DISTRIBUTION AND ABUNDANCE OF WILD MAMMALS IN SHIVAPURI NAGARJUN NATIONAL PARK AND HUMAN-WILDLIFE INTERACTION IN SUNDARIJAL VDC

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A thesis submitted in partial fulfillment of the requirements for the award of the degree of Master of Science in Zoology with special paper Ecology and Environment

Submitted to
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2015

DECLARATION

I hereby declare that the work presented in this thesis has been done by myself, and has not been submitted elsewhere for the award of any degree. All sources of information have been specifically acknowledged by reference to the author(s) or institution(s).

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LETTER OF RECOMMENDATION

This is to recommend that the thesis entitled "**Distribution and Abundance of wild mammals in Shivapuri Nagarjun National Park and Human-wildlife interaction in Sundarijal VDC"** has been carried out by Mr. Deependra Kumar Jha for the partial fulfillment of **Master's Degree of Science in Zoology** with special paper **Ecology and Environment**. This is his original work and has been carried out under my supervision. To the best of my knowledge, this thesis work has not been submitted for any other degree in any institutions.

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LETTER OF APPROVAL

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CERTIFICATE OF ACCEPTANCE

This thesis work submitted by Mr. Deependra Kumar Jha entitled "**Distribution and Abundance of wild mammals in Shivapuri Nagarjun National Park and Human-wildlife interaction in Sundarijal VDC"** has been accepted as the partial fulfillment for the requirements for **Master's Degree of Science in Zoology** with special paper **Ecology and Environment**.

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LIST OF ABBREVIATIONS

Abbreviated form	Details of abbreviations
BNP	Bardia National Park
BPP	Biodiversity Profiles Project
Cm	Centimetre
CITES	Convention on International Trade of Endangered Species
CNP	Chitwan National Park
CNPPA	Commission on National Parks and Protected Areas
DNPWC	Department of National Park and Wildlife Conversation
Hh	Household
HMGN	His Majesty's Government of Nepal
ICIMOD	Integrated Center of International Mountain Development
IUCN	International Union for Conservation of Nature
Kg	Kilogram
Km	Kilometer
KTWR	Koshi Tappu Wildlife Reserve
NAD	Net Area Damage or damaged
NPWC	National Park and Wildlife Conversation
PA	Park Area/Areas or Protected Area/Areas
RPI	Relative Preference Index
Rs.	Rupees
Nrs.	Nepalese rupees
%	Percentage
SNNP	Shivapuri Nagarjun National Park
SWR	Sukla-phanta Wildlife Reserve
SIWDP	Shivapuri Integrated Watershed Development Project
SWWR	Shivapuri Watershed and Wildlife Reserve
TAL	Tarai Arc Landscape
UNESCO	United Nations Educational, Scientific and Cultural Organization
VDC	Village Development Committee
WCMC	World Conservation Monitoring Centre
WWF	World Wildlife Fund

ABSTRACT

Distribution refers to the spatial (or local) arrangement or pattern of a species within an area where they are found. The abundance of populations in different parts of the Park gives an indication of the distribution of the population. This study was aimed to assess habitat characteristics and also to determine distribution, abundance and habitat preferences of wild mammals. The pellet groups counting along line transect was carried out in Shivapuri mountain of Shivapuri Nagarjun National Park and questionnaire survey was conducted in Sundarijal VDC adjacent to SNNP. Four major habitat types namely Salla forest, Mixed forest, Riverine forest and Grassland. The Salla forest was dominated by *Pinus* sp.; Mixed forest was dominated by *Rhododendron arboretum, Alnus nepalensis, Schima wallichii, Castanopsis indica* etc.; Riverine forest was dominated by *Syzigium cumini, Prunus cerrasoides* etc. and Grasssland was dominated by *Ficus neriifolia, Buddleja asiatica* etc. Total density of tree species in different habitat types were 254.75/ha in Salla forest, 219.75/ha in Mixed forest and 190.50 in Riverine forest. A total of 431 pellet groups were recorded from 100 quadrates in all four habitat types (25 quadrates in each). Rhesus monkey, Squirrel, Jungle cat, Ghoral, Langur, Barking deer, Rat, hare were found as main mammal species occupying the different parts of SNNP. Rhesus monkey was more abundant (1.14/quadrate) among the mammalian species followed by Squirrel, Jungle cat, Ghoral, Barking deer, Langur and Rat among the recorded mammals. Among four habitat types, Salla forest was found highly preferred (13.23%) for Rhesus monkey followed by Grassland (11.14%) for Rhesus monkey, Salla forest (5.34%) for Squirrel, Grassland (5.10%) for Hare etc. A non-parametric Spearman's correlation coefficient between pellet groups abundance and tree density (r = 0.87) and correlation coefficient between pellet groups abundance and canopy coverage (r = 0.86) shows that there is a high positive correlation between the pellet groups abundance and tree density as well as canopy coverage.

There were 505 reported cases of wild boar in sample areas, which is followed by monkeys, birds, deer, rats and bear. The total visit of wildlife was 1337. The highest percentage 32.05 of Net Area Damage of crops by Wild boar followed by deer, monkeys, rats, birds and bears 18.34, 17.11, 12.18, 10.11, and 4.42 percentages respectively. The loss of crop from Wild boar which was the highest amount of 32432.1 kg. It was in the first position of ranking of crop damage. Similarly, Rat in second position which destroyed 14314.15 kg of crop, Monkey in third position with 13568.5 kg crop damage.

(Key words: Distribution, Abundance, Pellet groups, Habitat Preference, Human-wildlife interaction, crops)

1. INTRODUCTION

1.1 Background

Population abundances of the mammals are informative indicators of the state of the populations. The abundance of populations in different parts of the PA gives an indication of the distribution of the population. The distribution indicator also shows temporal trends of the abundance in the sub-regions. Abundance is an ecological concept referring to the relative representation of a species in a particular ecosystem. It is usually measured as the large number of individuals found per sample. How species abundances are distributed within an ecosystem is referred to as relative species abundances. Abundance is contrasted with, but typically correlates to, incidence, which is the frequency with which the species occurs at all in a sample. When high abundance is accompanied by low incidence, it is considered locally or sporadically abundant (Bartelt et al. 2001).

A variety of sampling methods are used to measure abundance. For larger animals, these may include spotlight counts, track counts and road kill counts, as well as presence at monitoring stations. In many plant communities the abundances of plant species are measured by plant cover, i.e. the relative area covered by different plant species in a small plot (Bartelt et al. 2001).

Distribution refers to the spatial arrangement or pattern of a species within an area where they are found. Distribution should not be confused with dispersal, which can be defined as the movement of individuals away from an existing population or parent. Forest disturbance through natural or human induced events alters the structure and composition of forests, affecting regeneration patterns and the availability of food for animals and influences their distribution (Vedder 1984).

Vegetation type is an important factor determining the distribution and abundance of food and shelter for mammals and hence mammals' distribution. Most primates eat many kinds of food that vary in abundance and quality, and they can demonstrate various foraging tactics to maximize nutrient intake. Topography and the presence of natural barriers are also key factors as are climatic variables such as temperature, humidity, and rainfall. Climatic effects

are probably greatest where they determine what the vegetation types are and how productive they are, and therefore how many mammals the habitat can support. In models of plant growth it is generally accepted that the relative abundance and rate of plant regeneration are positively correlated with rainfall (Vedder 1984). Climate also influences the occurrence and prevalence of disease, and human activities in the habitat.

Wildlife conservation has been quite successful from the view point of habitats of several threatened species (Mishra 1991). Active conservation of habitat has increased the population of wildlife within the PA, which results the depredation of livestock and crops outside the park. The relation between park and people becomes crooked when the PAs animals damage the outer peripheral area and disturb the adjacent settlements. Damage of agricultural crop, human harassment, injuries and death and livestock depredations are the common unbalanced relationship (Jnawali 1989, Shrestha 1994, Studsord and Wegge 1995, Kasu 1996).

The local people, who once were enjoying free access to areas henceforth covered by protected areas and were able to meet their needs from inside resources, now no longer, have legal access. Local people have seen the protected areas as an attempt by the government to curtail their access to their traditional rights of resources use. However, the protected areas and buffer zones have become a very good resource for villagers to fulfil their needs through venturing into illegal activities like poaching, logging and hunting, all of which are directly conflicting with the park's objectives (Milton and Binney 1980, Mishra 1982).

Depredation of crops by wild boars (*Sus scrofa*) occurs to varying extend throughout their distributed range of Nepal, wherever cultivation encroaches the wild boar habitat. By different factors the wild boars damage the cultivated areas. However, in ultimate terms crop raiding can be thought of as an extension of their natural optimum foraging strategy (Sukumar 1989).

It is not unusual to see why animals of the protected areas are attracted to areas with grain or other crops. Cultivated crops are rich in protein and carbohydrates as well as some mineral nutrients than most of the wild plants and animals available in adjacent isolated stands or scattered throughout the forest, agricultural crops and cultivated animals occur in relatively large, concentrated stands. Thus, the animals of the protected areas to have such items do not have to expend as much energy searching for food. Many other animals like bear, deer,

porcupine etc. also play the main role for crop depredation in the agricultural farm near to the park. For searching food and for other purpose they damage the crops (Baral 1998).

Human activities and disturbances have become a major force of deforestation and environmental degradation. Deforestation is characterized by the loss of forest trees for the household and commercial purpose. It leads to soil erosion, decline in fertility of soil, ecological imbalances, danger to wildlife, flooding and landslides, shortage of food products (medicinal herbs), etc. and brings a series of unfavorable changes in the whole biosphere (Keshari et al. 2008).

Wildlife in general may be defined as a vast assemblage of plants and animals in their natural environment (Shrestha 2003). Wildlife management is then the art of producing a desired population of wild animals and plants.

In Nepal, National Park and Wildlife department, forest department is making commendable efforts for the preservation of wildlife habitat in Nepal by establishing National Parks and Reserves (Shrestha 2003).

Government of Nepal has been framed many rule and regulation for the protection of wildlife but the practices are still not succeeded, because local people require even more access to forest resources from nearby forest by illegal means. This also may be happened due to lack of buffer zones. Buffer zone is an area created to separate opposing force or groups which belongs to neither of them. People awareness also plays an important role towards the conservation programs and reduction in human-wildlife conflict in and around the National Parks and Reserves.

Various studies have been conducted on the wildlife in different areas of Nepal by many researchers. A study on Distribution and Abundance of wild mammals in Shivapuri Nagarjun National Park is rarely done by researchers. Latest study on the related topic is lacking. Due to lack of study on concerned topic, this research was done.

1.2 Objectives

General objective of this study was to assess the current distribution and relative abundance of wild mammalian species in Shivapuri Nagarjun National Park and human-wildlife interaction around it. Following specific objectives have been set to achieve research aim at SNNP.

1. To study the distribution pattern and abundance of wild mammals in Shivapuri Nagarjun National Park.
2. To explore the habitat of wild mammals in Shivapuri Nagarjun National Park.
3. To investigate human-wildlife interaction in Sundarijal VDC.

1.3 Limitation of study

For the study of distribution and abundance of wild mammals, I was concentrated in Shivapuri mountain of Shivapuri Nagarjun National Park and for the study of human-wildlife interaction; I concentrated in Sundarijal VDC, which is adjacent to SNNP.

The Present study was conducted within some randomly selected sample study sites. Pellet group data of different wild animals and list of plants specified to a number of quadrate in various randomly selected sample study sites were taken during summer season of the year 2015. Different data related to Hunan-wildlife interaction between people and wildlife was taken randomly during different seasons and events from July 2014 to Jun 2015. It was very difficult to count, collect and observe pellet groups in some areas where dense grasslands and steep slopes exist.

Lack of sufficient equipments and security problem also limited the study. The PA is surrounded by many VDCs and human settlements and also many small villages lie within the park area, but only four study sites within the park area for taking data regarding distribution and abundance of wild mammals; and only one site Sundarijal VDC to investigate human-wildlife interaction was possible.

1.4 Rational of the study

Various studies have been conducted on the wildlife in different areas of Nepal by many researchers. Several studies have been done on wild mammals too. So, I came to think about this study. Information on the distribution and abundance of mammalian species is most essential to monitor population dynamics over time or among habitats, and also to evaluate the success of wildlife management programme. Furthermore, most of the small mammals and hoofed mammals are the major prey for leopard and related carnivores, thus the management of carnivores depends on the management of their prey and time worthy for conservation planning of all ecologically important species.

This study has provided data on crop depredation in Sundarijal VDC for 2014/15. It has also given information on human harassment and impact on local people due to wild animals. The human wildlife conflicts have created tussel between the government and local people and which in turn has become problematic in management of wildlife. This scenario is felt all over the country and especially in adjacent VDCs of Shivapuri Nagarjun National Park. The present study aims at analyzing the complex issues of park-people's interference by focusing day to day problems faced by local people in the boundary of Shivapuri Nagarjun National Park.

2. LITERATURE REVIEW

2.1 Distribution and abundance of wild mammals

Mammology have been one the interesting subjects of study by both ancient and recent scholars. The wildlife of Nepal is now everywhere in decrease. Some of them are in danger and verging towards extinction. Therefore, there is a great need of Zoological Survey of Nepal to understand mode of occurrence, distribution, ecology, behaviour and life history of rare fauna of Nepal (Shrestha 2003).

Seven troops of different population sizes were observed in six potential sites were identified where likelihood of finding Assamese monkey is higher. The Assamese monkey in SNNP has found from Rholche/Cha-Gaun in East (0637835, 3079670) to Sanagaun (624630, 3071927) in West. Most of the troops were found inhabiting around higher cliffs (except Raniban and Sanagaun-Mudkhu troop whose residing area was not found). Small cascades accompany all the sites in Shivapuri. Altitudinal distribution covers from 1440 meters in Nagarjun Fulbari gate to Rholche/Cha-Gaun troop at an elevation of 1949 m (Chalise et al. 2013).

Eastern Himalaya supports a wide diversity of birds and mammals due to complex physiographic and bioclimatic zonation and also it lies in between Palaearctic and oriental zoo-geographic realms (Ives and Messereli 1989, Inskipp 1989). The distribution and diversity of birds and mammals depends on number of interrelated factors such as temperature, rainfall and vegetation structure. Disturbance plays an important role in the dynamics, structure and the function of ecosystems. Thus to understand the human impact, we need to study about birds and mammalian interactions over a variety of habitats and ecological conditions. Determination of birds and mammalian population in different habitats are central point to understand the community structure and niche relationship as well as intelligent management of population. Moreover seasonal monitoring is equally important to trace the dynamic movement of birds and mammals in such habitats (Green and Catterall 1998).

In temperate terrestrial ecosystems, large mammas that once had profound large-scale effects on the structure of plant communities but have been hunted to near extinction in historic

times include bison, bears and wolves. Joel Berger and colleagues (2001) demonstrated a cascade ecological events that were triggered by the local extinction of grizzly bears (*Ursus arctos horribilis*) and wolves (*Canis lupus*) from the Yellowstone ecosystem (Groom et al. 2005).

Abundance of prey species was found higher in grassland and Khair-Sissoo forest. Properly managed these habitats could help in stabilizing the tiger population. Sal dominant forest was found with lowest abundance of prey species compared to other habitats. Distribution pattern of prey species was found to be of clumped type with the highest pellet group recorded in grassland, this shows that prey base distribution is highest in grassland with clumped type. Relative index of prey species was found to be 0.344 mean pellets per 10 m^2. High distribution and abundance of prey species suggested that the grassland areas of this corridor are better habitats for wild ungulate species that explains presence of good number of tigers (Karki et al. 2012).

2.2 Habitat characteristics and preference

The area or natural environment in which an organism or population normally lives. A habitat is made up of physical factors such as soil, moisture, range of temperature, and availability of light as well as biotic factors such as the availability of food and the presence of predators. A habitat is not necessarily a geographic area—for a parasitic organism it is the body of its host or even a cell within the host's body (Arneberg et al. 1998).
(http://dictionary.reference.com/browse/habitat).

The SNNP has four types of forests. The sub-tropical habitat was used by Fulbari gate troop while others have sub-tropical to temperate forests. The common tree species found were *Schima wallichi, Castanopsis tribuloides, Castanopsis indica, Quercus lamelosa, Alnus nepalensis, Myrica esculenta, Pyrus pasia, Toona ciliata*, *Myrsine semiserrata, Desdmodium multiflorum, Rhus javanica, Myrsine capitellata, Taxus wallichiana*, *Litsea salicifolia, Symplocis theifolia* and a few thorny bushes of *Rubus foliolosus*, *Polypodium amoenum* and a few unknown climbers (Chalise et al. 2013).

The upper mixed hardwood forest was most preferred (RPI = 1.17) by barking deer while, pine forest (RPI = -0.72) and oak forest (RPI = -0.76) and lower mixed hardwood forest (RPI = -0.89) was totally avoided (Prasain 2015).

Pangolins belong to the least studied burrowing mammals whose information on distribution and ecology is still scarce in Nepal. Their distribution was studied in the Nagarjun forest of Shivapuri Nagarjun National Park during April 2013. We surveyed 700×60 m^2 strip transects for indirect data collection, 140 quadrates of 10×10 m2 were used for vegetation analysis. Total 235 burrows were recorded which were not uniform in distribution. Burrows were mostly distributed in the habitat dominant by *Schima wallichii*, *Castonopsis tribuloides*, *Castonopsis indica* and *Betula alnoides* with canopy cover between 25-50% in brown soil and in northwest aspect in the elevation range between 1450-1550 m (Bhandari and Chalise 2014).

Chilaune (*Schima wallichii*), Katus (*Castanopsis* sp.), Pines (*Pinus roxburghii*), Oaks (*Quescus semicapifolia, Q. lamelosa*) and Rhododendrons (*Rhododendron arboretum*) are the dominant vegetation in the park. The vegetation in the park can be categorized into four types: (i) Lower mixed hardwood forests (*Schima castanopsis*) between 1350 m and 1500 m, (ii) Chirpine forest between 1350 m and 1600 m, (iii) Oak forests between 2300 m and 2732 m and (iv) Upper mixed hardwood forests between 1500 m and 2732 m. The major tree species are *Schima walichii, Castanopsis indica, Alnus nepalensis, Pinus roxburghii, Myrica esculanta, Pyrus pasia, Quescus semicapifolia, Rhododendron arboretum, Juglans regea* etc. (SNNP 2011).

2.3 Human-wildlife interaction

Human–wildlife conflict is defined by the World Wide Fund for Nature (WWF) as "any interaction between humans and wildlife that results in negative impacts on human social, economic or cultural life, on the conservation of wildlife populations, or on the environment.

Human-wildlife conflict occurs when the needs and behaviour of wildlife impact negatively on the goals of humans or when the goals of humans negatively impact the needs of wildlife. Human-wildlife conflict occurs with various negative results. The major outcomes are:

- Injury and loss of life of humans and wildlife.

- Crop damage, livestock depredation, predation of managed wildlife stock.
- Damage to human property.
- Destruction of habitat.
- Collapse of wildlife populations and reduction of geographic ranges.

Kattel (1993) reported that 87% people had perceived about increasing number of wild boar (*Sus scrofa*) and it was one of the raiding animals in the neighbouring villages of Shivapuri. He found that wild boar was present from 1000-2700m. in altitude of Shivapuri Nagarjun National Park.

Gurung (2002) reported on wild boar distribution and park-people conflict in Shivapuri Nagarjun National Park. He found the sources of conflict. He also studied about the crop damage near the village of Shivapuri Nagarjun National Park.

Purkait and Chalise (2010) also reported that there was a great loss in the surrounding villages of Shivapuri Nagarjun National Park. There was a total loss of Rs. 587618.74 of a small village.

Kharel (1993) identified Wild boar (*Sus Crofa*), Himalayan black bear (*Selenarctos thibetanus*), Rhesus monkey (*Macca mulatta*) and Barking deer (*Muntiacus muntjak*) species were major crop raiders in Langtang National Park.

Most people living inside or outside of PAs depend on resources from these areas for their livelihood. But, once an area is declared as PA, the local communities are denied access (ICIMOD 2011). This can result conflict between park authorities and local communities. Different research studies have also revealed the fact that a restriction on use or harvesting forest resources from traditional land of poor people is the main cause of park people conflict. With the exhaustion and restriction of forest resources, people will tend to extract as much as possible from PAs in order to satisfy their immediate needs, without considering benefit to be gained from longer environment security. As a consequence, a vicious cycle the level of impoverishment in rural village increases and further environmental deterioration occurs (Ghimire 1994). Due to population pressure and poverty in developing countries, conservation strategies need to address local people's need.

3. MATERIALS AND METHODS

3.1 Study Area

Shivapuri Nagarjun National Park is located on the northern fringes of Kathmandu Valley. It is surrounded by 23 VDCs of three districts, Kathmandu, Nuwakot, and Sindhupalchowk (DNPWC 2010). It lays between $27^0$45'N - $27^0$52'N latitude and $85^0$15'E - $85^0$30'E Longitude (SWWR 1999). It covers 153 km^2 stretching approximately 9 km from north to south and 20 km from east to west (DNPWC 2010).

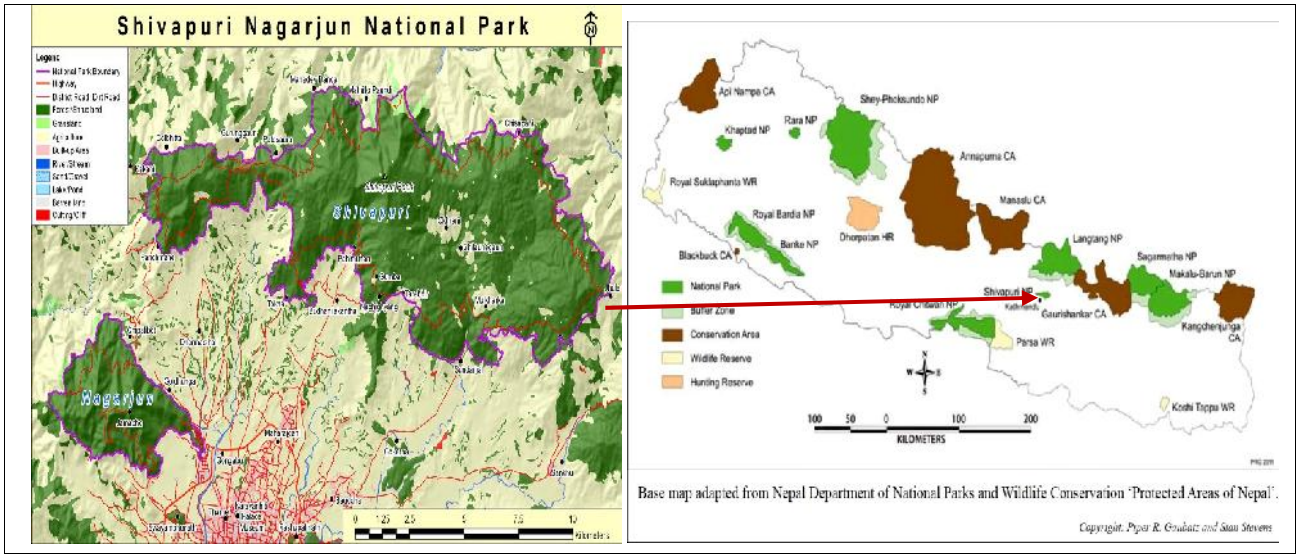

Figure 1: Map showing the Shivapuri Nagarjun National Park, Nepal

Sundarijal VDC is one of the adjacent VDCs of Shivapuri Nagarjun National Park which was the study area and it is located between $27^0$18'N - $27^0$27'N longitude and $85^0$22'E - $85^0$28'E latitude (SWWR 1999). The highest summit of the park (Shivapuri Hill) is at 2732m, which is second largest peak that surrounds Kathmandu valley and lowest point is at about 1336 m (BPP 1995). Shivapuri is the one of the sources of drinking water for the resident of Kathmandu valley.

The park is very important religiously as a number of Hindu temples and Buddhist monasteries located here such as Bagdwar, Bishnudwar, Tarevir, Nagi Gumba etc. Visitors are attracted to the park for trekking. Trekking routes to Nagarkot, Gosainkunda, Helambu

and Langtanng National Park also pass through the park. The total of 20% of Nepal's trekking tourism is mainly concentrated around Shivapuri area, affecting natural, cultural and socio-economical aspects (Karki 2002).

3.1.1 Climate

The park is located in a transition zone between subtropical and temperate climate. The annual precipitation of about 1,400 mm falls mostly from May to September, with 80% during monsoon. Temperatures vary from 2–17 °C (36 - 63°F) during the winter season, rising to 19–30 °C (66 - 86°F) during the summer season (Kunwar 2008).

3.1.2 Geology and soil

Geologically, Shivapuri area occupies the inner Himalaya region. The soils of the area range from loamy and sand on the northern side to sandy loam on the southern slope. Entire area is characterized by its steep topography. More than 50% of the area has greater than 30% slopes. In several spots soil erosion is a serious problem. Erosion hazard is very high in the northern slope. Landslides, gullies the stream bank erosion, both natural and man induced are found all over the area (SWWR 1999).

3.1.3 Flora and fauna

The vegetation in SNNP consists of variety of natural forest types, depending on altitude and aspect, including pine, oak, rhododendron, and so on. In general, forests in Shivapuri Nagarjun National Park can be categorized by four types. They are (a) lower mixed hardwood forests of *Schima castonpsis* (b) Chirpine forests dominated by *Pinus roxberghii* (c) Upper mixed hardwood forests to Rhododendron, Aesculus and Betula etc. (Chalise et al. 2013).

The establishment of protected area has led to an important increase in forest cover and standing stock. This and the greatly reduced levels of disturbance have resulted in a considerable improvement in wildlife habitats and an increase in forest dependent species. Recorded species in the Shivapuri area include: eight threatened mammal species, such as leopard (*Panthera pardus*), leopard cat (*Prionaliurus bengalensis*) and clouded leopard (*Pardofelis nebulosa*), 177 species of birds, including at least 9 threatened species, such as the orange-billed leaf bird (*Chloropsis hardwickii*), 102 species of butterflies, including a

number of rare and endangered species, such as the Kaiser-I-Hind (*Teinoplpus imperalis*) and 129 species of mushroom. It is also one of the view sites where the rare relict Himalayan dragonfly (*Epiophlebia laidlaw*) is found (SWWR 1999).

3.1.4 Land use in Sundarijal

The total area of Sundarijal VDC is 10180 ropani. The composition of land of Sundarijal VDC is being covered in the following patterns. Where 5430 ropani is agricultural land (Khet and Bari), 640 ropani is bushy land, 3510 ropani is forest land, 340 ropani is grassy land and 240 ropani is sandy land (VDC Profile 2013).

3.1.5 Socio- economic status

Sundarijal VDC constitutes of people of different castes. The Brahmin, Chhetri, Gurung, Lama, Pariyar, Sunar, Bishwokarma and Magar constitute the population of the VDC. The Brahmin constitutes the largest population of the VDC. Agriculture is the main source of income in the VDC. A good number of populations are engaged in army, police, teacher and employ of profession (VDC Profile 2013).

3.1.6 Animal husbandry

Animal husbandry forms an integral part of the economy. People mostly keep cow (*Bos indicus*), Buffalo (*Bubalus sp.*), Goat (*Capra hircus*) and Pig (*Sus sp.*). Male buffaloes and oxen are used for hauling and transportation. Goat husbandry is the major source of income (VDC Profile 2013).

3.1.7 Farming system

Paddy and Maize are the major crops in the study area which are grown in the rain-fed lowlands, millet and wheat are also grown. Farming system is primitive. The work is mainly done manually by draft animals. Compost manure is used as bio-fertilizer. Some farmers use chemical fertilizer and pesticides to increase the yield of crops. Most farmers practice kitchen garden and plant vegetables, fruits, potato, tomato, cauliflower, sweet potato etc. Vegetable farming is one of the major cash crops in the study area. They sell their surplus food grains in the nearby market.

3.2 Materials

The present study was concerned with distribution and abundance of wild mammals in SNNP, so to collect the data of the faecal matter or droppings, foot sign, burrows etc., and to collect the data of vegetation samples which needs to make quadrate, and the data regarding human-wildlife interaction around Sundarijal VDC, materials used were: Plastic bags, Measuring tape and Ruler/Scale, Plastic rope of length 100 m, Forceps, Still camera, Binocular, Physical and political map of SNNP, Photos of different mammal's droppings/pellets/scats, Long iron nails, Ribbon flags, Long bamboo sticks, Questionnaire, Diary, Marker pen, Pencil, Pen, Calculator etc.

3.3 Preliminary field survey

The preliminary field survey of this study was carried out in first two weeks of July 2014. During that time different trekking routes were observed in the park area following physical map of SNNP to study the distribution and abundance pattern of wild mammals in SNNP and in the third week of July 2014, Sundarijal VDC and its surrounding area were visited and conflicted areas and land use pattern were identified to investigate human-wildlife interaction in Sundarijal VDC. The survey also included field observation and interaction with local people. Sites for most crop raiding areas were selected to investigate human-wildlife interaction in Sundarijal as a representative sample site. Then whole wards were selected in VDC, where different wild animals were visiting frequently.

3.4 Distribution and abundance of wild mammals

3.4.1 Sampling Design

Distribution, abundance and habitat preference of mammals were determined by pellet groups counting method. To assess relative abundance of mammals, method developed by Smith et al. (1999) was used. A total of 25 quadrates were monitored in each habitat type, i.e. Salla Forest, Mixed Forest, Grassland and Riverine Forest (Thus, Total Plots = 25 × 4 =100) using simple random sampling. Each quadrate has 4 transects (sides) forming square shaped geometry for track line so each side of the sample is treated as the continuous lines for the purpose of analysis (Fig. 2).

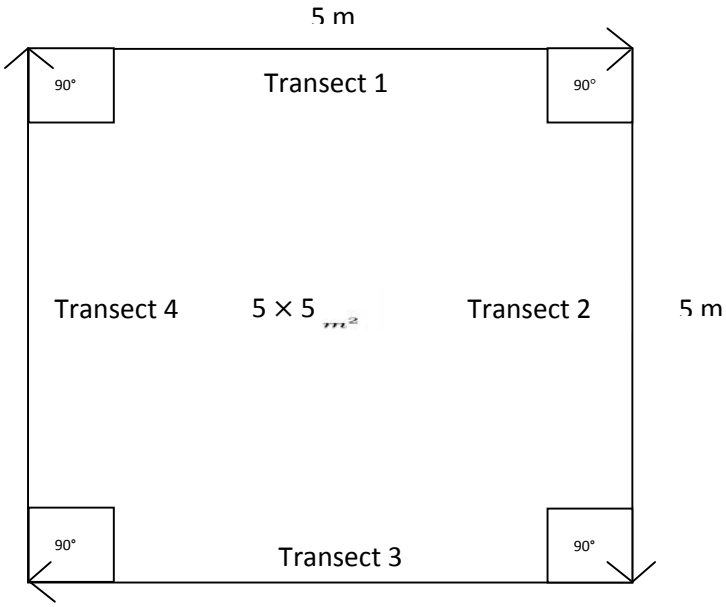

Figure 2: Diagrammatic track line of each sample

3.4.2 Indirect methods

Following indirect methods were adopted:

i) **Identification of footprint (pugmarks or tracks):** Footprints of different species of mammals are different with distinct characters in their shape size and presence or absence of claws. The exact structure of footprint was obtained by using photographs (WWF Nepal Program 1998). When photographing a footprint, a pen or ruler/Scale was placed on the bottom and sides of each footprint to scale the size. After measuring exact structure of the footprint, its identification was done by using references (Gurung and Singh 1996, WWF 1998, Singh 1999).

ii) **Identification of faeces (scats or pellets or dropping):** Identifying the species that deposited the faeces is a convincing indirect method because a) faeces are also long-lived, especially in area with little rain and minimal insect activity. b) faeces may be deposited solitary or in clump, typically, left on a shape pile or within a meter of a scrape but a long or next to a trail and c) scat of some felidae (e.g., leopard) and canidae (e.g. jackal) are often visible and easy to find sample per unit effort (WWF Nepal Program 2001).

3.4.3 Line transect method

Line transects is a tape or string laid along the ground in a straight line between two poles as a guide to a sampling method used to measure the distribution of organisms. A survey was conducted by walking through four fixed transects of total of around 15-20 km long and recording and collecting evidence of mammals during July 2014 to Jun 2015. In order to study mammalian distribution and abundance, the entire habitat was divided into four major habitat types i.e. Salla Forest, Mixed Forest, grassland and Riverine Forest. Each habitat type was surveyed by walking through transect lines of variable length depending on the availability of tracks (Fig. 3 and 4). Besides fixed lancets survey random search was also adopted to record the occurrence of mammalian species in the park.

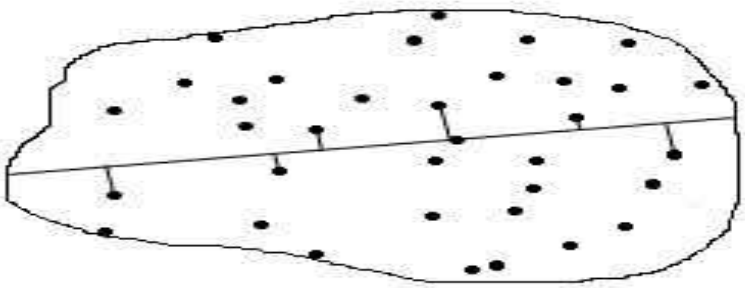

Figure 3: Diagrammatic presentation of line transect

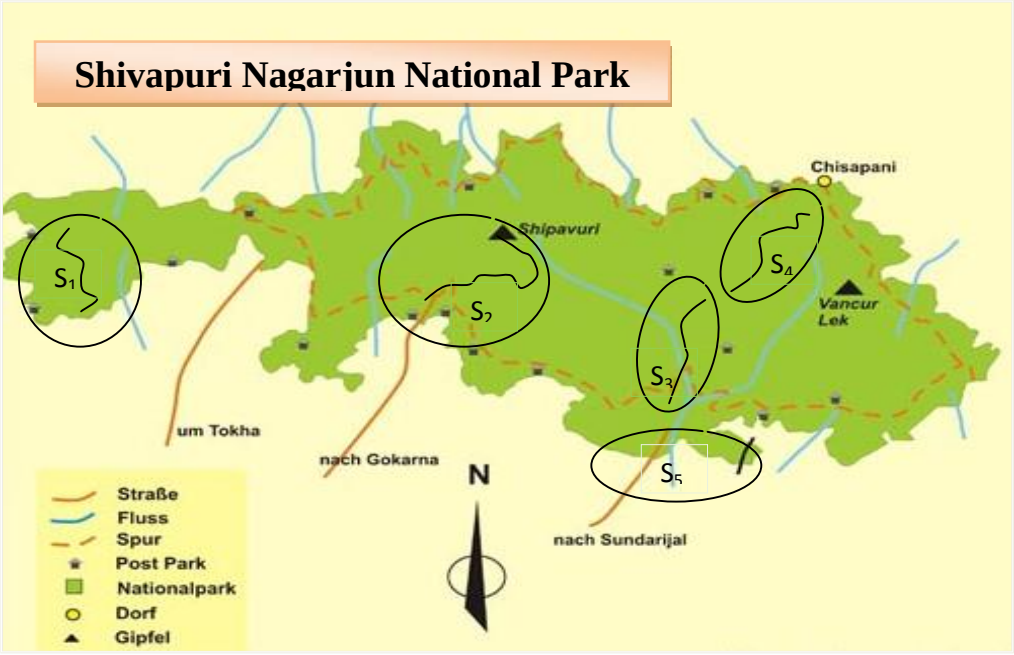

Figure 4: Map of study sites in SNNP

3.5 Habitat characteristics and Preference

3.5.1 Quadrate method

Quadrate sampling is based on measurement of replicated sample units referred to as quadrates or plots (sometimes transects). This method is appropriate for estimating the abundance of plants and other organisms that are sufficiently sedentary that we can usually sample plots faster than individuals move between plots. This approach allows estimation of absolute density (number of individuals per unit area within the study site).

1) **Measurement error**. In the real world, it is important to count organisms (or indirect signs such as foot prints, fecal matters, burrows etc.) carefully and lay out plots accurately for good estimates of density.

2) **Total area sampled.** In general, the more area sampled, the more precise the estimates will be, but at the expense of additional sampling effort.

3) **Dispersion of the population**. Whether the population tends to be aggregated, evenly spaced, or randomly dispersed can affect precision. Note that the dispersion pattern of the same population may be different at different spatial scales (e.g., 1 x 1 m plots Vs 100 x 100 m plots).

4) **Size and shape of quadrates**. The size and shape of the plots can affect sampling precision. Often, the optimal plot size and shape will depend on the dispersion pattern of the population.

3.5.2 Vegetation analysis

The vegetation data were collecting from same sampling stations from where faecal matters were collected for mammals. Vegetation was surveyed in different sized quadrate of 25×25 m^2, 20×20 m^2 and 5×5 m^2 for trees, shrubs and herbs respectively within the main quadrate of size 25×25 m^2. Each quadrate was laid at a distance of 200 m along transect. At each quadrate, number and coverage of each species were recorded for trees and shrubs while only coverage was recorded for herbs species. A total 0f 100 quadrates for trees and shrubs and 200 quadrates for herbs (i.e. 2 quadrates in each of main quadrate) were surveyed from 25 different samples in each of four types of habitat i.e. Salla Forest, Mixed Forest, grassland

and Riverine Forest. It is done so because study area was categorised into four major habitat type and to make standard of 100 quadrates, 25 quadrates were laid in each. So, 100 quadrates were made in total to collect the data of tree, shrubs and animals sign while 2 small quadrates of size 5×5 m^2 were made within the main quadrate because shrubs are very smaller as compared to trees and shrubs. The herbarium of unidentified species were collected and brought for identification.

3.5.3 Habitat preference

Habitat preference was calculated by using following formulae (Pokhrel 1996).

Habitat preference (HP) = $\frac{PPE}{TPP} \times 100$

Where,

PPE = Pellet present in each habitat type.

TPP = Total pellet present in all the habitat type.

Chi-square contingency test was used to analyze significant differences between habitat preferences of different mammals.

3.6 Human-wildlife interaction

3.6.1 Sampling

Sundarijal VDC was selected for the study. The latest household number and the human population were available from the VDC office. On the basis of number of households in each ward, the sample size for the study was determined. For the study, simple random sampling was adopted. Information was taken from key informants such as village head, local leaders, park authorities and army.

There are altogether 504 households in the study area but only 121 households were taken as sample for the present study due to time constraint. The sampled households constitute 24.70% of total households.

3.6.2 Data collection

This study was totally based on primary and secondary data. Primary data were collected by adopting various methods including field observation and questionnaire survey.

3.6.2.1 Field observation

During the study period from July 2014 to Jun 2015, all study sites were visited frequently. The field visit were mainly focused on categorization of study area, direct observation of animals and their events, to select suitable quadrate/plot for collection and observation of possibly more than more plant species, to find more than more animals' indirect signs such as droppings, scratches, pugmarks, burrows etc., and for this mostly hiding and dense places were selected. For this purpose, mammals' population data collection sheet was used (Appendix 5).

3.6.2.2 Questionnaire survey

A total of 121 households (with the head of the family and in some cases the person above 21 yrs) were interviewed using the semi-structured questionnaires. The interview focused on family composition, economic condition of the respondents, ethnicity, land, occupation and conflict issues such as crop damage and human harassment. Altogether twenty two questions were asked to the respondents from a set of a questionnaire named as household questionnaire and another set of questionnaire containing six questions were asked to VDC authorities and leaders. There was one more set of questionnaire for park staffs including five questions (Appendix 1) to explore local people knowledge on diversity of wild animal and also to find type of human-wildlife interaction and expectation of local people to reduce crop damage and human harassment from the park authorities.

3.6.3 Secondary data collection

Secondary data were collected from records and reports from different sources of VDC. Other secondary sources were from journals, books and unpublished dissertation works. The secondary data was also collected from the office of Shivapuri Nagarjun National Park.

3.6.4 Field observation and Net Area Damage measurement

Net area damage measurement method gives the idea to predict how the local people are harassed by frequently visiting wild animals to their crop field and to explore the level of damage, which suggest to adopt the techniques to reduce these impacts. Damage to crop field done by wild animals is very common to the surrounding areas of wildlife reserves and

national parks, therefore, the method of field observation and net area damage measurement was adopted.

This field observation was done for one year round. The seasonal crops were recorded during growing to harvesting period. Therefore, field survey was conducted several times within a year (from July 2014 to Jun 2015). A single visit included around five to seven days. The damaged area was measured with the help of measuring tape. The actual affected area was assessed with photographs taken on the spot.

Extend of damage in crop fields was measured as follows:

1. Damage plots were outlined and marked with ropes and ribbon flags.
2. The damaged plots were then sub-divided by parallel transects with the help of ropes and straight bamboo sticks.
3. The following formula was used to measure the size of damaged area.

   $A = \sum L \times d$

   Where, A= Area of damaged irregular plot.

   L= Length of transects

   D= distance between transects

At harvesting time, 3-5 control plots, each measuring 2×2 m^2 were laid out randomly around the damaged plots in a distance of 2-5m. The crop was harvested at maturity. Yields from the damaged plots and control plots were sun dried and weighed to determine the percentage lost due to damage. The percentage lost by damage was measured from early green stage to mature stage. Local techniques were used to harvest, winnowing and drying. The yield was measured in local units. Grains and crops were given back to the farmers after the work was finished.

3.7 Data analysis

3.7.1 Mammal's data

Following Calculations were done to analyze mammals' data:-

$$\text{Abundance} = \frac{Total\ number\ of\ pellet\ groups\ presence\ in\ all\ studied\ plots}{Total\ plot\ studied}$$

Distribution: Distribution pattern of mammals among 25 different samples in each of four habitat types was analyzed by calculating ratio of variance and mean value $\left(\frac{S^2}{\bar{X}}\right)$ (Odum, 1996). It is given as follows:

$\left(\frac{S^2}{\bar{X}}\right) = 1$ (random distribution)

$\left(\frac{S^2}{\bar{X}}\right) < 1$ (regular distribution)

$\left(\frac{S^2}{\bar{X}}\right) > 1$ (clumped distribution)

Where, S^2 = variance = $\frac{1}{n}\sum(X - \bar{X})^2$

$\bar{X}$ = mean value

Chi-square contingency test was used to find out significant differences in distribution of mammals in different studied samples.

Chi-square $(\chi^2) = \sum \frac{(O-E)^2}{E}$

Where, O = Observed value

E = Expected value = $\left(\frac{Row\ total \times Column\ total}{Grand\ total}\right)$

Relationships between pellet groups abundance and habitat variables (tree density and canopy coverage):

A non-parametric spearman's correlation coefficient was used to determine the relationship between habitat variables and the abundance of pellet groups (Kothari 2004).

$$r = \frac{\sum(X-\bar{X})(y-\bar{y})}{\left(\sqrt{\sum(X-\bar{X})^2\sum(y-\bar{y})^2}\right)}$$

Where, r = Spearman's correlation coefficient

x = Pellet group abundance

$\bar{X}$ = Mean of x obse

y = Habitat variables

$\bar{y}$ = Mean of y observations

3.7.2 Vegetation data

The vegetation data were analyzed by using Zobel et al. (1987) as following method.

Frequency (%) = $\frac{Total\ number\ of\ Quadrats\ in\ which\ species\ has\ occured}{Total\ number\ of\ Quadrats\ studied} \times 100$

Relative frequency (%) = $\frac{Frequency\ of\ individual\ species}{Total\ frequency\ of\ all\ species} \times 100$

Density = $\frac{Total\ number\ pf\ individual\ species}{Total\ number\ of\ Quadrats\ studied \times Area\ of\ Quadrat} \times 100$

Relative density (%) = $\frac{Density\ of\ individual\ species}{Total\ density\ of\ all\ species} \times 100$

Coverage = $\frac{Approximate\ area\ covered\ by\ a\ species}{al\ number\ of\ Quadrat\ studied}$

Relative coverage (%) = $\frac{Coverage\ of\ a\ species}{Sum\ of\ the\ coverage\ of\ all\ species} \times 100$

For the estimation of coverage, midpoint value was calculated by the help of range mid point conversion mentioned below.

Scale no.	Range of coverage (%)	Mid-point of conversion (%)
1	< 5	2.5
2	5 – 25	15
3	25 – 50	37.5
4	50 – 75	62.5
5	75 – 95	85
6	> 95	97.5

Importance Value Index = Relative frequency + Relative density + Relative coverage

3.7.3 Correlation coefficient

For correlation analysis of tree density and mammals, tools/formulae described by Gupta (1982) were used.

$$r = \frac{N.\sum XY - \sum X.\sum Y}{\sqrt{N.\sum X^2 - (\sum X)^2}\ \sqrt{N.\sum Y^2 - (\sum Y)^2}}$$

Where, N = Number of observation

$\sum X$ = Summation of sampling unit X

$\sum Y$ = Summation of sampling unit Y

The value of 'r' lies between +1 to -1

r = +1, Perfect positive correlation i.e. increase in one variable is accompanied by the increase in the other

r = 0, No correlation

r = -1, Perfect negative correlation i.e. increase in one variable is associated by decrease in the other.

3.8 Site Selections

Site S_1 - This site includes area of Paanchmane and Okharpouwa side and adjoining area. Altitude ranges from 1500 m to 2140 m. The vegetation includes *Sachima – Castanopsis*

forest in the lower elevation of southern face and oak – Rhododendron forest dominates the upper part of the forest, The northern part of this site includes forest of *Saurauia nepalensis*, *Rhus succedanea*, *Myrsine capitellata* etc.

Site S_2 - This site includes Budhanilkantha area up to the Shivapuri Peak, Nagi gumba, Tarebhir and Baghdwar. Altitude ranges from 1550 m to 2732 m. The vegetation types includes subtropical forest of *Sachima – Castanopsis* with *Pinus roxburgghii* in some places and *Alnus nepalensis* along the sides of streams. Upper part of this site is dominated by *Q. Semecarpifolia* and *Rhododendron arboretum* forest.

Site S_3 - This site includes the area of Sundarijal, Chilaune gaun and Okhreni. Altitudes ranges from 1387 m to 2000 m. The vegetation includes *Sachima – Casanopsis* forest with *Pinus roxburghii* in some places and *Alnus nepalensis* along the sides of streams.

Site S_4 - This site includes Chitre, Chisapani and its adjoining area. Altitude ranges from 2014 m to 2194m. Representative species of vegetation are: *Cinnamomum tamala*, *Cammelia kissi*, *Pterocarpus santalinus*, *Symplocus* sp. etc.

Site S_5 - This site includes all the wards of Sundarijal VDC, and it is specially selected as the site of human-wildlife interaction to investigate human-wildlife interaction around SNNP.

4. RESULTS

4.1 Distribution and abundance of wild mammals

4.1.1 Mammalian species

A total of 431 faecal (or pellet) groups of wild mammal species were observed from 100 quadrates in the study area (SNNP). Pellet group record showed that the Rhesus monkey, Squirrel, Jungle cat, Ghoral, Langur, Barking deer, Rat, hare were found as main mammal species occupying the different parts of SNNP (Table 1). Pellet groups of black bear was not recorded from studied samples, but it was found from questionnaire survey that they are found in SNNP.

Table 1: Faecal (or pellet) group abundance (pellet group/quadrate) of wild mammals (Species-wise)

Species	Total pellet gr.	Total plots	Pellet gr. Abundance (pellet gr./quadrate)
Jungle cat (*Felis chaus*)	43	100	0.43
Large civet (*Viverra zibetha*)	25	100	0.25
Golden jackal (*Canis aureus*)	22	100	0.22
Black bear (*Selenarctas thibetanus*)	00	100	0.00
Ghoral (*Nemarhaedus goral*)	38	100	0.38
Barking deer (*Muntiacus muntjak*)	33	100	0.33
Wild boar (*Sus scrofa*)	20	100	0.20
Rhesus monkey (*Macaca mulatta*)	114	100	1.14
Langur (*Semnopithecus schistaceus)*	33	100	0.33
Pangolin (*Manis pentadactyla*)	11	100	0.11
Hare (*Lepus nigricollis*)	23	100	0.23
Squirrel (*Dremomys lokriah*)	43	100	0.43
Rat (*Mus cervicolor*)	26	100	0.26

Rhesus monkey was more abundant (1.14) among the mammalian species followed by Squirrel, Jungle cat, Ghoral, Barking deer, Langur and Rat (Table 1 and Fig. 5).

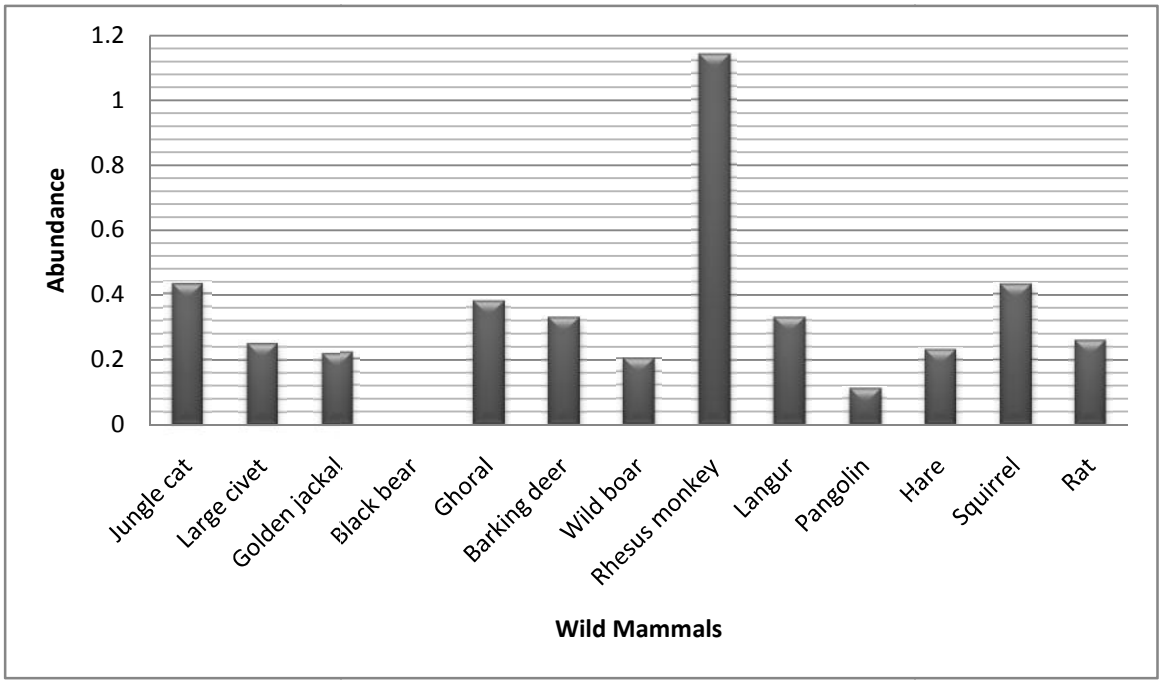

Figure 5: Bar diagram of pellet group abundance (pellet group/plot)

4.1.2 Habitat-wise (Total mammals)

Core area of SNNP comprises Salla forest, mixed forest, Riverine forest and grassland as the major habitat type. A total of 25 plots in each type of habitat were studied. Pellet frequency of mammals showed different pattern of abundance in different habitat types (Table 2).

Table 2: Faecal (or pellet) group abundance (pellet group/plot ± standard deviation) of wild mammals (Habitat-wise)

Habitat Type	Total pellet groups	Total plots studied	Abundance ± Standard Deviation
Grassland	181	25	7.24 ± 11.49
Mixed forest	34	25	1.36 ± 3.18
Riverine Forest	9	25	0.36 ± 0.99
Salla forest	207	25	8.28 ± 14.18

4.1.3 The average % distribution of each representative species

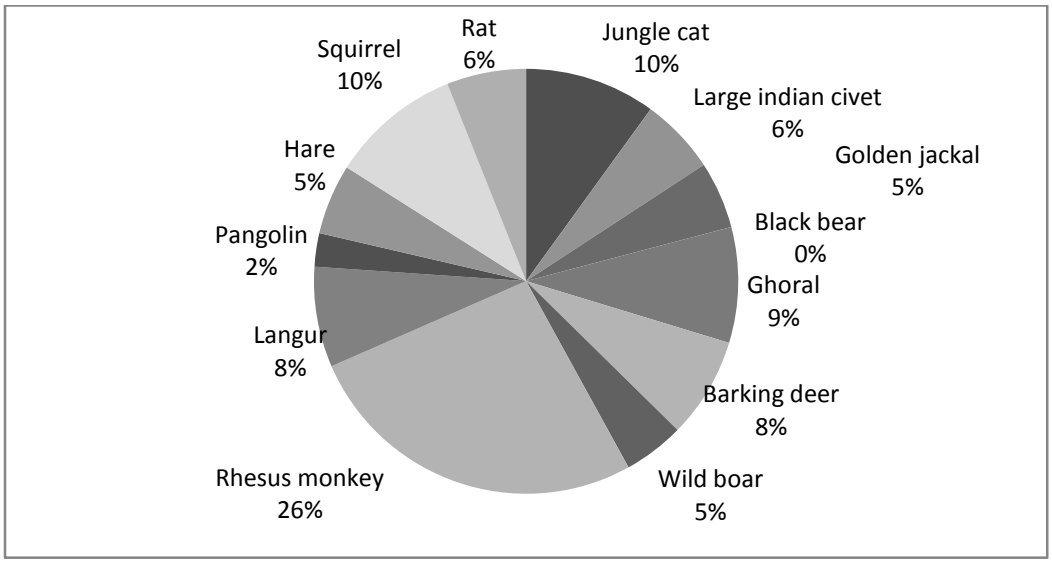

Figure 6: Pie chart showing average % distribution of wild mammals

4.1.4 Distibution pattern

Distribution pattern is of clumped type (Table 3).

Table 3: Table showing the calculation of distribution pattern

S.N.	Wild Mammals	GL	MF	RF	SF	Total (X)	Mean ($\bar{x}$)	$(X - \bar{x})$	$(X - \bar{x})^2$
1.	Jungle cat	13	10	2	18	43	33.15	9.85	97.02
2.	Large civet	7	1	0	17	25	33.15	-8.15	66.42
3.	Golden jackal	8	0	0	14	22	33.15	-11.15	124.32
4.	Blak bear	0	0	0	0	0	33.15	-33.15	1098.92
5.	Ghoral	7	4	0	27	38	33.15	4.85	23.52
6.	Barking deer	14	5	2	12	33	33.15	-0.15	0.02
7.	Wild boar	7	2	0	11	20	33.15	-13.15	172.92
8.	Rhesus monkey	48	8	1	57	114	33.15	80.85	6536.72
9.	Himalayan langur	12	3	1	17	33	33.15	-0.15	0.02
10.	Chinese pangolin	6	1	0	4	11	33.15	-22.15	490.62
11.	Black-naped hare	22	0	0	1	23	33.15	-10.15	103.02
12.	Himalayan squirrel	20	0	0	23	43	33.15	9.85	97.02
13.	Fawn colored mouse/rat	17	0	3	6	26	33.15	-7.15	51.12
	Grand Total					$\Sigma X = 431$			$\Sigma (X - \bar{x})^2 = 8861.66$

Mean ($\bar{x}$) = $\Sigma X / N = 431/13 = 33.15$

S^2 = variance = $\frac{1}{n}\sum(X - \bar{X})^2 = \frac{1}{13} \times 8861.66 = 681.62$

Variance (S^2) : Mean = 681.62 : 33.15 = 20.56

Thus, Variance (S^2) : Mean > 1 (clumped distribution) is correct.

Hence, Distribution pattern is of clumped type.

4.1.5 Chi-square test of significance

Chi-square (χ^2) = $\Sigma(O - E)^2/E$

Where, O = Observed value and E = Expected value

Table 4: Number of wild mamml's faecal (or pellet) group in different habitat type

S.N.	Wild Mammals	GL	MF	RF	SF	Total
1.	Jungle cat	13	10	2	18	43
2.	Large civet	7	1	0	17	25
3.	Golden jackal	8	0	0	14	22
4.	Ghoral	7	4	0	27	38
5.	Barking deer	14	5	2	12	33
6.	Wild boar	7	2	0	11	20
7.	Rhesus monkey	48	8	1	57	114
8.	Himalayan langur	12	3	1	17	33
9.	Chinese pangolin	6	1	0	4	11
10.	Black-naped hare	22	0	0	1	23
11.	Himalayan squirrel	20	0	0	23	43
12.	Fawn colored mouse/rat	17	0	3	6	26
	Total	181	34	9	207	431

Let's take the hypothesis that all the wild mammals are uniformly/evenly distributed in all the four habitat types. On the basis of this hypothesis, the expected frequency of the mammals in all habitat type was calculated and tabulated as (Table 5):

Table 5: Calculation of chi-square (χ^2) test of significance

Wild Mammals	Habitat type	Observed value (O)	Expected value (E)	(O-E)	$(O-E)^2$	$(O-E)^2/E$
Jungle cat	GL	13	18.06	5.06	25.6036	1.4177
	MF	10	2.4	7.6	57.76	24.0667
	RF	2	0.9	1.1	1.21	1.3444
	SF	18	20.65	2.65	7.0225	0.3401
Large civet	GL	7	10.5	3.5	12.25	1.1667
	MF	1	1.97	0.97	0.9409	0.4776
	RF	0	0.52	0.52	0.2704	0.5200
	SF	17	12.01	4.99	24.9001	2.0733
Golden jackal	GL	8	9.24	1.24	1.5376	0.1664
	MF	0	1.74	1.74	3.0276	1.7400

	RF	0	0.46	0.46	0.2116	0.4600
	SF	14	10.57	3.43	11.7649	1.1130
Ghoral	GL	7	15.96	8.96	80.2816	5.0302
	MF	4	3	1	1	0.3333
	RF	0	0.79	0.79	0.6241	0.7900
	SF	27	18.25	8.75	76.5625	4.1952
Barking deer	GL	14	13.86	0.14	0.0196	0.0014
	MF	5	2.6	2.4	5.76	2.2154
	RF	2	0.69	1.31	1.7161	2.4871
	SF	12	15.85	3.85	14.8225	0.9352
Wild boar	GL	7	8.4	1.4	1.96	0.2333
	MF	2	1.58	0.42	0.1764	0.1116
	RF	0	0.42	0.42	0.1764	0.4200
	SF	11	9.16	1.84	3.3856	0.3696
Monkey	GL	48	47.87	0.13	0.0169	0.0004
	MF	8	8.99	0.99	0.9801	0.1090
	RF	1	2.38	1.38	1.9044	0.8002
	SF	57	54.75	2.25	5.0625	0.0925
Langur	GL	12	13.86	1.86	3.4596	0.2496
	MF	3	2.6	0.4	0.16	0.0615
	RF	1	0.69	0.31	0.0961	0.1393
	SF	17	15.85	1.15	1.3225	0.0834
Pangolin	GL	6	4.62	1.38	1.9044	0.4122
	MF	1	0.87	0.13	0.0169	0.0194
	RF	0	0.23	0.23	0.0529	0.2300
	SF	4	5.28	1.28	1.6384	0.3103
Hare	GL	22	9.66	12.34	152.2756	15.7635
	MF	0	1.81	1.81	3.2761	1.8100
	RF	0	0.46	0.46	0.2116	0.4600
	SF	1	11.05	10.05	101.0025	9.1405
Squirrel	GL	20	18.06	1.94	3.7636	0.2084
	MF	0	3.39	3.39	11.4921	3.3900
	RF	0	0.9	0.9	0.81	0.9000
	SF	23	20.65	2.35	5.5225	0.2674
Rat	GL	17	10.92	6.08	36.9664	3.3852
	MF	0	2.05	2.05	4.2025	2.0500
	RF	3	0.54	2.46	6.0516	11.2067
	SF	6	12.49	6.49	42.1201	3.3723
Total						**$\Sigma(O - E)^2/E$ = 106.47**

Hence, $\chi^2 = \Sigma(O - E)^2/E = 106.47$,

Degrees of freedom = (c – 1) (r - 1) = (4 - 1) (12 - 1) = 3×11 = 33.

The value of χ^2 for 33 degree of freedom at 5 per cent level of significance is 47.40. The calculated value of χ^2 is much higher than this table value. So, it is significant. It means distribution pattern of mammals are uneven/non-uniform.

4.2 Habitat characteristics

A total of 42 plant species were recorded from the study area (Appendix 3).

4.2.1 Vegetation communities

Cluster analysis on the field data yielded four broad vegetation communities viz;

i. Salla forest (Dominated by *Pinus* sp.)
ii. Mixed forest (*Rhododendron arboretum, Alnus nepalensis, Schima wallichii, Castanopsis indica* etc.)
iii. Riverine forest (*Syzigium cumini*, *Prunus cerrasoides* etc.)
iv. Grassland (*Ficus neriifolia, Buddleja asiatica* etc.)

Most of the area is occupied by different stages of the Salla forest (Yadav et al. 2000). In overall analysis *Pinus* sp. was recorded with highest density (254.5 individuals/hectare) in Salla forest (Table 6 and Fig. 7).

Table 6: Tree densities and canopy coverage in different forest types

S.N.	Habitat	Tree density (individuals/ha)	Canopy coverage (%)
1	Salla forest	254.75	56.50
2	Mixed forest	219.75	67.5
3	Riverine forest	190.50	59.25

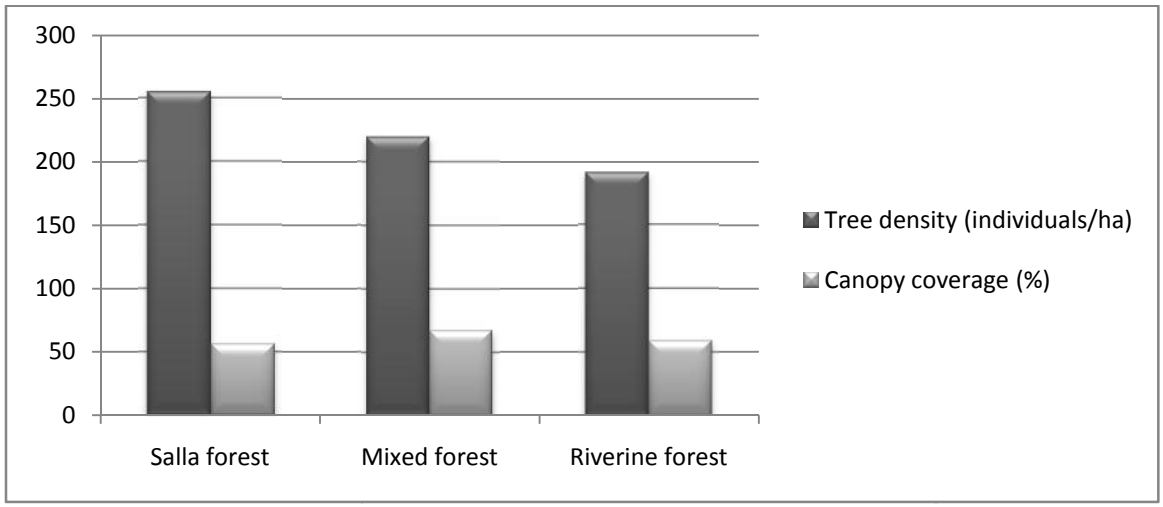

Figure 7: Tree densities and canopy coverage in different forest types

4.2.2 Habitat preference

Among four habitat types, Salla forest was found highly preferred (13.23%) for Rhesus monkey followed by Grassland (11.14%) for Rhesus monkey, Salla forest (5.34%) for Squirrel, Grassland (5.10%) for Hare etc., (Table 7).

Table 7: Habitat preferences

Species	Habitat Types	Tot. no. of plots	Pellet groups	H.P.(%)
Jungle cat	GL	25	13	3.02
	MF	25	10	2.32
	RF	25	2	0.46
	SF	25	18	4.18
Large civet	GL	25	7	1.62
	MF	25	1	0.23
	RF	25	0	0.00
	SF	25	17	3.94
Golden jackal	GL	25	8	1.86
	MF	25	0	0.00
	RF	25	0	0.00
	SF	25	14	3.25
Black bear	GL	25	0	0.00
	MF	25	0	0.00
	RF	25	0	0.00
	SF	25	0	0.00
Ghoral	GL	25	7	1.62
	MF	25	4	0.93
	RF	25	0	0.00
	SF	25	27	6.26
Barking deer	GL	25	14	3.25
	MF	25	5	1.16
	RF	25	2	0.46
	SF	25	12	2.78
Wild boar	GL	25	7	1.62
	MF	25	2	0.46
	RF	25	0	0.00
	SF	25	11	2.55
Rhesus monkey	GL	25	48	11.14
	MF	25	8	1.86
	RF	25	1	0.23
	SF	25	57	13.23
Langur	GL	25	12	2.78
	MF	25	3	0.70
	RF	25	1	0.23

	SF	25	17	3.94
Pangolin	GL	25	6	1.39
	MF	25	1	0.23
	RF	25	0	0.00
	SF	25	4	0.93
Hare	GL	25	22	5.10
	MF	25	0	0.00
	RF	25	0	0.00
	SF	25	1	0.23
Squirrel	GL	25	20	4.64
	MF	25	0	0.00
	RF	25	0	0.00
	SF	25	23	5.34
Rat	GL	25	17	3.94
	MF	25	0	0.00
	RF	25	3	0.70
	SF	25	6	1.39

The number of pellet group is highest at Salla forest (SF) which is followed by the Grassland (GL), Mixed forest (MF) and Riverine forest (RF) (Fig. 8).

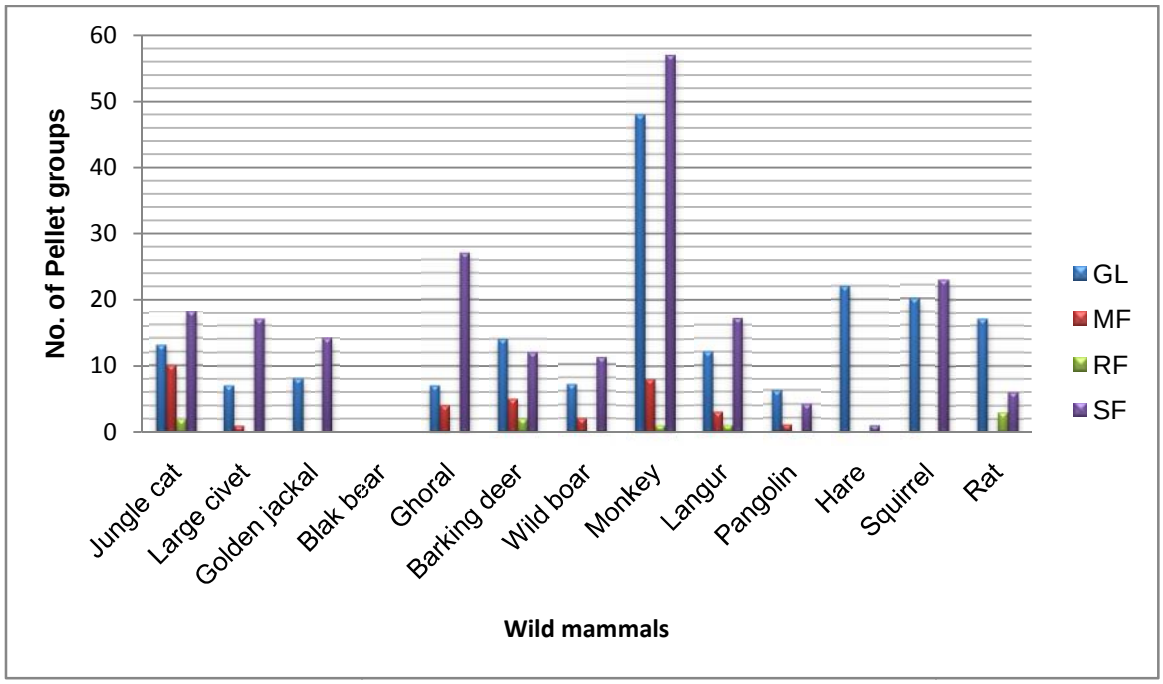

Figure 8: No. of different mammals at different habitat

4.2.3 Pellet groups abundance with respect to habitat variables

Data regarding pellet group abundance with respect to habitat variables namely tree density and canopy coverage were recorded as (Table 8):

Table 8: Correlation between pellet groups abundance and tree density as well as canopy coverage

S.N.	Sites	Tree Density (individuals/hectare)	Canopy Cover (%)	No. of pellet group	Pellet Abundance
1.	S_1	158.25	46.5	113	4.52
2.	S_2	196.50	56.5	125	5.00
3.	S_3	162.25	38.25	102	4.08
4.	S_4	148	42	91	3.64

A non-parametric Spearman's correlation coefficient between pellet groups abundance and tree density is (r = 0.87), which shows that there is a high positive correlation between the pellet groups abundance and tree density (Table 9).

Table 9: Calculation of correlation coef. between pellet gr. abundance and tree density

S.N.	Sites	Pellet gr. Abundance (X)	corr $\bar{x}$	X - $\bar{x}$	(X-$\bar{x}$)²	Tree Density (indiv./ha) (Y)	r. abt $\bar{y}$	Y - $\bar{y}$	(Y - $\bar{y}$)²	(X - $\bar{x}$)×(Y - $\bar{y}$)
1.	S_1	4.52	4.31	0.21	0.0441	158.25	166.25	- 8	64	-1.68
2.	S_2	5.00	4.31	0.69	0.4761	196.50	166.25	30.25	915.0625	20.8725
3.	S_3	4.08	4.31	-0.23	0.0529	162.25	166.25	- 4	16	0.92
4.	S_4	3.64	4.31	-0.67	0.4489	148	166.25	- 18.25	333.0625	12.2275
	Total	17.24			1.022	665			1328.125	32.34

Mean of X = 17.24/4 = 4.31 Mean of Y = 665/4 = 166.25

Correlation coefficient (r) $= \frac{\sum(X-\bar{X})(y-\bar{y})}{\left(\sqrt{\sum(X-\bar{X})^2 \sum(y-\bar{y})^2}\right)} = \frac{32.34}{(\sqrt{1.002 \times 1328.125})} = \frac{32.34}{(\sqrt{1357.34375})} = \frac{32.34}{36.84}$

$= 0.87$

A non-parametric Spearman's correlation coefficient between pellet groups abundance and canopy coverage is (r = 0.86), which shows that there is a high positive correlation between the pellet groups abundance and canopy coverage too (Table 10).

Table 10: Calculation of correlation coef. between pellet gr. abundance and canopy cover

S.N.	Sites	Pellet gr. Abundance (X)	$\bar{x}$	X - $\bar{x}$	$(X-\bar{x})^2$	Canopy cover (%) (Y)	$\bar{y}$	Y - $\bar{y}$	$(Y-\bar{y})^2$	$(X-\bar{x})\times(Y-\bar{y})$
1.	S_1	4.52	4.31	0.21	0.0441	46.5	45.8125	0.6875	0.472656	0.144375
2.	S_2	5.00	4.31	0.69	0.4761	56.5	45.8125	10.6875	114.2227	7.374375
3.	S_3	4.08	4.31	0.23	0.0529	38.25	45.8125	-7.5625	57.19141	1.739375
4.	S_4	3.64	4.31	0.67	0.4489	42	45.8125	-3.8125	14.53516	2.554375
	Total	17.24			1.022	183.25			186.4219	11.8125

Mean of X = 17.24/4 = 4.31 Mean of Y = 183.25/4 = 45.8125

Correlation coefficient (r) = $\frac{\sum(X-\bar{X})(y-\bar{y})}{\left(\sqrt{\sum(X-\bar{X})^2\sum(y-\bar{y})^2}\right)} = \frac{11.8125}{(\sqrt{1.002\times1186.4219})} = \frac{11.8125}{(\sqrt{190.5232})} = 0.86$

4.2.4 Direct observation

Table 11: Mammals observed along the studied transects

S.N.	Wild mammals	Total observed number
1.	Jungle cat (*Felis chaus*)	1
2.	Large civet (*Viverra zibetha*)	1
3.	Golden jackal (*Canis aureus*)	0
4.	Black bear (*Selenaectos thibetanus*)	0
5.	Ghoral (*Nemarhaedus goral*)	11
6.	Barking deer (*Muntiacus muntjak*)	6
7.	Wild boar (*Sus scrofa*)	2
8.	Rhesus monkey (*Macaca mulatta*)	37
9.	Central Himalayan langur (*Semnopithecus schistaceus*)	17

10.	Chinese pangolin (*Manis pentadactyla*)	3
11.	Black-naped hare (*Lepus nigricollis*)	13
12.	Orange-bellied Himalayan squirrel (*Dremomys lokriah*)	6
13.	Fawn-colored mouse/rat (*Mus cervicolor*)	7
	Total	**104**

A total of 104 individual mammals of different species were observed along the studied transect. Jungle cat, Large civet, Ghoral, Barking deer, Wild boar, Rhesus monkey, Langur, Pangolin, Hare, Squirrel and Rat were the observed mammals in transect. Among them, Rhesus monkey was the highest (37) observed species (Table 11).

4.3 Human-wildlife interaction

4.3.1 Frequency of wildlife's visit to different crops

The frequency of wildlife visits in the crop land that was not the same throughout the year (Fig. 9). There were 505 reported cases of wild boar in sample areas, which is followed by monkeys, birds, deer, rats and bear. The total visit of wildlife was 1337.

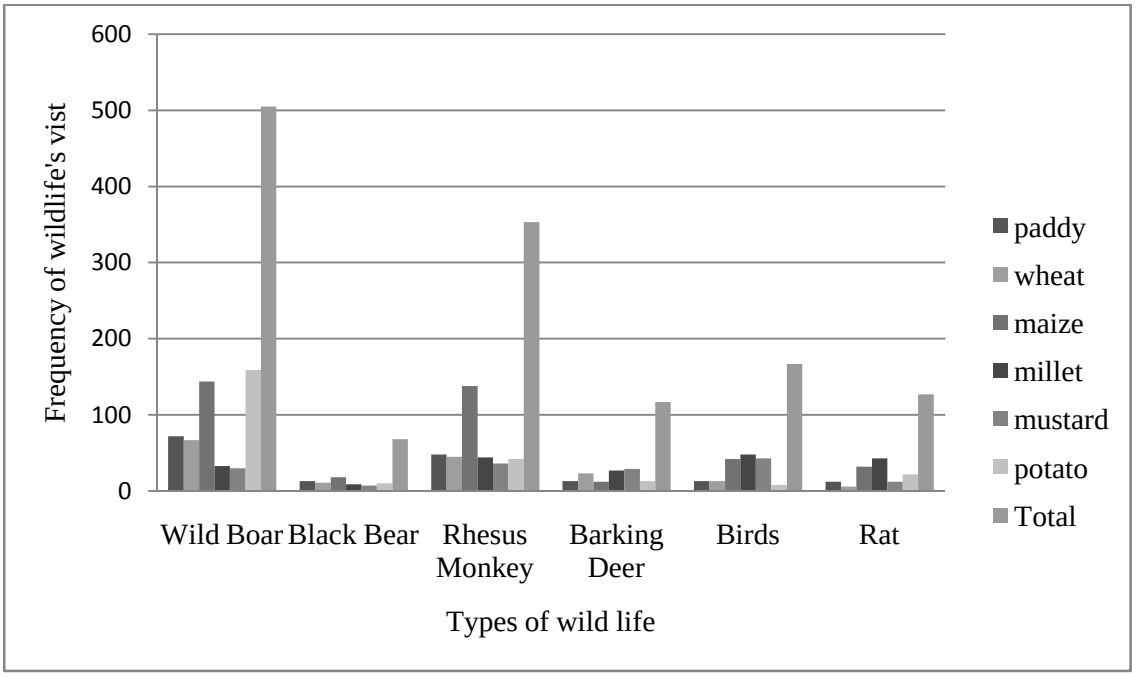

Figure 9: Frequency of wildlife's visit to different crops in the sampled area.

4.3.2 The Gross Area and Net Area Damaged of crops by wildlife

The highest total Gross Area and Net Area Damage by wildlife were indicated for paddy, the total Gross Area was 2155.6 ropani and the total Gross Area affected by wildlife was 455.50 ropani, which was 21.13 percentage of total Gross Area (Fig. 9). The Net Area Damaged by wildlife was 107.70 ropani and its NAD percentage was 4.99. The lowest Gross Area and Net Area Damage were found for mustard, the total Gross Area was 421.50 ropani. The total Gross Area affected by wildlife was 81.60 ropani, which was 19.35 percentage of total Gross Area. The Net Area Damaged by wildlife was 32.42 ropani. NAD percentage in terms of Gross Area was 7.69 (Fig. 10).

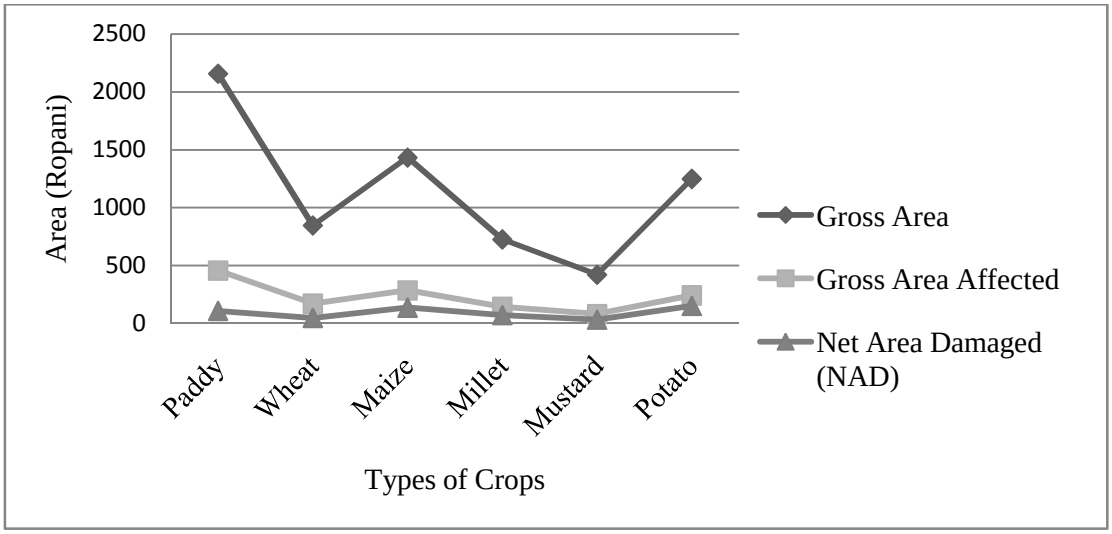

Figure 10: Total Gross Area and Net Area Damage of crops by wildlife in the sampled area (in ropani).

4.3.3 Net Area Damage (NAD) of crops by wildlife

The highest total Net Area Damage of crops done by Wild boar was 175.90 ropani, which is followed by porcupine, deer, monkey, rats, bear and birds by 95.09, 87.40, 72.83, 60.68, 27.10 and 26.90 ropani respectively. Similarly it is shown at Total Net Area Damage in paddy, wheat, maize, millet, mustard and potato were 107.77, 46.99, 136.42, 70.73, 32.42 and 151.57 ropani respectively (Fig. 10). Total Net Area Damaged was 545.90 ropani (Fig. 11).

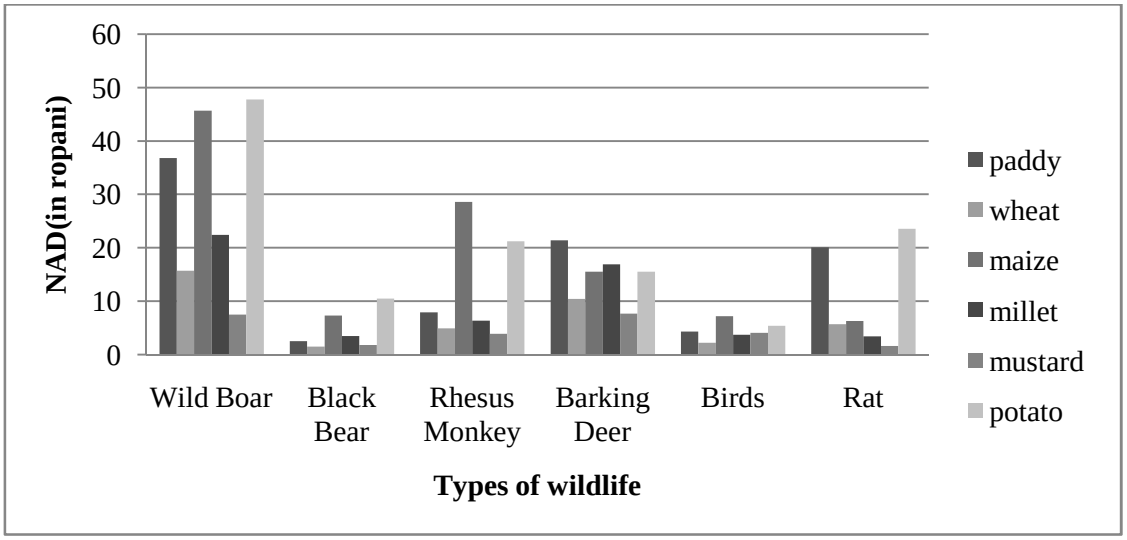

Figure 11: Net Area Damage (NAD) of different crops by different wildlife.

4.3.4 Percentage of Net Area Damage (NAD) of crops by wildlife

The highest percentage 32.05 of Net Area Damage of crops by Wild boar followed by deer, monkeys, rats, birds and bears 18.34, 17.11, 12.18, 10.11, and 4.42 percentages respectively (Fig.12).

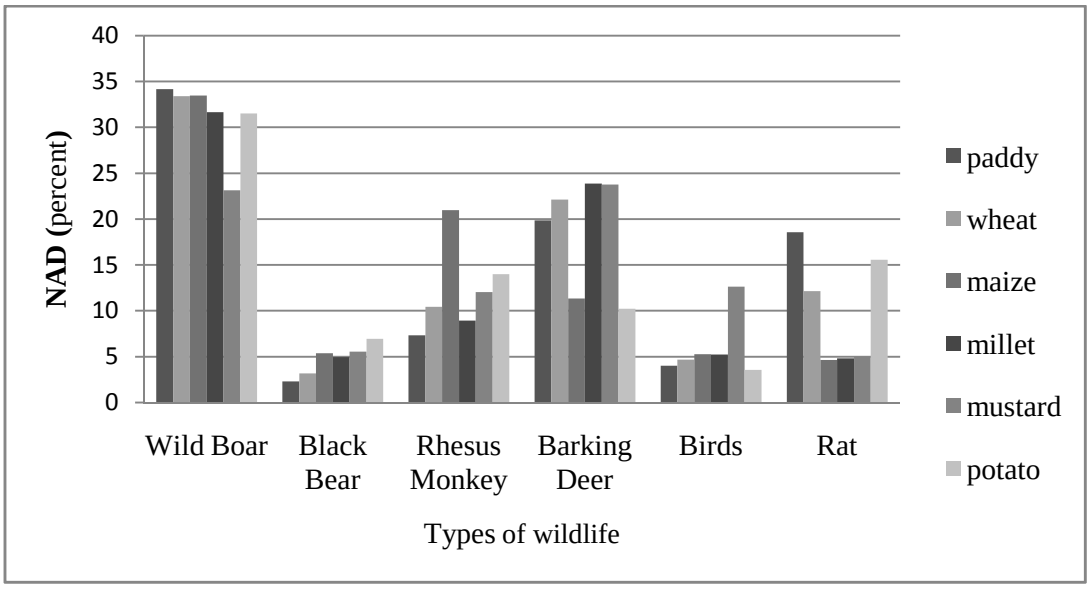

Figure 12: Percentage of Net Area Damage of different crops done by different wildlife.

4.3.5 Ranking of wildlife in crop damage

The loss of crop from Wild boar which was the highest amount of 32432.1 kg. It was in the first position of ranking of crop damage. Similarly, Rat in second position which destroyed 14314.15 kg of crop, Monkey in third position with 13568.5 kg crop damage. On the descending order of crop damage were Barking Deer (13046.41 kg), Black Beer (5935.92 kg), and birds (4092.46 kg) (Fig. 13).

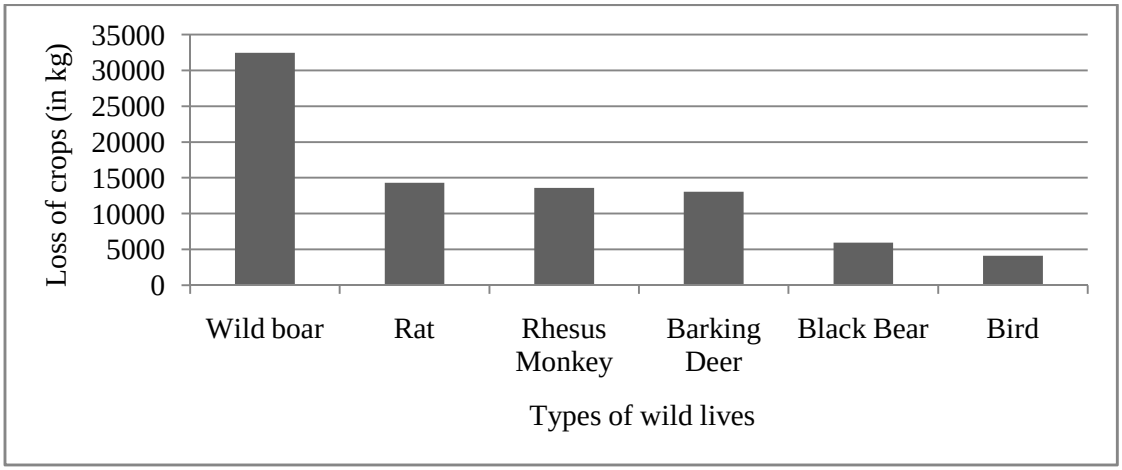

Figure 13: Ranking of wildlife in crop damage.

4.3.6 Total number of livestock reared by the sampled households

Chicken was the highest number by 512, which was followed by goat 232, buffalo 70, bull 50, cow 43, pig 32 and duck 12 (Fig. 14).

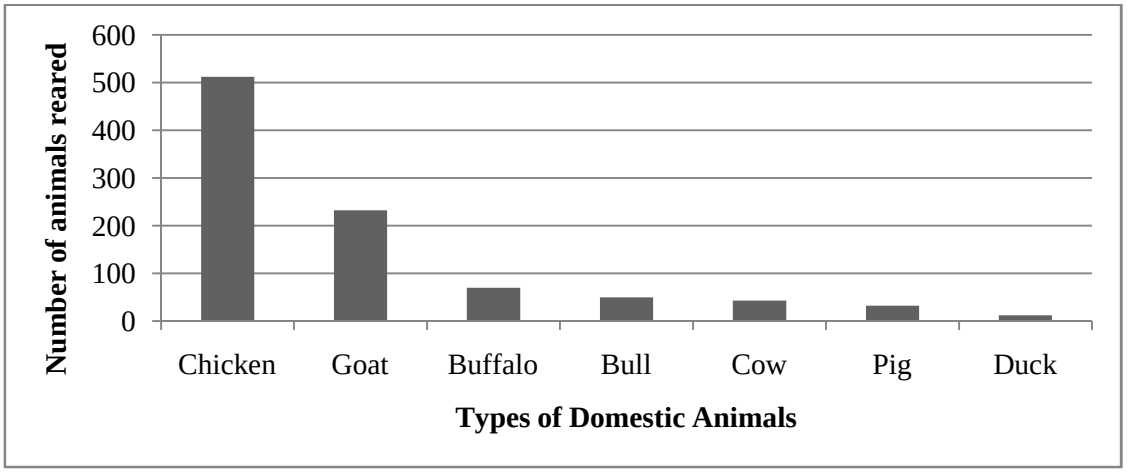

Figure 14: Total number of animals reared in the study area

5. DISCUSSION

5.1 Distribution and abundance of wild mammals

5.1.1 Mammal's distribution and abundance

Mammals in Shivapuri Nagarjun National Park were found to be abundant in the grassland areas. The highest population of mammals were concentrated in Shivapuri grassland. Generally grassland is preferred habitat for grazing animals. In fact, high quality habitat of grassland support high mammals biomass (Shrestha 2004). In this study relatively low abundance of mammals were recorded in Riverine forest. The spotted deer (deer sp.) can adapt in the habitat with differential forage production rather than a homogeneous vegetation structure (Thapa 2003).

Rhesus monkey was found in all types of habitats but it was relatively highly abundant in salla forest followed grasslands than in other habitats. Chalise et al. (2013) found distribution of Rhesus monkey in all types of habitats. The distribution of Jungle cat, Large Indian civet, Golden jackal, Ghoral, Barking deer, Wild boar, Rhesus monkey, Central Himalayan langur, Chinese pangolin, Black-naped hare, Orange-bellied Himalayan squirrel and Fawn-colored mouse/rat were found to be 43, 25, 22, 38, 33, 20, 114, 33, 11, 23, 43 and 26 per 100 quadrates each of size 25×25 m^2 respectively. The highly distributed mammal was Rhesus monkey followed by Ghoral, Barking deer and Langur. The lowest average distributed mammal was Pangolin and Black bear was not recorded in study sites while by questionnaire survey, it was found that Black beer is also one of the major crop damaging wild mammals.

Bhandari and Chalise (2014) found about pangolin that the distribution of burrows was high in the forest dominated by Chilaune (*Schima wallichii*) (40%) where as least in saur (*Betula alnoides*) (15.7%). The distribution was higher in the canopy cover of 25-50% (71%) while least above 75%. Here, forest dominated by Chilaune (*Schima wallichii*) is categorized as mixed forest, where Pangolin burrow were found least, which is not consistent with Bhandari and Chalise (2014), this may be due to low number sample study sites.

5.1.2 Distribution pattern

Distribution pattern of mammals in Shivapuri Nagarjun National Park was clumped type. Shrestha (2004) also reported similar type of mammalian distribution in Tarai Arc Landscape (TAL). Such distribution pattern is generally exhibited by biological populations in natural habitat (Odum, 1996). In addition to specific preference the grassland, availability of water holes at Site 'S_2' facilitates the distribution pattern of wild mammals.

5.1.3 Pellet (or faecal) group abundance with respect to habitat variables

Correlation between pellet (or faecal) groups abundance and tree as well as canopy coverage showed high positive correlation. Such a correlation could be due to highly preferred habitat type and available environment, hence barking deer is one of the most abundant mammals in SNNP. This is not consistent with (Thapa, 2003) because different kinds of nature of Barking deer at micro level environment. The tendency of barking deer to avoid thick cover and preference for under storey of grassland and forbs (Schaller 1967, Geist 1974, Dinerstein 1987, Mishra and Wemmer 1987) emphasize the anti-predatory strategy while choosing its environment at smaller scale (Thapa, 2003). Barking deer relies on visual detection of its predators to scape (Dinerstein 1979, Moe and Wegge 1994) which shows the low positive relationship of Barking deer distribution with tree density and canopy coverage.

5.2 Habitat characteristics

5.2.1 Vegetation assessment

Vegetation in the Shivapuri Nagarjun National Park is temperate type. In present study, the vegetation was classified into four major types: (i) Salla forest, (ii) Mixed forest, (iii) Riverine forest and (iv) Grasslands. The highest density of tree was found in site 'S_2' of the study area, this may be due to undisturbed area and lowest density of tree was found in site 'S_4', this may be due to north facing topography with less intensity of sunlight. As increasing altitude the *Schima – Casanopsis* forest of southern slope was found to be replaced by Oak – Rhododendron forest up to the highest point (2732 m) of the Park. The dominant vegetations recorded in northern slope were *Cinnamomum tamala*, *Camellia kissi*, *Pterocarpus santalinus*, *Rhus saccedanea* and *Symplocus* sp. These vegetation were not dominant in

southern slope. The difference in vegetation structure is due to different type of climatic condition.

Low diversity of plant species was recorded in the present study, because the vegetation data was collected only from those samples where animal data were collected. Such sampling technique could be insufficient to predict the vegetation of whole area of Shivapuri Nagarjun National Park.

Highest tree density was recorded in the Salla forest than in Mixed forest and Riverine forest. Most of the area was covered by Salla forest. The Salla forest is mainly occupied by *Pinus roxburghii* and other associated species. Mixed forest is dominated by *Rhododendron arboretum* and *Alnus nepalensis.* Similarly in Riverine forest *Syzygium cumini* is dominant tree species. Bhatta and Shrestha (1977), Schaaf (1978) Yadav et. al. (2000) have made similar observation.

5.2.2 Habitat Preference

Present study analyzed habitat utilization by wild mammals in four different habitat of Shivapuri Nagarjun National Park. Rhesus monkey was generalist in the habitat use but it has relatively more preference to the Salla forest and low preference to the grasslands. The result is consistent with the results of Thapa (2003) and Ghimire (1996). The Barking deer is specific to the habitat use in open grasslands of Shivapuri is preferred habitat in Shivapuri Nagarjun National Park. Pokhrel (1996) and Gyawali (2003) also reported high preference of deer sp. is in open grasslands and low preference in riverine forest, marsh and salla forest.

Similarly, Hare and Rat also preferred to use grassland than other habitat type in Shivapuri Nagarjun National Park. Similar results were made by Tamang (1982) and Dinerstein (1987) in low land of Nepal.

Barking deer preference was found high in Grasslands followed by Salla forest. This result was consistent with the findings of Thapa (2003) and Heggdal (1999). Barking deer is a selective feeder and depends on easily digestible food with low fibers but high protein contents that are available in forested habitats (Thapa 2003) and so may have preferred to inhabit in Grasslands and Salla forest and were often seen in meaodows (Tamang 1982).

The distribution of burrows was high in the forest dominated by Chilaune (*Schima wallichii*) (40%) where as least in saur (*Betula alnoides*) (15.7%). The distribution was higher in the canopy cover of 25-50% (71%) while least above 75% (Bhandari and Chalise 2014). Here, forest dominated by Chilaune (*Schima wallichii*) is categorized as mixed forest, where Pangolin burrow were found least, which is not consistent with Bhandari and Chalise (2014), this may be due to selection of sample study site is very less in number.

5.3 Human - wildlife interaction around SNNP

This study was conducted in Sundarijal VDC of Kathmandu District which has been facing the serious problems of wild animal's especially wild boars and many other wild animals from SNNP for many years. 72% people during the survey said that presence of Park resulted in loss of their crop and livestock from wildlife. Similarly, park had been a source of irritation for local people who did not follow rule and regulation for livestock grazing, fodder, timber and firewood collection and poaching of wildlife among 24 respondents from park staffs. Park and local people realized that conflict between these two groups arose due to four major sources: i) Fuel wood and fodder, ii) Crop damage, iii) Livestock grazing and iv) Human harassment. This is due to the presence of park near by the VDC, the illegal use of park by local people for their requirement and the visiting of wild life in agriculture field for the food.

Upreti (1985) also pointed similar types of conflicts, such as crop damage, encounter between man and wildlife, loss of livestock by predators, fishing and hunting, antipathy towards parks and reserves and tourism. Sharma (1991) found causes of conflict in Royal Chitwan National Park where crop and livestock damage, loss of human life by wild animals nearest to the park due to habitat encroachments from local people.

This study also showed that the total Net Area Damaged (NAD) was 27.34 hectare. Out of which the highest was by Wild boar 32.22% followed by deer 16.02%, monkeys 13.34%, rats 11.12%, bears 4.96% and birds 4.92%. Similarly, the highest Net Area Damaged was found in potato field 27.76% followed by maize 24.98%, paddy 19.74%, millet 12.95%, wheat 8.62% and mustard 5.93%. The Wild boar was the main crop raider so it ploughed the field, ate tuber of potato at that time it damaged most of the areas and it had made the highest damage in potato field. Wild boars mostly visited in the season when the potato was planted

or in the growing stage. Wild boar and other animals raided the crops just before the harvesting time.

Gurung (2002) also pointed similar type of result finding total NAD was 23.39 hectare in Sunkhani VDC in Kathmandu district. The highest NAD was by Wild boar in 38.53%, which was followed by porcupine 20.83%, monkey 20.09%, deer 8.72%, bear 9.12% and birds 2.68%.

This study shows that wild boar was found as main crop raider in Sundarijal VDC, adjacent to SNNP. Other crop raiders were rhesus monkey, Himalayan black bear, barking deer, fawn-colored mouse/rats and different birds. Due to the availability of food near to the park around it in nearby villages, at the time of seasonal changes, intra and inter specific competitions, temperature changes in winter and summer seasons and population of the wildlife, the wildlife came out of the park and they entered to the cultivated area and raided. In the study, Wild boar was found most visited wild animals in the cultivated land and mostly raiding in tuber like potato, sweet potato etc. Other wildlife like bear, rat, monkey, deer etc. were also found raiding in different types of plants according to the taste and season of plants.

Similarly Kharel (1993) identified wild boar, Himalayan black bear, rhesus monkey and barking deer species as major crop raiders in Langtang National Park. Sharma (1995) found wild buffalo (*Babulus babulis arnee*) and wild boar as main crop raider in KTWR. Previous study of Soti (1995), Gurung (2002) and Purkait and Chalise (2010) found wild boar as a principal crop raider in SNNP. In these studies, wild boar seemed to be one of the main crop raiders in most of the parks and reserves of Nepal.

Local people of Sundarijal VDC had adopted different kinds of preventive measures to protect their crop damage. For instance, spending night in watch towers and machan, use of noise making tools, beating tins and boxes, chasing with stones, guarding by dogs to deter the Wild boars and other wild animals etc. Shouting and chasing with fires, beating tins and boxes, spending whole night in watch towers and machan were more popular methods. According to the villagers, spending whole nights in watch towers and machans had an adverse effect on the people's health as well as on the efficiency of villagers' work. They become irritated from park because they lose their valuable time for chasing the wildlife and guarding their crops and livestock and extra loss of money for keeping dog.

6. CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

Shivapuri Nagarjun National Park supports many species of plants and animals along with wild mammalian species. Most of the area of the park was covered by Salla forest. Pinus species was dominant among the tree species.

A total of 431 pellet groups of mammals were observed from 100 plots each of 25×25 m^2. Thirteen different species of mammals namely; Jungle cat, Large Indian Civet, Golden Jackal, Black Bear, Ghoral, Barking Deer, Wild Boar, Rhesus Monkey, Central Himalayan Langur, Chinese Pangolin, Black-naped/Indian Hare, Orange-bellied Himalayan Squirrel and Fawn-colored Mouse/Rat were recorded from the Shivapuri Nagarjun National Park. The high distribution and abundance suggested the grassland areas of Shivapuri Nagarjun National Park are good habitat for wild mammal species. Himalayan black bear was not observed during this study period.

Present study found clumped distribution and high abundance of mammals which explains the presence of good quality habitat. Pellet (faecal matter) count survey in line transect was found to be feasible option for mammal monitoring because this method does not require presence of animals and does not need more man power during monitoring. In contrast direct observation required more man power and could be more expensive and very difficult to observe as most of the wild animals are shy and have the exclusive type of nature obstructed due vegetation and terrain.

The study of park-people conflict was conducted in Sundarijal VDC of Kathmandu district, located adjacent to the south-east side of SNNP. This study indicates that the poor socio-economic condition creates conflicts between local people and park. The main causes of conflict are: breaking the rules and regulations of the park; crop and livestock depredation and human harassment due to wildlife, livestock grazing, hunting and poaching and fodder, timber and firewood cutting by local people inside the park.

6.2 Recommendations

Following measures are suggested to mitigate the problems:

1. To gather more information in distribution and abundance of wild mammals, monitoring in Nagarjun should be conducted.
2. Those who live at the proximity of the core area should be shifted to other suitable places where crop damage is higher & feasibility of village settlement and re-wooding.
3. Conservation education and awareness program should launch around buffer zone to make local people positive to park and authorities and understand wildlife behaviour and alterative crops.
4. The park should provide preventive measures including the effective noise producing equipments and other scaring devices to chase out wild animals. Park also has to provide wood for making machan (raised platforms) and should encourage farmers to unite watching the fields.
5. Local people should use modern preventive measures leaving traditional preventive measures like strong boundary wall around their houses, cattle and live stocks should be kept in pen, shed etc.
6. Park office or government should provide compensation for damage in time.
7. Black bear was not recorded during this study, but were visiting the cultivated land of Sundarijal VDC according to questionnaire survey, thus a base line study on the species should be conducted in Shivapuri Nagarjun National Park.
8. Present study observed low abundance of mammals in Riverine forest in comparison to other habitat types and limited plots were surveyed in this habitat. So, a detailed study in Riverine forest is necessary.

7. REFERENCES

Arneberg, P.; Skorping, A.; Grenfell, B.; Read, A.F. (1998). *"Host densities as determinants of abundance in parasite communities"*. Proceedings of the Royal Society of London. Series B: Biological Sciences 265 (1403): 1283–1289.

Baral, N. 1998. Wild boar-Man conflict: Assessment of Crop Damage by Wild boar in the South–Western Section of Bardia National Park, Nepal. M. Sc. Thesis in Zoology, Tribhuvan University, Kirtipur, Kathmandu.

Bartelt, Gerald A.; Rolley, Robert E.; Vine, Lawrence E. (2001). *Evaluation of abundance indices for striped skunks, common raccoons and Virginia opossums in southern Wisconsin (Research report (Wisconsin. Dept. of Natural Resources), Report 185)*. Madison, Wisconsin: Wisconsin Dept. of Natural Resources, Bureau of Integrated Science Services. *Retrieved 2006-12-15*.

Berger, J., Stacey, P.B., Bellis, L. and Johnson, M.P. 2001. A mammalian predator-prey imbalance: Grizzly bear and wolf extinction affect avian Neotropical migrants. Ecol. Appl. 11:947-960. [8, 12]

Bhandari, N. and Chalise, M.K. 2014. Habitat and Distribution of Chinese Pangolin *(Manis Pentadactyla* Linnaeus, 1758*)* in Nagarjun Forest of Shivapuri Nagarjun National Park, Nepal. *Nepalese Journal of Zoology*.Online Volume 2 Issue 1: 18 p.

Bhatta, D.D. and Shrestha, T.K. 1977. The environment of Suklaphanta. Curriculum Develoment Centre, Tribhuvan University, Nepal.

BPP. 1995. Biodiversity Profile of the Midhills Physiographic Zones. DNPWC, Ministry of Forest and Soil Conservation and HMGN.

Chalise M.K., Bhattarai, G.P. and Pandey, B. 2013. Ecology and Behaviour of Assamese Monkeys in Shivapuri-Nagarjun National Park, Nepal. Journal of Natural History Museum, Nepal. 27: 12-24.

Dinerstein, E. 1979. An ecological survey of the Royal Karnali-Bardia Wildlife Reserve, Nepal, Part II: Habitat/Animal interaction Biological Conservation, 16: 265-300.

Dinerstein, E. 1987. Deer, plant phenology and succession in the low land forest of Nepal. In: Wemmer, C.N. (Ed) Biology and Management of the Cervidae, Research symposia of the national zoological park Smithsonian institution, pp 272-288. Smithsonian Institution Press, Washington D.C., USA.

DNWPC. 2010. Protected Area of Nepal. A booklet published by Department of National Park and wildlife Conservation in Nepal, Babarmahal, Kathmandu.

Geist, V. 1974. On the relationships of social evolution and ecology in ungulates. American Zoologist, 14: 200-205.

Ghimire, J.N. 1996. Status and distribution of barasingha (*Cervus duvauceli diouvauceli*) population in RBNP Nepal. M.Sc. dissertation submitted to the Central Department of Zoology, Tribhuvan University, Kirtipur, Kathmandu.

Ghimire, K.B. 1994. Conservation and Social Development: A Study Based on an assessment of Wolong and Other Panda Reserve in China. Discussion Paper 56. Geneva, United Nations Research Institute of Sustainable Development.

Green, R.J. and Catteral, C.P. 1998. The Effect of Forest Clearing and Regeneration on the Fauna of Wivenhoe Park, South-East Queensland. Wildlife Research 25: 677-690.

Groom M.J., Meffe G.K. and Carrol C.R. 2005. Principles of Conservation Biology. Sinauer Associates, Inc. Publishers Sunderland, Massachusetts U.S.A, 263 p.

Gupta, S.P. 1982. Statistical Method. Sultan Chand and Sons. New Delhi.

Gurung, D. 2002. People Conflict. Assessment of Crop damage by Wild Animal in Shivapuri Nagarjun National Park, M.Sc. thesis in Zoology, T.U., Kathmandu, Nepal.

Gurung, K.K. and Singh, R. 1996. Field Guide to the Mammals of the Indian Subcontinent. Indian Experience, Oxford.

Gyawali, N. 2003. Population status and habitat use of barasingha (*Cervus duvauceli duvauceli*) in Royal Suklaphanta Wildlife Reserve. B.Sc. Thesis, Institute of Forestry, T.U., Pokhara.

Heggdal, P. 1999. Spatial Organization, habitat preferences and activity of barking deer (*Muntiacus muntijak*) during the dry season in Royal Bardia National Park, Lowland of Nepal. M. Sc. Thesis, Agriculture University of Norway.

http://dictionary.reference.com/browse/habitat, accessed on 5 September, 2015.

ICIMOD, 2011. Protected Area and Payment for Environmental Services: A feasibility Study in Shivapuri Nagarjun National Park. Lalitpur, Nepal: ICIMOD.

Inskipp, C. 1989. Nepal's forest birds: their status and conservation. International Council for Bird Preservation. Monograph No. 4. Cambridge, UK.

Ives, J.D. and Messereli, B. 1989. The Himalayan Dilemma: Reconciling Development and Conservation. Rutledge, London, UK.

Jnawali, S.R. 1989. Park-People Conflict: Assessment of Crop Damage and Human Harassment by Rhinoceros (*Rhinoceros unicornis*) in Sauraha area adjacent to Chitwan

National Park, Nepal. M.Sc. unpublished Thesis, Agricultural University of Norway.85-102p.

Karki, A.B. 2002. A short glimpse of Shivapuri National Park. *Danphe* 11(1): 38-39, BCN, Kathmandu.

Karki, A., Jnawali, S.R., Adhikari, S. and Sharma, S.K. 2012. Banko Janakari, Vol. 22, No. 2. Abundance and distribution of tiger prey base at Bardia-Katarniyaghat corridor forest, Nepal,Department of Forest Research and Survey (DFRS), Ministry of Forests and Soil Conservation, Government of Nepal. 55 p.

Kasu, B.B. 1996. Studies on Park-People Conflict in the Parsa Wildlife Reserve. M.Sc. thesis in Zoology, Tribhuvan University. Nepal, 99 p.

Kattel, B. 1993. A study on Assessment of Wildlife Diversity and Wildlife Reserve. Sivapuri Integrated Watershed Development Project, GCE/ NEP/ 048/ NOR, National Consultant Report.

Keshari, A. K., Ghimire K. R., Mishra B. S. and Adhikari, K. K. 2008. A text book of Higher Secondary Biology, Vidyarthi Pustak Bhandar, Kathmandu, Nepal.

Kharel, F.R. 1993. Status Park-People Conflict in Langtang National Park, M.Sc. unpublished thesis Submitted to Lincoln University, Canterbury, New Zealand, 145 p.

Kothari, C.R. 2004. Research Methodology Methods and techniques (Second Revised Edition), New Age International Publishers, New Delhi, 139-140 p.

Kunwar, K. J. (2008). "Payment for Environmental Services in Nepal (A Case Study of Shivapuri National Park, Kathmandu, Nepal)". The Initiation **63**: 63–72.

Milton, J.P. and Binney, G.A. 1980. Ecological Planning in the Nepalese Tarai. A report on Resolving Resource Conflicts between Wildlife Conservation and Agricultural Land use In Padampur Panchayt. Threshold, International Centre for Environmental Renewal, Washington D.C. USA, 35 p.

Mishra, H.R. 1982. Balanching Human Needs and Conservation in Nepal's Chitwan National Park, Ambio 11(5): 246-251 p.

Mishra, H.R. 1991. Regional Review: South and South-East Asia. A Review Developed from a Regional Meeting on National Parks and Protected Areas held in Bangkok, Thailand, 199 p.

Mishra, H.R. and Wemmer, C.M. 1987. The comparative breeding ecology of four cervids in Royal Chitwan National Park. In: Wemmer, C.M. (Ed) Biology and management of the cervidae: Pp. 259-271, Smithsonian Institution Press, Washington, D.C. USA.

Moe, S.R. and Wegge, P. 1994. Spacing behaviour and seasonal habitat preferences of axis deer (*Axis axis*) in Royal Chitwan National Park, Nepal. Canadian Journal of Zoology, 72: 1725-1744.

Odum, E.P. 1996. Fundamental of Ecology. Third Edition, Nataraj Publishers, Deharadun, India.

Pokhrel, C.P. 1996. Food habit and habitat utilization of swamp deer (*Cervus duvauceli duvauceli*) in the RBNP, Nepal. M. Sc. Dissertation submitted to the Central Department of Zoology, Tribhuvan University, Kirtipur, Kathmandu.

Prasain, J. 2015. Population status, distribution and habitat use of barking deer (*Muntiacus muntjak*) in Shivapuri Nagarjun National Park, Kathmandu, Nepal. M.Sc. Thesis. Central Department of Zoology, Tribhuvan University, Kirtipur, Kathmandu.

Purkait, S. and Chalise, M. K. 2010. Park- People Conflict and its Management in Shivapuri National Park: A Case Study of Sundarijal Village Development Committee. Lifescience Journal Magazine, Volime 2

Schaaf, C.D. 1978. Population size and structure and habitat relations of the barasingha (*Cervus duvauceli duvauceli*) in RSWR, Nepal. Ph.D. dissertation, Michigan State University.

Schaller, G.B. 1967. The deer and the tiger: a study of wildlife in India. University of Chicago Press, Chicago, USA.

Sharma, U. R. 1991. Park-People Interactions in Chitwan National Park, Nepal. The University of Arizona, USA 113-116. Compiled by S.M. Amatya, P. Sayami, T.B.S. Mahat. Compendia of Graduate Thesis in Forestry and Allied Subjects: Doctoral and Master Degrees Related to Nepal.

Sharma, B.K. 1995. An Assessment of Crop Damage by Wild Animals and Depredation of the Wildlife due to Activities of Local People in Koshi Tappu Wildlife Reserve. M.Sc. thesis in Zoology, T.U. Kathmandu Nepal. 46pp

Shrestha, B., 1994. Studies on Park People Conflict, Investigation on Resolving Resources Conflict between Park Conservation and adjoining Settlements in the Northern Boundary of CNP. M.Sc. unpublished thesis in Zoology, T.U., Nepal, 133 p.

Shrestha, M.K. 2004. Relative Ungulate Abundance in fragmented landscape: Implications for tiger's conservations. A thesis submitted to the faculty of the graduate school of the University of Minnesota. In partial fulfilment of the requirements for the degree of Doctor of philosophy.

Shrestha, T.K. 2003. Wildlife of Nepal. Mrs. Bimala Shrestha, Kathmandu Nepal, 215-613 p.

Singh, L.A.K. 1999. Tracking Tigers: Guidelines for Estimating Wild Tiger Populations using the Pugmark Technique. WWF Tiger Conservation Program, 36 p.

Smith, J.L.D., Dougal, C.Mc., Ahearn, S.C., Joshi, A. and Conforti, K. 1999. Metapopulation structure of tigers in Nepal. Pages 176-189 in J. Scidensticker, S. Christie and P. Jackson editors, riding the tiger: tiger conservation in human-dominated landscapes. Cambridge University Press, Cambridge United Kingdom.

SNNP 2011. A prospectus. Department of National Parks and Wildlife Conservation, Kathmandu, Nepal.

Soti, J. 1995. Assessment of Crop Depredation due to Wildlife in the Neighborhood of Shivapuri Watershed and Wildlife reserve. M.Sc. thesis in Zoology, T.U., Kathmandu, Nepal, 82 p.

Studsord, J.E. and Wegge, P. 1995. Park People Relationships: A Case Study of Damaged Caused by Park Animals Around the BNP, Nepal. Environment Conservation 22(2): 133-142.

Sukumar, R. 1989. The Asian elephant. Ecology and Management. Cambridge University Press, Cambridge.

SWWR. 1999. Shivapuri Watershed and Wildlife Reserve. A brochure published by Shivapuri Watershed and Wildlife Reserve, Panimuhan, Budhanilkantha, Nepal, 20 p.

Tamang, K.M. 1982. The status of the tiger (*Panthera tigris*) and its impact on the principal prey population in the RCNP, Nepal. Ph.D. Thesis, Michigan State University.

Thapa, R. 2003. Study on habitat structure of RSWR, Western Lowland, Nepal. B.Sc. Thesis, Institute of Forestry, T.U., Pokhara.

Upreti, H.K. 1995. An Assessment of Agriculture and Livestock Depredation Through Wild Animals in Pathihani and Jagatpur Area near the CNP, M. Sc. Thesis in Zoology, T.U., Kathmandu, Nepal, 66 p.

Vedder, A. L. 1984. Seasonal changes in food resource distribution and feeding sites selected by Japanese macaques on Koshima Islet, Japan, Primate Research Institute, Kyoto University, Kanrin, Inuyama, Aichi 484-8506, Japan,Volume 51: 149-158.

WWF Nepal Program, 1998. Tiger Manual: Indirect Field Study Techniques for the Kingdom of Nepal. WWF Nepal.

WWF Nepal Program, 2001. Snow Leopard Manual: Indirect Field Study Techniques for the Kingdom of Nepal. WWF Nepal.

Yadav, U.R., Joshi, D., Khadka, R.B., Karki, T.B. and Sutihar, D.N. 2000. The Study of Shivapuri Watershed Environment HMG, National Council for Science and Technology, 117 p.

Zobel, D.B., Behan, M.T., Yadav, U.K.R. and Jha, P.K. 1987. A practical manual for ecology. Ratna Book Distributors, Baghbazar, Kathmandu, Nepal.

APPENDIX 1

Questionnaire

About the issues of Human Conflict in SNNP

Household Questionnaires

Name:……..... Village/VDC:……

Ward No.: …… Occupation:……..

1. How many members are there in your family?

   ……

2. Do you have livestock/avian stock?

   Yes…… No……

   If yes how many do you have?

   Cattle……Buffalo……Goat……Pig……

   Chicken…….Duck……Pigeon…….....Parrot……

   Others……

3. How many livestock/avian stock were lost due to wild animal?

Wild animals	Cattle	Buffalo	Goat	pig	Chicken	Duck	Pigeon	parrot	Other
By Leopard									
By Jackal									
By wild cat									
By Mongoose									
By Bird									
By others									

4. How much land do you have?

   …… Ropani

5. How much khet and how much bari?

   Khet……ropani, bari …… ropani

6. In how many ropani of land do you grow following crops?

   Paddy…… Wheat…….. Maize…….

   Millet……..

   Mustard……. Potato…….. Radish…….

   Other……

7. Do you practise mixed cropping system?

   Yes…….. No…….

   If yes, which crop do you plant together?

   ……

8. What is the average yield of crops?(Kg/ropani)

   Paddy……. Wheat……. Maize……

   Millet……..

   Mustard…….. Potato……. Radish……..

   Other……..

9. What is the total production of these crops?(In Kg)

   …….

10. Do wild animals attack on your crops?

    Yes…….. No……

    If yes, which are the main wild animals?

    Wild boar…… Bear…… Deer…….

    Porcupine…… Monkey……Bird…….

    Other…….

11. Which animals attack crops?

	Paddy	Maize	Millet	Wheat	Mustard	Potato	Other
Wild boar							
Bear							
Deer							
Porcupine							
Monkey							
Birds							
Other							

12. What is the frequency of their visit on crops?

Wild boar……. Bear…….. Deer……

Porcupine…… Monkey……..

13. What is the total loss of crops?(In Kg)

Paddy……. Maize……. Wheat…….

Millet…….. Mustard…… Potato…….

14. What is the total lost of crops by wild animals? (In Kg)

	Paddy	Maize	Millet	Wheat	Mustard	Potato	Other
Wild boar							
Bear							
Deer							
Porcupine							
Monkey							
Birds							
Other							

15. If there was no such wildlife damage problem, what would have been the total production? (in Kg)

Paddy…… Wheat…….. Maize……. Millet……

Mustard……Potato……....Radish……..Other……

16. Any crop you didn't grow because of the fear of wild animals?

Paddy……Wheat……..Maize…….....Millet……

Mustard…….....Potato…….....Radish…….....Other……..

17. Do you apply any techniques to protect your crop from wild animals? If yes, mention

a) …… b) ……. c) …….....d) …….....

18. Because of such wildlife damage problem. Are you thinking of leaving this place and going somewhere else?

Yes……. No……

19. Any other kind of injuries of harassment?

Yes……. No……

20. Have you received any compensation?

Yes……. No……

21. What are the sources of human conflict in SNNP?

……

22. What would be the best controlling measures? Any idea or recommendation do you have?

……

Questionnaires for park staffs

1. What are the main causes that conflict between the park authorities and local people?

   a) Livestock grazing…… b) Hunting and poaching……

   c) Fodder cutting…….....d) Crop damage……..

   e) Loss of live stock and avian stock……. f) Human harassment……..

   g) Other……..

2. In your opinion, why do animals come out of the park and do the damage?

   a) Lack of foods inside the park……

   b) Crop preference……..

   c) Lack of proper fence……

   d) Other……..

3. Are the local people aware of the importance of National park and its rule and regulations?

   ……

4. Have you adopted any measures to control the wild animals to come outside the park?

   ……

5. What is the better and permanent solution to minimize the conflict between the park authorities and the local people?

   ……

Questionnaires for Community Leader

1. What is your perception about the wild animals and national park?

   ……

2. Would you like to tell your suggestion for the management of the park and maintaining of its balance?

   ……

3. Are there any complaints from public sector?

   a) Yes…… b) ……

4. Have you ever visited park officer about public complaints for solving the problems?

   ……

5. What are your suggestions for managing the p-ark using its resources for the local people?

   ……

6. In your opinion, have you found any differences between past and current park management approach?

   a) Yes…….. b)……

   If yes, what are the differences?

   ……

APPENDIX 2

Annual rainfall (mm) at station Sundarijal

a) At latitude (deg/min) 2745, longitude (deg/min) 8525 and elevation (m) 1360 from 2010 to 2012.

Year	Jan	Feb	Mar.	Apr.	May	June	July	Aug	Sep	Oct	Nov	Dec
2010	1.2	22.5	16.4	31.8	101.9	291.3	352.0	449.8	DNA	DNA	DNA	DNA
2011	17.2	61.4	37.3	103.3	246.3	288.5	534.3	605.8	393.3	27.4	24.2	0.1
2012	12.5	33.4	27.4	129	82.2	212.5	472.5	590.6	446.4	27.6	4.0	0

b) At latitude (deg/min) 2746, longitude (deg/min) 8525 and elevation (m) 1490 from 2012 to 2014.

Year	Jan	Feb	Mar.	Apr.	May	June	July	Aug	Sep	Oct	Nov	Dec
2012	21.2	27.1	20.4	100.4	57.5	350.6	598.9	711.7	419.2	24.3	3.1	0.0
2013	16.1	53.6	3.2	56.6	330.2	495.4	761.1	786.9	178.9	160.2	0.0	0.0
2014	6.5	2.9	66.2	16.1	88.5	310.3	579.1	627.7	DNA	DNA	0.0	30.2

APPENDIX 3

Mean Importance Value Index (IVI) of Vegetation in SNNP recorded from Different samplers

S.N.	Name of species	Mean (IVI)	**Local name**
1	*Albizia procera* (Roxb.) Benth	4.60	Sipligan
2	*Alnus nepalensis* D.Don	0.88	Lapsi
3	*Buddleja asiatica* Lour.	15.50	Angeri
4	*Camellia kissi* Wall.	5.63	Lali gurans
5	*Castanopsis hystrix* Miq.	3.61	Uttis
6	*Castanopsis indica* (Roxb.) Miq.	2.27	Gogan
7	*Castanopsis tribuloides* Sm. And A. DC.	0.08	Rani bhalayo
8	*Choerospondias oxallaris* Roxb., B.L. Brutt	4.47	Bhakimlo
9	*Cinnamomum tamala* Nees and Eberm.	9.07	Mayal
10	*Crateva unilocularis* Buch.	2.38	Seti kath
11	*Engelhardia spicata* Lsch. Ex Bl.	4.43	Kali kath
12	*Eriobotrya dubia* (Lindl.) Decne.	7.53	Kaulo
13	*Erythrina stricta* Roxb.	13.96	Khasru
14	*Eurya acuminate* DC.	2.23	Khasru
15	*Ficus neriifolia* Sm.	0.42	Phalat
16	*Ligustrum confusum* Decne.	0.68	Banjh
17	*Lithocarpus elegans* (Blume) Hatus ex Soep.	5.94	Vanshi
18	*Lyonia ovalifolia* Wall.	6.85	Mauva
19	*Myrica esculenta* Buch.-Ham.ex D. Don	8.92	Painyu
20	*Myrsine capitellata* Wall.	1.01	Rani Salla
21	*Myrsine semiserrata* Wall.	0.4	Gobre salla
22	*Persea odoratissima* (Nees) Kosterm.	2.01	Chilaune
23	*Phoebe lanceolata* Nees.	0.96	Ankha taruva
24	*Pinus roxburghii* Sargent	0.69	Masure katus
25	*Pinus wallichiana* A.B. Jackson	0.53	Dhale katus

26	*Prunus cerrasoides* D. Don	0.40	Patle katus
27	*Pterocarpus santalinus* L.F.	8.75	Kaphal
28	*Pyrus pashia* Buch.-Ham.ex D.Don	4.09	Tegar
29	*Quercus glauca* Thunb.	2.01	Dhusurlo
30	*Quercus lamellsa* Sm.	0.61	Seto siris
31	*Quercus lanata* Sm.	11.85	Dudhilo
32	*Quercus semecarpifolia* J.E. Smith.	0.4	Phaledo
33	*Rhododendron arboretum* Smith	100.71	Bhimsen pate
34	*Rhus javanica* L.	24.15	Jure kaphal
35	*Rhus saccedanea* L.	23.3	Hinguva
36	*Ribes takare* D. Don	15.40	Jamun
37	*Saurauia napaulensis* DC.	80.12	Kanike phul
38	*Schima wallichii* DC. Korth	125.69	Sisi
39	*Symplocus theifolia* D. Don	0.96	Bakalpati
40	*Syzygium cumini* (L.) Skeels	25.40	Rakta chandan
41	*Trichilia connaroides* (Weight and Arn.) Bentvelzen	54.4	Hade vayar
42	*Zizyphus incurve* Roxb	0.86	Jhakri kath

APPENDIX 4

Density of individual tree species in different habitat types (Specific to quadrates)

		Density/ha.		
S.N.	**Name of the species**	**Salla forest**	**Mixed forest**	**Riverine forest**
1.	*Choerospondias oxallaris*	-	8.46	-
2.	*Rhododendron arboretum*	43.62	31.25	-
3.	*Alnus nepalensis*	11.6	12.5	-
4.	*Myrsine capitellata*	4.0	5.2	-
5.	*Myrsine semiserrata*	4.8	6.0	-
6.	*Quercus semecarpifolia*	2.3	3.0	-
7.	*Quercus lanata*	1.2	1.9	-
8.	*Prunus cerrasoides*	0.9	1.2	2.3
9.	*Pinus roxburghii*	64.0	12.0	-
10.	*Pinus wallichiana*	51.0	10.1	-
11.	*Schima wallichii*	9.9	8.1	-
12.	*Castanopsis tribuloides*	1.2	3.4	-
13.	*Castanopsis indica*	1.6	2.9	-
14.	*Myrica esculenta*	3.4	8.9	-
15.	*Albizia procera*	-	2.7	-
16.	*Ficus nerrifolia*	-	-	8.1
17.	*Zizyphus incurve*	-	2.4	3.2

APPENDIX 5

SNNP mammals' population data collection sheet

Date: Site:

Habitat type: Transect No.:

Starting Time: Ending Time:

Plot No.	Pellets groups/dropping/burrows/pugmarks etc. of										
	Jungle cat	Jackal	Bear	Mongoose	Goral	Deer	Squirrel	Rat	Monkey	Any other	Unidentified

APPENDIX 6

Photo Plates

Plate 1: Aerial view of Salla forest in SNNP

Plate 2: Burrow of Rat

Plate 3: Cow dung in SNNP near boarderline

Plate 4: Faeces of Jackal

Plate 5: Faeces of Bear

Plate 6: SNNP entrance gate, Panimuhan

Plate 7: Rhesus macaque in Nagigumba, SNNP

Plate 8: Making quadrate in study site

Plate 9: Taking data of tree

Plate 10: King cobra in grassland of SNNP

Plate 11: Measuring circumference of old tree

Plate 12: Pellets of Rat