the highest percentage account of share of 14.28 per cent and 14.95 per cent. The species used for tantras and mantras are of 0.99 per cent; moreover, species having insecticidal properties are in the share of 0.33 per cent. The ferns and lichens are distributed as per the percentage of 03.32 per cent and 0.33 per cent, respectively. The sanctuary is rich in wide plantation of exotic pines. Twenty four species have been found occurring and identified in different locations.

The sanctuary has a constitutional distribution of angiosperms, gymnosperms, ferns and lichens 92.76, 3.6 and 3.26. A total of 8 gymnosperms are present in the Shilli Wildlife Sanctuary.

The sanctuary possesses a wide range diversity of ethnobotanical species present over there. A total of 40 species of ethanobotanical importance are present within the sanctuary.

In total, there are 301 species present in the sanctuary which shows high diversity in the entire sanctuary area. The 301 species include 86 families but the dominating families amongst the sanctuary are Asteraceae, Papilionaceae, and Verbenaceae. Rosaceae and Acanthaceae are less dominant ones among the 301 species present therein.

## CONCLUSIONS:

- Vegetation in Shilli Wildlife Sanctuary is comprised of 301 woody and non woody species.
- *Pinus roxburghii* is the dominant tree species present in Zone I (1200-1400 m amsl).
- *Zanthoxylum armatum* is the dominant shrub species present in Zone I (1200-1400 m amsl).
- *Cynoglossum denticulatum* is the dominant herb species present in Zone I (1200-1400 m amsl).
- *Quercus leucotricophora* is the dominant tree species present in Zone II (1400-1600 m amsl).
- *Woodfordia fruticosa* is the dominant shrub species present in Zone II (1400-1600 m amsl).
- *Rubia cordifolia* and *Digitalis lanata* is the dominant herb species present in Zone II (1400-1600 m amsl).
- *Cedrus deodara* the dominant tree species present in Zone III (1600-1800 m amsl).

- *Geranium nepalense* is the dominant herb species present in Zone III (1600-1800 m amsl).
- Abundance to frequency ratio is used as an indicator of spatial distribution of species in the community. A close look at the study depicts that most of the tree species were contagiously distributed and rest are randomly distributed tree species and none of the tree species was reported with regularly distributed.
- There are 283 species of angiosperms from 171 genera and 86 families, 08 gymnosperms of 06 genera and 03 families, 10 species of ferns of 08 genera and families, and 01 lichen species belonging to 01 genera as well as 01 family.
- The constitution percent share of species in Shilli Wildlife Sanctuary were recorded as, angiosperms are having 93.79 per cent, gymnosperms are having 3.6 per cent and ferns and lichens are 3.20 per cent.
- There are 24 exotic pines, which were introduced in Shilli Wildlife Sanctuary during the years 1968-1972.
- A total count of 22 timber yielding species, 36 fodder species, 04 fibre and flosses species, 19 tans and dyes, 02 gums and resins, 47 fuelwood species, 42 bee flora species, 03 tantras and mantras species and 01 insecticides species are documented during the present investigation in Shilli Wildlife Sanctuary.
- In total, 40 ethanobotanical important species are present in the sanctuary which are being widely used by the villagers living around the sanctuary. Grazing is considered and found a threat to natural regeneration which requires special attention.
- Presently the Sanctuary has been undertaken with all the conservation practices through research efforts of Dr. Y.S, Parmar University of Horticulture and Forestry, Nauni, Solan having its research farm therein as well as of HFRI, Shimla at Shilli.
- The natural regeneration of the species is also an important part of the study area. There are biotic interferences of local villagers in Shilli Wildlife Sanctuary grazing their domestic animals.
- It is also seen that, initial stages of succession diversity increases while at closing stages, it decreases. The natural regeneration of the species which require special attention for the protection of Wildlife Sanctuary from the local inhabitation for biodiversity conservation.
- It is still unclear whether all basic requirements of villagers can be filled economically and in agreement with the concept of ecological sustainability.

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**8. Major crops grown:**

Tomato

Beans

Capsicum

Cauliflower

Others

**9. Livestock number:**

Cows:..... Ox: ..... Buffaloes: ..... Sheep: .....

Goat:..... Any other: .....

**10. Income Source: (Yes / No)**

- *Crops:*
- *Livestock:*
- *Service:*
- *Any other (Please specify):*

**11. Do you practice Open Grazing in the Wildlife Sanctuary? (Yes / No)**

**Why?**

.....

.....

.....

.....

**12. Do you have any dependence on the Wildlife Sanctuary? (Yes / No)**

***Please specify:***

- Fuelwood: .....
- Grazing:.....
- Water- Drinking/Irrigation:.....
- Wild Fruits:.....
- Medicinal Plants:.....
- Local believes/ Temples:.....
- Any other:.....

13. Is this dependence increasing or decreasing over the years?

Increasing / Decreasing:.....

What are the reasons of these fluctuations?

.....  
.....  
.....

14. What are the other type of interactions are made by the farming community with the Sanctuary?

*Please specify:*

.....  
.....  
.....  
.....

15. Do you have any restrictions of movements extraction/management due to Wildlife Sanctuary? (Yes / No)

*Please Specify:*

.....  
.....  
.....

16. Do you desire any income from the biotic/abiotic resources of the Sanctuary?

(Yes / No)

*Please specify:*

.....  
.....

17. Did you experienced any man-animal conflict for last three years ?

*Please give specific details:*

.....  
.....  
.....  
.....

18. The occurring frequency of man-animal conflict is increasing over time? (Yes / No)

*Why?*

.....  
.....  
.....  
.....

19. Do you collect medicinal plants from the sanctuary? (Yes /No):.....

20. Please give names of medicinal plants collected from the Sanctuary:

.....  
.....  
.....

21. Why do you collect those medicinal plants?

- Income (Y / N):.....
- Treatment (Y / N):.....
- Pharmaceuticals (Y / N):.....
- Any other (Y / N):.....

22. What other plants are being collected and Why?

.....  
.....  
.....  
.....

23. Any sacred grove is maintained in area?

Yes / No

.....  
.....  
.....

24. Species of Ethanobotanical Importance

S.NO.	SPECIES	LOCAL NAME	MEDICINAL USE	AVAILABILITY OVER THE YEARS(INC/DEC)

SIGNATURE

**Dr. Y.S. Parmar University of Horticulture and Forestry  
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Department of Tree Improvement and Genetic Resources**

<b>Title of thesis</b>	:	<b>Phytosociological and Ethnobotanical studies in Shilli Wildlife Sanctuary, Solan (H.P.)</b>
Name of the student	:	Akshiptika Chandel
Admission number	:	F-2016-31-M
Major Advisor	:	Dr. H.P. Sankhyan
Major Field	:	Forestry
Minor Field(s)	:	Forest Genetic Resources
Degree Awarded	:	M.Sc. (Forestry)
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**ABSTRACT**

The present investigation entitled “**Phytosociological and Ethanobotanical Studies in Shilli Wildlife Sanctuary in District Solan, Himachal Pradesh**” was conducted in the Shilli Wildlife Sanctuary under College of Forestry, Dr. Y S Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh during year 2017-2020. The investigation was aimed at determining the Phytosociological and ethnobotanical importance of the species present in the area of Shilli Wildlife Sanctuary, Solan. The study includes the phytosociology of three altitudinal zones of Shilli Wildlife Sanctuary which are divided as: Zone I (1200-1400 m amsl), Zone II (1400-1600 m amsl), and zone III (1600-1800 m amsl). In all altitudinal zone, 54 quadrats were laid with the size of 30×30 m for trees, with sub quadrats of 5×5 m for shrubs and 2×2 m for herbs as per Species Area Curve Method. The sanctuary area found comprised of 301 woody and non woody species. *Pinus roxburghii* is the dominant tree species present in Zone I (1200-1400 m amsl). *Zanthoxylum armatum* is the dominant shrub species present in Zone I (1200-1400 m amsl). *Cynoglossum denticulatum* is the dominant herb species present in Zone I (1200-1400 m amsl). *Quercus leucotricophora* is the dominant tree species present in Zone II (1400-1600 m amsl). *Woodfordia fruticosa* is the dominant shrub species present in Zone II (1400-1600 m amsl). *Rubia cordifolia* and *Digitalis lanata* is the dominant herb species present in Zone II (1400-1600 m amsl). *Cedrus deodara* the dominant tree species present in Zone III (1600-1800 m amsl). *Geranium nepalense* is the dominant herb species present in Zone III (1600-1800 m amsl). Abundance to frequency ratio is used as an indicator of spatial distribution of species in the community. A close look at the study depicts that most of the tree species were contagiously distributed and rest are randomly distributed tree species and none of the tree species was reported with regularly distributed. There are 283 species of angiosperms from 171 genera and 86 families, 08 gymnosperms of 06 genera and 03 families, 10 species of ferns of 08 genera and families, and 01 lichen species belonging to 01 genera as well as 01 family. The constitution percent of Shilli Wildlife Sanctuary recorded as, Angiosperms are having 93.79 percent, gymnosperms are having 3.6 percent and ferns and lichens are 3.20 percent. There are 24 exotic pines species found occurring which have been introduced in Shilli Wildlife Sanctuary during the years 1968-1972. A total count of 22 timber yielding species, 36 fodder species, 04 fibre and flosses species, 19 tans and dyes, 02 gums and resins, 47 fuelwood species, 42 bee flora species, 03 tantras and mantras species and 01 insecticidal species are documented during the present investigation in Shilli Wildlife Sanctuary. In total, 40 ethnobotanical important species are present in the sanctuary which is widely being used by the villagers living around the sanctuary. Grazing is considered and found a threat to natural regeneration which requires special attention. Presently the Sanctuary has been undertaken with all the conservation practices through research efforts of Dr. Y.S, Parmar University of Horticulture and Forestry, Nauni, Solan having its research farm therein as well as of HFRI, Shimla. The natural regeneration of the species is also an important part of the Sanctuary. There are biotic interferences of local villagers in Shilli Wildlife Sanctuary grazing their domestic animals. It is also seen that, initial stages of succession diversity increases while at closing stages, it decreases. The natural regeneration of the species which require special attention for the protection of Wildlife Sanctuary from the local inhabitation for biodiversity conservation. Study is quite helpful in developing working plan of the area by the State Forest Department of Himachal Pradesh in view of flora and fauna of this protected area.

**Signature of Major Advisor**

**Signature of Student**

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