

**ASIATIC BLACK BEAR (*Ursus thibetanus*) ABUNDANCE,  
HABITAT OCCUPANCY AND CONFLICTS WITH HUMANS IN  
AND AROUND DACHIGAM NATIONAL PARK, KASHMIR.**

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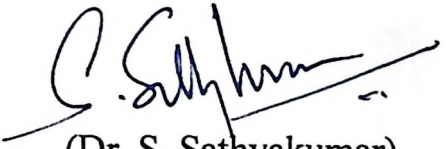
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## Certificate

This is to certify that the thesis of Ms. Samina Amin Charoo entitled '**Abundance, habitat occupancy and conflicts with humans in and around Dachigam National Park, Kashmir**' is an original piece of work submitted to Saurashtra University, Rajkot, Gujarat for the award of the **Doctor of Philosophy in Wildlife Science**.

Ms. Samina Amin Charoo has put more than five term of research work embodied in this thesis under my guidance and supervision. This work presented in this thesis has not been submitted for any degree of any other University or Institution

Place: Dehradun  
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(Dr. S. Sathyakumar)  
Supervisor



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Appendix -- II: Format used for Black Bear – Human Conflict questionnaire Survey in, Kashmir during 2007-09.

## Executive Summary

*Asiatic black bear (Ursus thibetanus) is one of the four species of bears distributed in India. The India Himalaya and northeastern hill States of India possess one of the best populations of black bears in Asia but only a few short term studies account for this species in India. The existing studies mostly account for their status and distribution and there were no long term studies for this species in India prior to the present study. Asiatic black bears are declining in numbers due to increased human activities, including habitat alteration or destruction, increased human settlements, and activities such as livestock grazing in bear habitat, shifting cultivation, poaching, unregulated killing for sport, and retaliatory killings attributed to depredation of crops and livestock. The increase in retaliatory killings and human attitude towards bears is detrimental towards conservation of this species. The scientific management of a species such as black bear owes to sufficient basic information about its ecology and behavior. The present study focused on the abundance estimation, habitat use patterns and human – bear interactions in Dachigam National Park and Dachigam Landscape, Jammu and Kashmir, India during the period 2007-2010.*

*The abundance estimation is the basic information needed for any species. In this study abundance estimation of black bears was tried out through various methods: sign surveys, camera trapping and non- invasive genetic method. Sign surveys were carried out to understand the encounter rates of black bears within Dachigam National Park.*

*A total of 2520 km was walked for monitoring of 13 transects from 2008 to 2010. The encounter rates of black bears varied monthly, seasonally and year wise. Encounter rate was found to be highest in summer (June - August) followed by spring (March - May), autumn (September - November) and lowest during winter (December - February). The encounter rates varied across the years for each season. For spring, it was highest in 2010 ( $0.75 \pm 0.05$ ), followed by 2009 ( $0.66 \pm 0.1$ ) and least for 2008 ( $0.52 \pm 0.11$ ). For summer 2009 ( $1.33 \pm 0.12$ ) had maximum encounter rate followed by 2010 ( $1.06 \pm 0.09$ ) and 2008 ( $0.97 \pm 0.14$ ). In case of autumn encounter rate was highest for 2010 ( $0.94 \pm 0.06$ ) followed by 2008 ( $0.9 \pm 0.25$ ) and 2009 ( $0.87 \pm 0.05$ ). In case of winter, it was highest in 2009 ( $0.41 \pm 0.21$ ) followed by 2008 ( $0.34 \pm 0.2$ ) and 2010 ( $0.22 \pm 0.05$ ).*

*A total of 120 of samples were collected in the summer months (May- July) for this analysis. DNA was extracted from all of these hair samples and were tried to amplify on the 20 selected microsatellite markers. Each sample was genotyped twice to minimize the genotyping errors for individual identification. Only those samples were considered for individual identification that produced identical genotypes in duplicate genotyping. Few samples were repeated as they did not produce the identical genotypes in first run. It started with 80 hair samples and 24 samples did not amplify at all. This occurred as the starting material was low (because of less hairs or hairs without root) and seven hair samples did not produce identical genotypes even after repeating thrice. 49 hair samples were genotyped, that produced identical genotypes in duplicate genotyping and 18 unique genotypes were identified in a pool of 49 genotypes. It was found that a combination of five or more loci is necessary to get the unique genotype using a single locus.*

*The density of black bear as proposed by capture recapture model could not be estimated because of the low sample size. Based on this study, however, it has been proven that appropriate number of samples can lead to density estimates for a species such as black bear.*

*A total effort of 6900 camera trap nights resulted in 389 black bear captures. The site occupancy estimate was 0.97 (0.82-1.12) and based on this the abundance calculated was estimated to be 44 (CL, 23-113). The density calculated was 48/100 Km<sup>2</sup>. The capture rate (#/100 trap nights) ranged from 0 -18 across different sites and based on this the study area was categorized as high, medium and low capture sites.*

*Habitat occupancy patterns of black bears were assessed at three scales.*

*(i) Intensive study area scale (ii) Landscape scale and (iii) Individual scale*

*At the intensive study area level i.e. Dachigam National Park, camera trapping technique was used to study habitat use patterns. The intensive study area of 90 km<sup>2</sup> was divided into 23, 2X2 km grids and in each grid a camera trap (Wildview) was placed to make sure that at least one camera is representative of a sampling unit (grid in the present study). Within the grids the cameras were placed in a good bear habitat such that they have the best chance of being visited by the black bears based on the literature and the field surveys. The data was collected for both the response variable (capture and no capture for bears) and the predictors (habitat factors) for*

each camera site. For each site the camera traps were run on 24 hr (day- night) period and capture histories were recorded. The observed presence-absence at each visit is a binary random variable defined as follows: 1 if detected at site and 0 if not detected. The results presented here are for three years 2008, 2009 and 2010 with a total effort of 6900 number of capture days (24 hr) for 23 camera sites. Occupancy based models using program PRESENCE, v.2.2 were run to estimate the site occupancy rate relative to the sampling variables such as elevation, aspect, slope, canopy cover, ground cover, habitat type, distance from water and disturbance. Akaike Information Criterion values were used to rank the occupancy model (or to select the best fit model). Season was taken as considerable ecological period to compare the occupancy patterns and results showed significant differences across the seasons. The occupancy models for spring season take various habitat variables into consideration but the best fit model based on the AIC ranking considered ground cover and elevation only. The site occupancy ( $\psi$ ) is comparatively low in spring (0.54), the camera sites at lower elevations got less captures. Summer had the highest site occupancy (0.78) compared to all the three seasons as almost all the sites got photo captures of black bears. The best positive predictors of black bear occupancy during summer were canopy cover, ground cover and shrub density. During autumn, the best fit occupancy model considered tree density, elevation and slope as the predictors of black bear occupancy. The site occupancy for autumn was 0.61.

Habitat use patterns at landscape level was studied using Compositional analysis of seven Asiatic black bears were captured, radio collared and tracked. The collared animals included four males (02 M, 08 M, 10 M and 100 M) and three females (00 F, 04 F and 06 F). In total 967 use locations from 7 black bears was used for the analysis. For the habitat selection analysis, both VHF locations and ARGOS based locations (2-3 locations/week) were used. Due to the inaccessibility of tracking animals regularly, satellite data was used for filling up of the information gaps. The overall 100% MCP (Minimum Convex Polygon) home ranges for all the radio collared was generated. For availability the composite home ranges was generated after the combinations of all the MCPs of seven animals. The composite home ranges were selected as the area of analysis or the available area for the habitat use analysis. Six habitat types were classified: Riverine, Mixed forest, Pine forest, Grassland and scrubland, Human habitation and Orchard. The overall habitat use by

black bears was not random ( $\lambda = 0.0395$ ,  $\chi^2 = 22.62$ ,  $df = 5$ ,  $P < 0.001$ ,  $n = 7$ ). Riverine habitat type ranked highest among all the six different types of habitat associations followed by mixed forest type and it was lowest for the human habitation habitat type. Black bear use of different cover types was disproportional to availability within the composite home ranges or the area of analysis. Compositional analysis of second order selection resulted in ranking matrices that ordered habitats from the most to least use during the study period. The simplified matrix ranked the habitat use in the order: Riverine > Mixed forest > Pine forest > Grassland & Scrubland > Cropland > Human habitation

For habitat selection patterns at individual level the information on each radio collared bear was used following Euclidean distance based approach. For habitat analysis, distances from estimated bear locations were compared with distances from random points generated throughout each home range. To ensure an adequate number of random points for high precision, 1000 random points were generated from a uniform distribution within the population range and then calculated mean distances for increasing number of points for the representative habitat types. Mean distances from the representative habitats were stabilized and a selection of 250 random numbers of points within each home range was decided to be adequate for the analysis. Distances were calculated from random points and bear locations to each habitat type using the Hawth's tool in Arc GIS 9.3. For each individual bear, distances for eight vectors (Aspect, Slope, Proximity to water source, food patch, road, trail, human habitation) was created for the analysis. A binary logistic regression was run to understand the differences between the bear and random location of different habitat parameters using SPSS 16.0. For binary logistic regression data including eight variables extracted from vector layers for both animal and random locations was used for model prediction. A cross-correlation matrix was prepared initially to see if the variables were highly correlated to one another. Variables with correlation coefficients  $> 0.60$  were removed from the analysis. Enter elimination processes were applied to identify and remove redundant variables and those variables that did not contribute significantly in detecting presence of any species in the study area. Overall prediction efficiency of the variables was assessed based on Nagelkerke- $R^2$  and  $- \text{Log Likelihood}$  values. Influence of individual variables including categorical variables was assessed using Wald statistics. Hosmer

and Lemeshow goodness-of-fit test (chi square test) and concordance analysis (classification tables) were done to understand the fit of the model. The  $\beta$  coefficients indicate the selection or avoidance of a resource and were used to evaluate the response of covariates on the habitat selection of black bears in the landscape. The affect of various habitat parameters varied across different individuals. The areas with steeper slopes were avoided by most of the radio collared animals. In case of female bears a varying affect of habitat parameters was revealed, proximity to stream showed an overall negative trend. Male bears showed a positive approach towards higher elevations, proximity to stream and a negative effect on proximity to food, road and trail.

All the three scales were useful in better understanding of habitat use patterns of black bears in the study area. The habitat use of bears in relation to food in the form of riverine habitats with fruiting trees and shrubs, orchards, crop lands and higher altitudes at definite season for herbs and grasses was clearly depicted by the results of this study.

Black bear- human interactions is a major concern throughout the western Himalayas and particularly in the Kashmir valley of Jammu and Kashmir State. The Black bear-human conflicts were assessed using Questionnaire surveys (n=227) around Dachigam National Park Landscape. About 72% of the villagers interviewed claimed to be dependent on the forest produces and about 56% were below poverty line status. Black bear- human interactions were more frequent on the northern region of Dachigam National Park. The bear- human interactions were more intense in close vicinity of bear habitats at the altitudinal ranges of 1800- 2200m. The black bear – human conflicts recorded were in the form of crop damage, livestock predation, human attacks and sometimes even death of humans. Crop damage was observed to be the most common type of conflict as reported by more than 80% of the respondents. The extent of crop damage varied in different months and can be related to the cropping pattern. Crop damage and livestock damage was estimated for the areas surveyed. Crop raiding by black bear was reported as a common problem in the villages that are located in the close vicinity of forests around Dachigam Landscape. Summer being the most productive season for most of the agricultural and horticultural crops in the area, had maximum number of crop damage cases (87%) followed by autumn (9%) and the remaining in winter. Most of the crop deprecations

*occurred in August and September (70%) that coincides with the production of maize and apple, followed by June and July (12%) for cherry. During October and November, there were fewer cases (9%) and the instances of crop depredation declined as autumn progressed, with only 3% of cases reported in December (winter). The various crop protection measures adopted by the villagers to scare off bears included: drumming empty tin or metal containers, putting up scare crows, keeping guard dogs, barbed wire fencing and animal-proof walls. Drumming empty tin/metal containers was the most commonly used protection measure, as 74% respondents reported using this technique, followed by use of barbed wire fencing (17%), scare crows (29%), guard dog (7%) and animal-proof wall (4.8%).*

*A total of 19 attacks on humans were recorded during the survey (May 2007-April 2009). Most of the bear attacks were on people working in crop fields [n=13; (68%)] followed by people working in forests for resource use [n=4; (21%)] and about 10% of cases (n=2) occurred in villages. Bear attacks occurred during the period May to November. Most of the cases (61%) occurred in summer followed by autumn (22%), spring (8%) and winter (9%). Over 60% of the attacks occurred during crepuscular period, 25% during day time, and 15% during night.*

*The intensive periods of bear-human interaction corresponds well to the periods of increased human activity. Major cultivation activities in the area between May – December, increases human movement in summer and autumn and probably makes humans vulnerable to bear attacks. During the interviews local people claimed black bears more active in the crop lands during crepuscular time resulting in more number of casualties during these hours.*

*The number of livestock killed by black bears within the surveyed localities during 2007-09 was 28 in 7 incidences. Of these, 19 livestock were killed by black bears during nights in cattle sheds or night shelters and three were killed in forest. Most of the livestock killings (n=21) occurred in winter, possibly due to non-availability of food. Of the 21 number of livestock killed in winter, 11 were killed by a black bear in a single incidence.*

*Based on the interview data and field surveys carried out around Dachigam Landscape during 2007-09, some basic understanding of the black bear-human interactions in this region has been obtained. Some patterns have been observed and*

*these need to be monitored in future to guide management interventions that reduce human-bear conflicts. Some measures/improvements based on the current study and after the evaluation of some conflict situations by visiting the rescue operations and have been made. They are:*

- 1. Black Bear-Human Conflict Database Development and Maintenance*
- 2. Creation of Conflict Management Team*
- 3. Awareness Creation*
- 4. Reducing livestock depredation by Black Bear*
- 5. Guarding of crop/orchards from black bear damage*
- 6. Monitoring of Conflict areas*
- 7. Translocation and Marking of problem bear*
- 8. Aversive Conditioning of problem bears*
- 9. Strengthening of local and traditional black bear deterrent methods*

## ORGANIZATION OF THESIS

Chapter 1 provides a general introduction of the study species and highlights the significance of the present study. It reviews the national and international studies on the related subject and culminates with objectives of the present study.

Chapter 2 describes the study area in detail.

Chapter 3 describes the general study design and research methodology for the overall study.

Chapter 4 deals with the methodology, results and discussion of Asiatic black bear abundance in the study area.

Chapter 5 presents the methodology, results and discussion of the habitat use by Asiatic black bear and the factors affecting its distribution at Dachigam National Park.

Chapter 6 deals with the methodology, results and discussion of the black bear – human interactions in Dachigam Landscape.

Chapter 7 synthesizes the study outcomes and provides some management recommendations.

The list of references and Appendices follow Chapter 7.

# CHAPTER -1: INTRODUCTION

## 1.1 General Introduction

Bears are mammals belonging to the family Ursidae and are represented by eight species worldwide. They are widespread, appearing in a wide variety of habitats throughout the Northern Hemisphere and partially in the Southern Hemisphere. Bears are distributed in more than 60 countries of North America, South America, Europe, and Asia (Servheen 1990). Out of the eight species in the world, five are distributed in Asia. India has four species of bears: the sloth bear (*Melursus ursinus*), the Asiatic black bear (*Ursus thibetanus*), the Himalayan brown bear (*Ursus arctos isabellinus*) and the sun bear (*Helarctos malayanus*).

This young family (Ursidae) evolved from smaller, tree-climbing, predatory Canid ancestors (Miacids) during late Oligocene and early Miocene about 20-25 million years ago (Cowan 1972). There are many issues with the ursid taxonomy. The recent divergence of ursids and canids make some taxonomists believe that canids and ursids should be considered as one family and dividing them is due to "custom of more than a century" (Simpson 1945). However, taxonomists have separated these two families but frequently disagree on where the line between canids and ursids should be drawn. Recently, the families Ursidae and Otariidae have been placed in the superfamily Ursoidea. These two families have been joined with members of the Canoidea superfamily, Canidae, Procyonidae, Mustelidae, and Phocidae, into the suborder Caniformia (Wozencraft 1989). However, this taxonomic approach is not widely accepted (McLellan and Reiner 1994). An urgent need subsist for establishing a robust taxonomy for the family ursidae (integrating molecular and morphological studies of geographical variation) for enhanced conservation management and action (Kitchener 2010).

Bears occupy extremely wide habitats lowland tropical rain forests along the equator, coniferous and deciduous forests, prairie grasslands, desert steppe, coastal rainforests, arctic tundra and alpine slopes. Although descended from carnivores, most of the bear species are omnivorous (except Polar bear *Ursus maritimus* which is a carnivore) in their dietary habits. Their diet varies from plant foliage, roots, and fruits; insect adults, larvae, and eggs; animal matter from carrion and predation; and fish. (Herrero 1999). The brown or grizzly bear (*Ursus arctos*), the American black

bear (*Ursus americanus*), the Asiatic black bear, the sun bear and the spectacled bear (*Tremarctos ornatus*) are dietary generalists. Much of their diet is in the form of fruits, nuts, insects, fish, carrion and mammals (Mattson 1998). The giant panda feeds exclusively on bamboo species throughout the year (Jie et al. 2000). The sloth bear is specialized feeder on insect aggregations, but also depends on fruits, honey and green plants. It has lost the first pair of inner incisor teeth thus creating a channel through which it sucks insect aggregations (Herrero 1999).

Bears have been found to be associated with human culture throughout the world. Bears are known for their physical strength and spiritual power. Numerous human cultures around the world symbolically or physically try to incorporate the power of bears into their people. This is done by worshipping bears, eating various parts of bears, wearing their claws or skins as ornaments, taming or displaying bears, photographing them, and even by doing research on them. Throughout temperate zones, the bear is a symbol of vitality and magic to aboriginal people because of its ability to apparently enter the earth each fall and be “buried” (hibernation), and to be reborn each spring after its winter internment (Herrero 1999).

In temperate and arctic portions of the northern hemisphere, most bear species hibernate during non-availability of food. The hibernation of bears is not accepted as true hibernation as the body temperature is not reduced and body functions continue to some degree compared to other hibernating creatures. Hibernation period varies across species and regions and may last for up to seven months, without the bear eating, drinking, defecating, urinating, or significantly losing bone mass (Floyd and Nelson 1990). In certain cases littering occurs during hibernation so suckling may occur (Harlow et al 2002).

Due to their sensitivity to habitat alterations, bears are considered as environmental indicators (Pelton and Beeman 1975). They are key indicators of ecosystem health wherever they are found. Their conservation will help in conserving habitats for many other important species. Unfortunately, bear numbers and range are declining in most areas of their range. Some species have been reduced in numbers by 50% or more in the past 100 years (Cowan 1972; Swenson et al. 2000).

Bears have the highest brain to body mass ratio of all carnivores (Gittleman 1986), and bear behavior is highly influenced by learning (Herrero 2002). As people

continue to live, recreate, and develop in bear habitats, the potential for bear-human conflicts increases (Peine 2001). These positive interactions in which bears gain rewards from human food sources can lead them to adapt and utilize human food sources. This behavior has the potential to perpetuate through generations resulting in conflicts with humans (Beckmann and Berger 2003). Several factors are thought to explain increases in bear-human conflicts and the spatial and temporal variability of their occurrence including: 1) an increase in human population, development, and activity into bear habitat, 2) an increase in bear numbers causing bear populations to expand their range into human development areas, and 3) natural food shortages caused by climatic patterns that result in bears searching for alternative food sources (Mattson 1990; Witmer and Whittaker 2001; Beckmann and Berger 2003; Zack et al. 2003; Huygens et al. 2003; Hwang 2003; Sathyakumar and Choudhury 2007).

## 1.2 Asiatic black bear

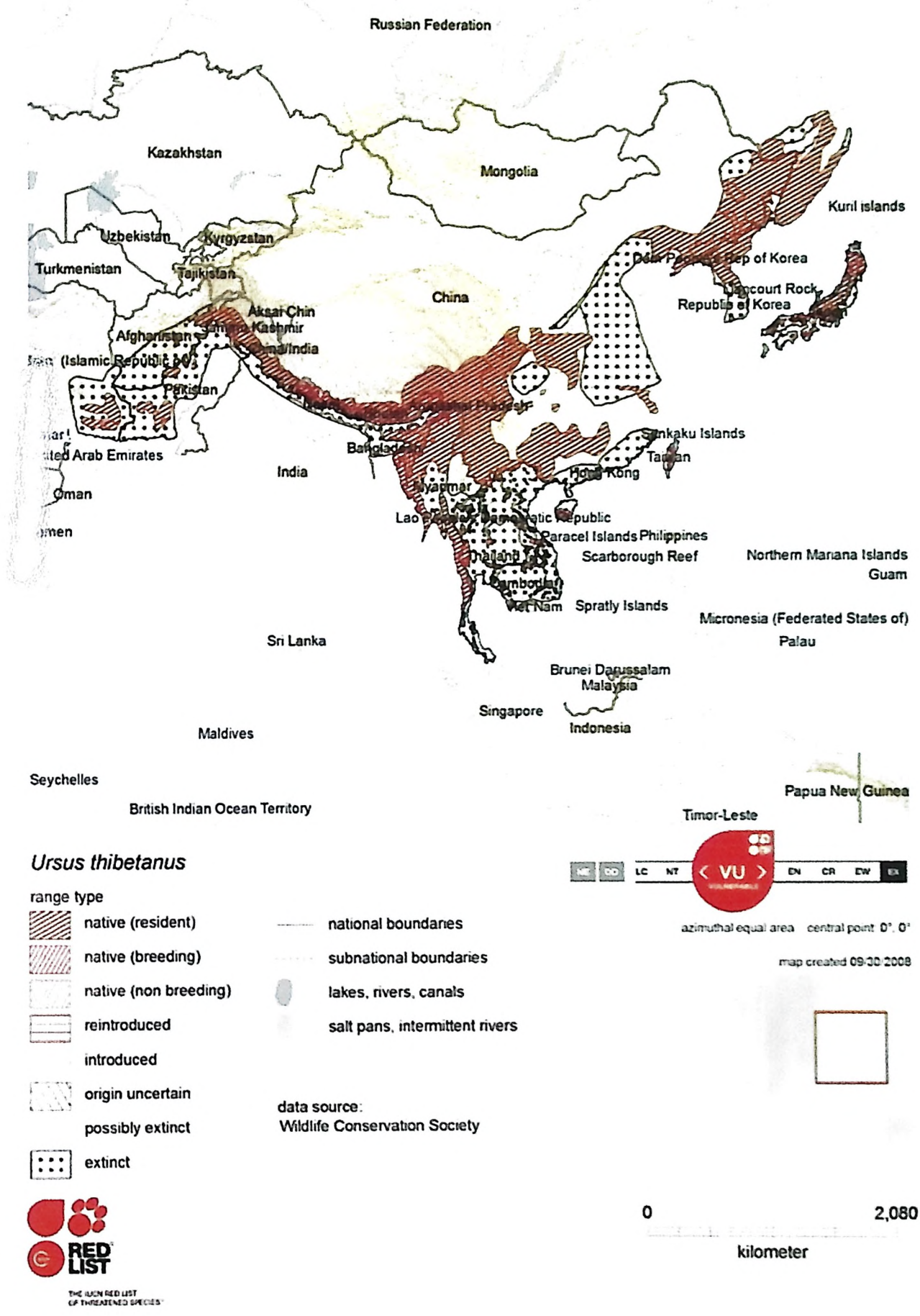
Asiatic black bears are one of the least known bear species in the world (Servheen 1990). The Asiatic Black Bear is commonly known as 'moon bear' because of the characteristic V- mark on the chest may vary from white, yellow to buff. In India they are also known as Himalayan black bear, *Kala bhalu* (Hindi), *Haput* (Kashmiri) and other names. These are big-headed mammals with large, heavily built bodies, short powerful limbs, and short tails. The body size of male is larger than female. The average weight ranges from 110-50 kg for males and 65-90 kg for females. Roberts (1977) reports exceptionally large male weighing 173 kg but that an adult female of 47 kg. According to Prater (1980) males in the autumn may scale 180 kg when fat with high feeding and the average weight ranges from 90-115 kg. The body length is 1.3 to 1.6 m and tail length is 76-106 mm. Males vary from 4ft. 8 in. to 5ft. 5in. (140-165 cm), a large male measured 6ft. 5in. (195 cm) from nose to rump. Female size is about 5 ft. 8 in. (170 cm) (Prater 1980). The coat is long and shaggy and the coloration is usually black but is sometimes reddish brown or rich brown, chin is white or buff. Its shorter smooth coat and black claws distinguish it from sloth bear (Nowak 1999). The ears are fringed with elongated hairs. Black bears have broad naked-soled feet which help them in climbing trees (Prater, 1980). They have a plantigrade walk, all the limbs have five digits and the claws are strong, recurved, black and used for tearing and digging. Their padded feet, long and powerful limbs makes them versatile climbers for getting food from trees. Asiatic black bears find

much of their food on the ground, or dig for insects below the surface of soil by using their long curved claws (Prater 1980).

Asiatic black bears occupy a variety of forested habitats, both broad-leaved and coniferous, from near sea level to an elevation of 4300m. They also infrequently use open alpine meadows. Individual bears move to different habitats and elevations seasonally (Izumiyama and Shiraishi 2004), tracking changes in food abundance. Foods include succulent vegetation (shoots, forbs and leaves) in spring, turning to insects and a variety of tree and shrub-borne fruits in summer, and finally nuts in autumn (Huygens et al. 2003) and sometimes scavenge on carcasses (Sharma 2012 unpublished). In temperate forests, Asiatic black bears rely heavily on hard mast in autumn, to accumulate sufficient fat reserves for winter denning (hibernation). Therefore, these bears tend to focus their activities in habitats with high abundance of oak acorns, beechnuts, walnuts, chestnuts, hazelnuts, or stone pine seeds (Schaller et al. 1989; Hashimoto et al. 2003; Sharma 2012 unpublished). Asiatic black bears form characteristic platform or “nest” by breaking branches and piling them up in the canopy to feed on hard mast trees. Males may socially exclude females from rich stands of hard mast (Huygens and Hayashi 2001; Hwang 2003) but such observations were not made in this study as males along with females and sometimes their cubs were observed in a feeding congregation on oak acorns (personal observation).

In northern latitudes, where food becomes unavailable in winter, both sexes hibernate. In the most northerly parts of their range, Asiatic black bears enter dens as early as October and exit as late as the end of May (Seryodkin et al. 2003). They den in rock crevices, in hollow trees or stumps, under upturned trees, in dug-out earthen dens, or in ground nests. In the tropics, Asiatic black bears generally do not hibernate, except females giving birth during winter (Hwang and Garshelis 2006). They still make use of hard mast, but additionally consume numerous species of soft fruits.

Asiatic black bears generally breed during June–July and give birth during November–March; however, timing of reproduction is not known for all portions of the range. Age of first reproduction is 4–5 years, and they normally produce litters of 1 or 2 cubs every other year (at most). Maximum lifespan is over 30 years, but average lifespan is less in the wild (IUCN 2011).



**Figure 1.1. Map showing the global distribution of Asiatic black bear.**

*Source: IUCN/SSC 2011*

### **1.3. Distribution in Asia**

The Asiatic black bear is distributed in southern and eastern Asia from westward Pakistan and Afghanistan to Baluchistan Province of Iran; east to Indo-China through much of China, Korea, and Japan, with an isolated population in Taiwan (Cowan 1972; Servheen 1990) (Fig 1.1). Schaller (1977) reported a wide distribution for Asiatic black bear from Russia and Korea to Indo-China and from the forests of the Himalayas below an altitude of 3,750 m west as far as Afghanistan and Iran. In eastern Asia, the species extends northeast through the China along the Borelnsky mountain ridge to the Baranja River (Cowan 1972). Fossil remains of the Asiatic black bear have been found as far west as Germany and France, but in historic times the species has been limited to Asia. The species now occurs very patchily through much of its former range, especially in Iran, Afghanistan, Pakistan, mainland Southeast Asia and China (IUCN 2011).

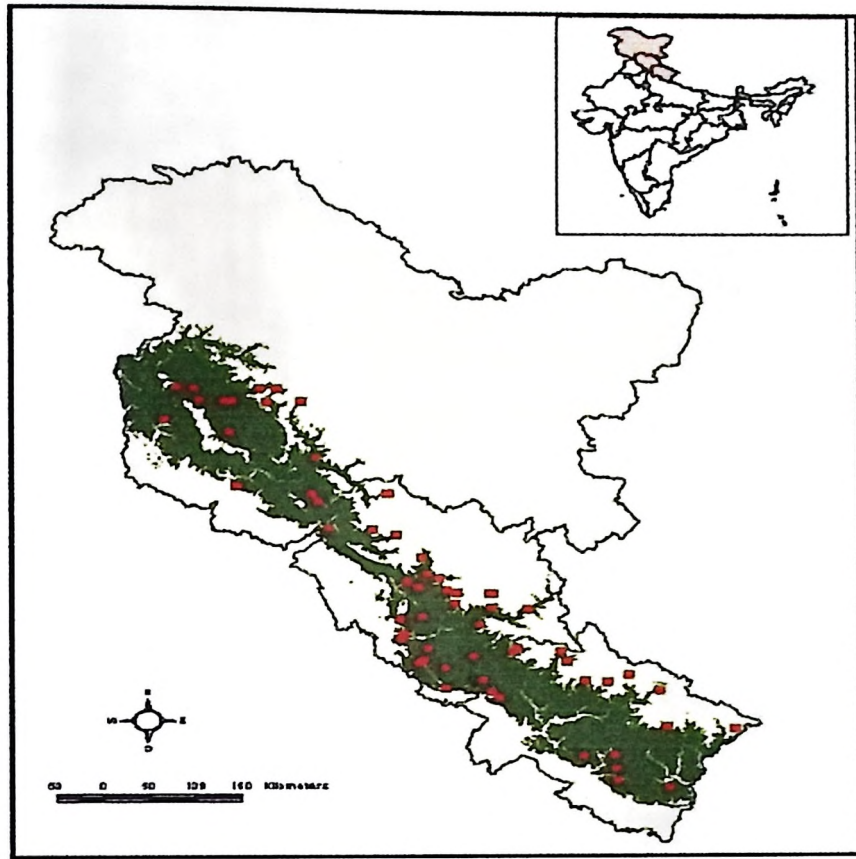
The distribution of the Asiatic black bear roughly coincides with forest distribution in southern and eastern Asia (FAO 2006), except that in central and southern India this species is replaced by the sloth bear. In southern Thailand and Malaysia it is replaced by the sun bear and north and west of the Russian Far East it is replaced by the brown bear (Tougaard 2001). However, the Asiatic black bear overlaps the ranges of each of these species, especially the sun bear in a large portion of Southeast Asia (IUCN 2011).

### **1.4 Distribution in India**

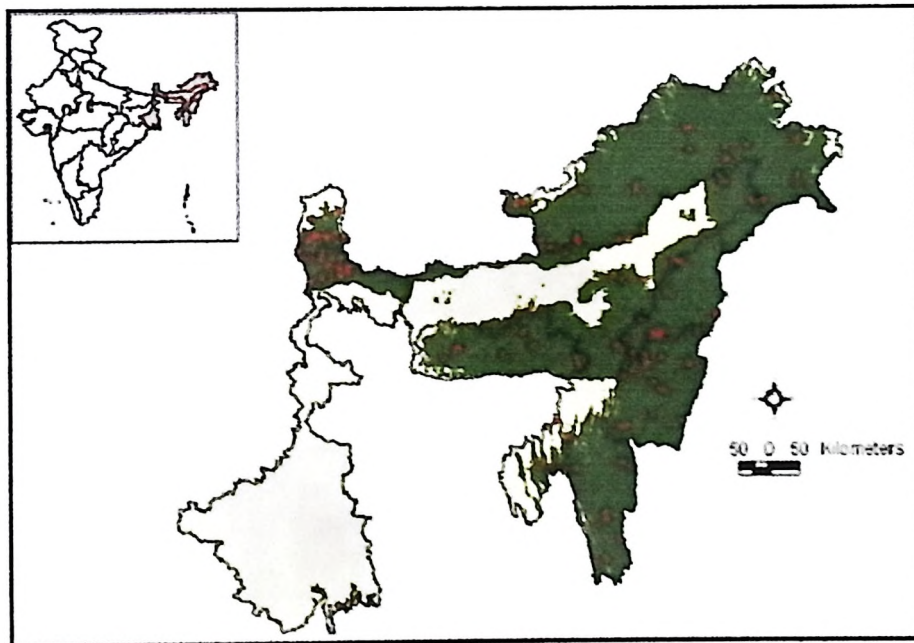
The Himalayan region covers 591,800 km<sup>2</sup> (18%) area of India (Singh 2006) and probably support one of the largest populations of Asiatic black bear (Sathyakumar 2001). In India, the Asiatic black bear inhabits forested hills ranging from 1,200m to 3,300m in the Himalayas and Northeastern hill States (70 - 4,300 m) (Fig.1.2). There is an estimated potential habitat of about 2,70,000 km<sup>2</sup> for black bears in India. Its range overlaps with that of the sloth bear below 1,200m and the Himalayan brown bear above 3,000m. The Asiatic black bear is distributed throughout the Himalayan ranges (Fig.1.2) in the northwest (Jammu and Kashmir, Himachal Pradesh), west (Himachal Pradesh and Uttarakhand), central (Sikkim and northern West Bengal) and east (Arunachal Pradesh). The species is also present in some hills of other northeastern states of India (Meghalaya, Mizoram, Tripura). Asiatic black bear distribution in the Indian subcontinent is contiguous with Nepal

(eastward from Uttarakhand to Sikkim) and Bhutan (eastward from Sikkim to Arunachal Pradesh) (Sathyakumar 2001; Sathyakumar 2006; Sathyakumar and Choudhury 2007). The use of plantations, orchards, cultivated areas, scrublands, and even villages to move between forested areas has resulted in the continuous distribution of the Asiatic black bear in North India, all along the Himalayas and hills of northeastern India (Johnsingh 2003).

Asiatic black bears are known to be fairly common in the State of Jammu and Kashmir. They have been reported to occur in 16 Protected areas (PAs) and more than 20 Forest divisions and Reserve forests. The areas with fairly common black bear population include: Dachigam National Park (Dachigam National Park), Kistwar NP, Overa-Aru wildlife sanctuary (WS), Limber WS, Lachipora WS, Thajwas WS, Pinjore FD, Naranag-Wangat FD, Tral, Shikargarh, Shar, and Daksum conservation reserves, Pahalgam and Ajas forest area (Sathyakumar and Choudhury 2007).



A



B

**Figure. 1.2. Distribution of Asiatic black bear in India  
(A -North and B -North Eastern States).**

*Source: Sathyakumar and Choudhury 2007*

## 1.5 Population

No rigorous population estimates exist for this species. Japan estimates 8–14,000 bears on Honshu Island, however, these estimates are not considered valid at present. In Russia, biologists have presented a range wide estimate of about 5-6,000, but the reliability of these is unclear (Aramilev 2006). Some crude density estimates have been made for some portions of Pakistan, and the extrapolated population for country-wide estimates the population to be about 1000 (Sheikh 2006). In China, a countrywide estimate for Asiatic black bears accounted for 5-46,000 with an official government estimate (2003) of about 28,000; none of these estimates have been substantiated (Garshelis 2002; Gong and Harris 2006),

In India, population estimates with proper methodology does not exist for Asiatic black bears but are reported to occur in 53 PAs and in 62 other localities (Sathyakumar 2001). A population of 5,400 – 6,750 black bears was estimated for India by extrapolating the densities of 1/40 km<sup>2</sup> and 1/50 km<sup>2</sup> in 270,000 km<sup>2</sup> potential habitat (Sathyakumar and Choudhury 2007)

## 1.6 Conservation status

The Asiatic black bear is totally protected throughout Southeast Asia in every range country. It is listed as ‘Vulnerable’ in the Red Data Book (IUCN 2011), in Appendix I of CITES in India since 1990 and in Schedule II of the Indian Wildlife (Protection) Act. The species is protected under Class 2 of China's Wildlife Protection Law (a limited number of permits are issued to kill nuisance animals. In South Korea Asiatic black bear is designated as a national monument (No. 329) within the Cultural Properties Protection Law and also as an Endangered Wild Animal. In Japan, this species is listed under the Law for Conservation of Endangered Species of Wild Fauna and Flora, which for trade requires certification of legal take; however, gall bladders and paws are exempted. In Myanmar, this species is classified as “normally protected”, meaning that it may be killed with a special license (although such licenses are rarely issued). In Afghanistan, it is listed as a protected species, imposing a Government ban on all hunting and trading of this species within the country. Sport hunting of Asiatic black bears is legal only in Japan and Russia (Garshelis and Steinmetz 2008).

Throughout much of the southern portion of the range of this species, efforts to reduce habitat degradation outside PAs and to increase the number and/or area of PAs would be highly beneficial. An increasing number of PAs are being established in China, India, and a few other countries within the range of Asiatic black bears (Chape *et al.* 2003), mainly to protect other species, but serving as well to increase protection for bears.

### **1.7 Major threats to Asiatic black bear**

Asiatic black bears, in most of their distributional ranges share habitats in human dominated landscapes. The major threats to black bear are loss of habitat due to excessive use of their natural habitats by humans and uncontrolled developmental activities in the bear habitats. Habitat loss due to expansion of human settlements, agricultural/horticultural areas, roadway networks, and hydro-power stations pose a serious threat to black bear survival. Other than these, hunting for skins, paws and gall bladders are the main cause of rapid depletion of population in several areas. Human-black bear interactions around black bear habitats is another limiting factor for black bears. In India, about 10% of the species range is protected within PAs, but areas outside PAs are subject to development projects and extraction of wood for fuel and livestock fodder (Sathyakumar and Choudhury 2007).

Asian bears face a combination of these threats, exacerbated by lack of knowledge about their status, distribution, and requirements for survival. The International Union for the Conservation of Nature (IUCN) Bear Specialists Group (BSG) has indicated that Asiatic black bears are at risk in many areas of Southeast Asia, and lists the initiation of surveys for their status and distribution as a priority action for bear conservation (Servheen *et al.* 1999).

In India, one of the limiting factors for black bear conservation is black bear-human interaction. Bear populations usually require large areas of land to survive. They typically compete directly with people for resources such as space, food, security and cover. Asiatic black bears are known to be involved in human attacks, crop depredation, livestock depredation (Prater 1980; Chauhan 2003; Sathyakumar 2001). Although black bear-human interactions exist since long, there is a rapid increase in reporting of these cases. Sathyakumar and Choudhury (2007) specified various possible causes for these increased incidences of human – bear interactions. In

State of Jammu and Kashmir, an increase in human – bear interactions are being reported (Choudhury et al. 2008). The most common type of interaction between humans and black bears in Dachigam Landscape, Jammu and Kashmir is crop depredation. The increase in the contacts between bears and humans during crop depredations also lead to attacks on humans (Charoo et al. 2011)

### **1.8 Present study: background and scope**

Asiatic black bear is less studied compared to its ecological counterpart American black bear. Although India Himalaya and Northeastern hill States of India possess one of the best populations of black bears, only a few short time studies exist for this species in India. The existing studies mostly account for their status and distribution (Sathyakumar 2001; Johnsingh 2003; Sathyakumar and Choudhury 2007), human – black bear conflict patterns (Chauhan 2003; Chaudhury et al. 2008) and food habit aspects (Schaller 1969; Manjeraker 1989; Sathyakumar and Vishwanath 2003). However, all these studies are either based on short surveys/studies or secondary information. There were no long term studies for this species in India prior to the present study. Asiatic black bears are declining in numbers due to increased human activities, including habitat alteration or destruction, increased human settlements, and activities such as livestock grazing in bear habitat, shifting cultivation, poaching, and retaliatory killings attributed to depredation of crops and livestock. Existing information on ecology and conflicts is insufficient to conserve and manage Asiatic black bear in Indian Himalayas. No prior study has contributed to a detailed understanding of basic ecology and population of Asiatic black bears in India. Keeping the above in view, this study was initiated at Dachigam National Park. The present study is expected to provide base line information for black bears in North Western Himalayas in general and to the Kashmir Himalayas in the State of Jammu and Kashmir in particular. The abundance estimations will be helpful in management of habitat and evaluating their need. The comparison of these estimates with the earlier ones is expected to provide information on population patterns of black bears in the study area. The habitat use patterns as discussed in the present study provides a potential to landscape planning for conservation needs of this species and other flora and fauna in general. Based on this study, a few recommendations are being made and are expected to be helpful in minimizing and

regulating human – black bear interactions in the areas around Dachigam National Park.

### **1.9 Objectives of the present study:**

The objectives of the study were as follows:

1. To estimate the abundance of Asiatic black bear in Dachigam National Park.
2. To investigate habitat occupancy patterns of Asiatic black bear in Dachigam National Park in different seasons.
3. To assess the extent and magnitude of Black bear – Human conflicts in and around Dachigam National Park and to identify causes for conflicts.

## CHAPTER – 2: THE STUDY AREA

The Himalaya, a land of Superlatives, is endowed with a variety of flora and fauna. The Indian Himalayan region ranging from Jammu and Kashmir (J&K) to Arunachal Pradesh is one of the major repositories of biodiversity (Pant 2003). It comprises of five biotic provinces *viz.* Trans- Himalaya (Cold deserts in Ladakh region of J&K, Lahaul and Spiti of Himachal Pradesh and North Sikkim), North West- Himalaya (J&K and Himachal Pradesh), Western Himalaya (Himachal Pradesh and Uttarakhand), Central Himalaya (Sikkim and Darjeeling district of West Bengal) and East Himalaya (Arunachal Pradesh) (Rodger and Panwar 1988). The present study was carried out in North West Himalaya in Kashmir region of the State of J&K, India. The study site selected was Dachigam Landscape comprising of two National Parks, two Wildlife Sanctuaries and eight Conservation Reserves. The area of Dachigam National Park is 141 km<sup>2</sup> within this the intensive study area was selected. This National Park is administratively divided into two parts: Lower Dachigam and Upper Dachigam (Fig. 2.1). These two areas also differ in altitudinal and vegetation characteristics.

### 2.1. Location

Dachigam National Park (Dachigam National Park) lies between 34° 05'N - 34° 11'N and 74 ° 54'E -75 ° 09'E in the 2A Biotic province of North West Himalaya in the State of J&K (Rodgers et al. 2000). It is located in Zabarwan mountain range of Great Himalaya, 21 km north-east to Srinagar, the summer capital of J&K State. The area of Dachigam National Park comes under the civil jurisdictions of Srinagar, Anantnag and Pulwama districts of Kashmir region of J&K (Naqash and Sharma 2011).

### 2.2. History

The name of Dachigam National Park, *Dachigam* reveals its history. '*Dachigam*' is a combination of three Kashmiri words, '*Da*' meaning 10 (ten), '*chi*' – '*are*' and *gam* – '*village*'. Before the declaration of '*Dachigam*' as a game reserve and afterwards a National Park, there were ten villages situated in this area. To declare it as a game reserve, these ten villages were translocated by Maharaja Harisingh, then the Maharaja of the State. *Dachigam* remained a game reserve (locally called '*rakh*') of the Maharaja Harisingh, from 1910 up to 1947. After this, its management was

handed over to the Department of Hospitality and Protocol (Fisheries Department, Directorate of game preservation) and subsequently to the Forest Department. It was managed under the Wildlife wing of Forest Department and later Dachigam was declared a Wildlife Sanctuary by the state of J&K, in 1951 (Holloway and Schaller 1970; Holloway and Wani 1970). Dachigam Wildlife Sanctuary was upgraded to National Park in 1981 by the government of J&K. Dachigam National Park is managed by the Department of Wildlife Protection, J&K since 1982. Dachigam National Park is now managed in IUCN category- II (National Parks).

### **2.3. Geology**

Most of the area of Dachigam National Park is mountainous. It has crystalline rocks such as granite, phyllites and schists with embedded lime stone characteristic of the core of the Zaskar range, a fold of which encloses Dachigam National Park. The region from Khanmoh to Mahadeo consists of calcareous slates, shale and blue limestone (Singh and Kachroo 1977). Most of the sediments composing these ranges have been laid from Cambrian to tertiary. The crystalline axis of the Himalayan system contains the oldest rocks and in the northern flank of these, crystalline axes are found fossiliferous sediments of marine origin (Lydekker 1876). The soil depth in Dachigam on the slope from lower to middle reaches is less than 25 cm and hence falls under the category of very shallow soils (Bhat 1985).

### **2.4. Terrain**

Dachigam National Park possesses Great Himalayan feature with steep mountains separated with deep valleys. The altitudinal gradients vary from 1600 to 5,000 m (Fig 2.2). The series of undulations present a variety of aspects (Fig 2.3) and slope (Fig 2.4) supporting an array of vegetation types (Naqash and Sharma 2011).

### **2.5. Climate**

The Kashmir valley experiences four distinct seasons: winter (December-February), spring (March-May), summer (June-August), and autumn (September-November). The climate in Dachigam National Park is sub-Mediterranean type with bixeric regime having two spells of dryness of June and September-November (Singh and Kachroo 1978). Dachigam National Park has a temperate climate with cool summer and chilling winter. The temperature recorded in summer shows a maximum and minimum mean temperature of 27.3 and 2.0°C.

The area observes irregular weather conditions with a considerable variation in the amount of precipitation. Snow is the main source of precipitation and in some parts melts till June. The annual minimum and maximum rainfall of Dachigam National Park ranges between 32 mm to 546 mm (Bhat 1985). The relative humidity is generally low during major period of the year (Naqash and Sharma 2011).

## 2.6. Water Sources

Dachigam National Park has numerous perennial streams (locally called 'nallahs'), springs, glaciers, and the main stream, *Dachigam nallah*. The main *nallah* receives water from a high altitude lake 'Marsar Lake' located in Upper Dachigam which supplies water in the area throughout the year. *Dachigam nallah* is the main source for catchment of *Dal Lake* and the Srinagar city (Naqash and Sharma 2011).

## 2.7. Vegetation

As per revised Champion and Seth (1968) classification the vegetation of Dachigam National Park is typically Himalayan moist temperate forest: subalpine forest and alpine forest type and can be classified into following forest types:

1. Moist temperate deciduous forest
2. *Parrotiopsis (pohu)* scrub forest
3. West Himalayan low level blue pine forest
4. Western mixed coniferous forest
5. Deciduous alpine scrub
6. West Himalayan sub-alpine birch-rhododendron forest
7. Dwarf juniper scrub
8. Dry temperate scrub

A detailed study on vegetation structure in lower Dachigam was carried out by Singh and Kachroo (1978). The vegetation of the valley is very patchy. The tree species such as *Ulmus wallichiana*, *Salix alba* and *Populus cilia* are found along the streams. *Prunus armeniaca* is found in open scrub areas, *Quercus robur* and *Robina pseudoacacia* in distinct pure patches which show evidence of having been planted on abandoned agricultural fields. Shrubs species are quite evenly distributed throughout the valley. Common shrub species in the lower parts of Dachigam are four species of *Prunus*, two species each of *Rubus*, *Berberis*, *Vibernum*, *Rosa*, *Indigofera* and *Parrotiopsis* (Ahmad 2006; Charoo et al. 2011). The vegetation on the southern

aspects is characterized by grassy slopes with *Prunus armeniaca*, *Rosa webbiana* and *Rubus niveus*. The *nallahs* (streams) have reasonable tree cover, including species such as *Aesculus indica* and *Juglans regia*. The northern aspects have more tree and shrub cover with species such as *Pinus griffithi*, *Aesculus indica*, *Prunus armeniaca* and *Parrotiopsis jacquemontiana* (Ahmad 2006).

## 2.8. Fauna

The Dachigam National Park supports rich faunal diversity. The animal diversity includes *Hangul* or Kashmir red deer (*Cervus elaphus hanglu*), Asiatic black bear, Brown bear, Common leopard (*Panthera pardus*), Serow (*Capricornis thar*), Kashmir grey Langur (*Semnopithecus ajax*), Kashmir Musk deer (*Moschus cuprens*), Rhesus Macaque (*Macaca mulatta*), Himalayan yellow throated marten (*Martes flavigula*), Long tailed marmot (*Marmota caudata*), Himalayan weasel (*Mustela ermania*), Red fox (*Vulpes vulpes*), Jackal (*Canis aureus*), jungle cat (*Felis chaus*), Leopard cat (*Prionailurus bengalensis*), Small Indian civet (*Viverricula indica*), Common otter (*Lutra lutra*) and Indian Porcupine (*Hystrix indica*). Serow was recorded after 20 years in Dachigam National Park during the camera trapping carried out in the present study. The first record of Small Indian civet was reported from Dachigam National Park, Kashmir valley of J&K was made during this study (Charoo et al. 2010). The avifaunal diversity of Dachigam National Park is represented by about 250 species (Naqash and Sharma 2011).

## 2.9. Surroundings of Dachigam National Park

Dachigam National Park is contiguous to many PAs in the region i.e, the City Forest National Park, Over-Aru Wildlife Sanctuary (WS), Thajwas WS and 10 Conservation Reserves viz., Brian-Nishat, Dara, Khonmoh, Khrew, Khiram, Shikargah, Wangat, Khangund, Panyer, Hajin and some parts of Sindh Forest Division. Administratively, these areas fall under the Central and South Wildlife Divisions of Kashmir region. There are about 40 revenue villages surrounding this Landscape.

The livelihood of villages is dependent on agriculture, horticulture, animal husbandry, poultry and dairy activities. The villagers in the close vicinity of the Dachigam National Park face problems such as crop depredation and livestock depredation by wild animals including Asiatic black bear. The main communities in

these villages are *Kashmiris* and *Gujars*. The *Gujar* community is the only tribal community in the area and the socio-economic condition of this community is poor (Naqash and Sharma 2011).

## **2.10 Biotic and abiotic interference**

The management of Dachigam National Park experiences various limitations. Apart from infrastructure of Wildlife Protection Department (Fig. 2.5) there are many other government department settlement in Lower Dachigam which include: Sheep breeding farm (Sheep Husbandry Department), Trout fish form (Department of Fisheries), Draphama Guest house (Department of Hospitality and Protocol), irrigation works (Department of water supplies), Flood control working Department and Power supply Department. The various activities of these departments sometimes limit the main objective of management of wildlife inside the national park.

The area which is under the biotic interference starts from the gate up to Draphama VIP guest house, most of the infrastructure of these government lies in between Dachigam gate and Draphama guest house in Lower Dachigam. In Upper Dachigam the grazing pressure is by the migratory graziers (Naqash and Sharma 2011).

## **2.11. Significance of the study area**

The significance of Dachigam National Park can be enumerated in several ways. The national park provides a natural habitat for a number of threatened and endangered species. Dachigam National Park is known worldwide for holding the viable population of the only existing red deer subspecies '*Hangul*' in Asia.

Asiatic black bear is fairly common in Dachigam National Park (Sathyakumar and Choudhary 2007) and a high density has been reported in high fruit abundance period (Saberwal 1989). Asiatic black bears are easy to sight in daytime in Dachigam National Park (Schaller 1969, Manjeraker 1989) though known to be nocturnal in behavior in other areas (Prater 1980). The areas surrounding Dachigam National Park, however, are considered as high interaction zone between Asiatic black bears and humans (Choudhury et al. 2008; Charoo et al. 2009; Charoo et al. 2011).

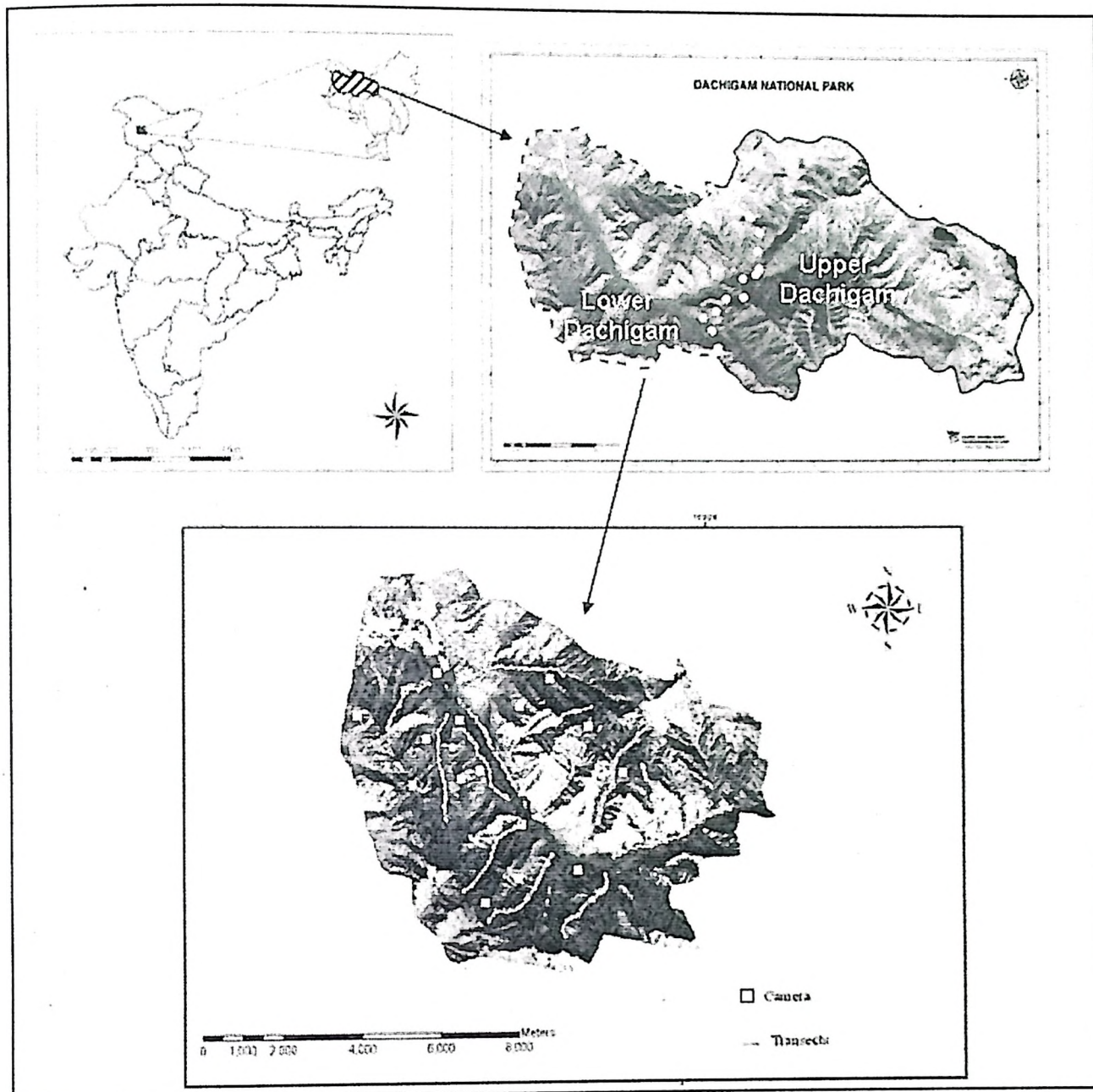
The ease in access because of being close to the Srinagar city also adds to the significance. Dachigam National Park has been a well studied area from research point of view.

## **2.12. Earlier studies in Dachigam National Park**

There have been a few studies carried out in Dachigam National Park and mostly focused on *Hangul* ecology and include: Gee (1965), Schaller (1969), Holloway (1971), Kurt (1978), Shah et al. (1984) Ahmad (2006), Shah et al. (2009), Qamar et al. (2009). Bhat (1985) studied vegetation composition of grasslands. Saberwal (1989) assessed black bear distribution and abundance. Manjeraker (1989) investigated feeding habits and habitat use of black bears. Katti (1989) evaluated bird community structure of Dachigam National Park. Iqbal et al. (2004) analyzed prey predator relationship with reference to hangul and leopard. Bhat (2009) studied bioecology of Hangul in the national park.

## **2.13 Intensive Study Area**

An intensive study area of 90 km<sup>2</sup> was selected in Lower Dachigam for the present study (Fig. 2.1). This part of Dachigam National Park represents all the major habitat types used by black bears (Plate 1). The area is accessed by a loop road on both side of *Dachigam Nallah* and connected at Pehlipora- the last point that can accessed by vehicle. The two roads are connected to main road of Harwan by gate number 1 and 2 at the entrance of the Dachigam National Park.



**Figure. 2.1. Map showing Dachigam Landscape, Dachigam National Park and intensive study area in Kashmir, J&K, India.**

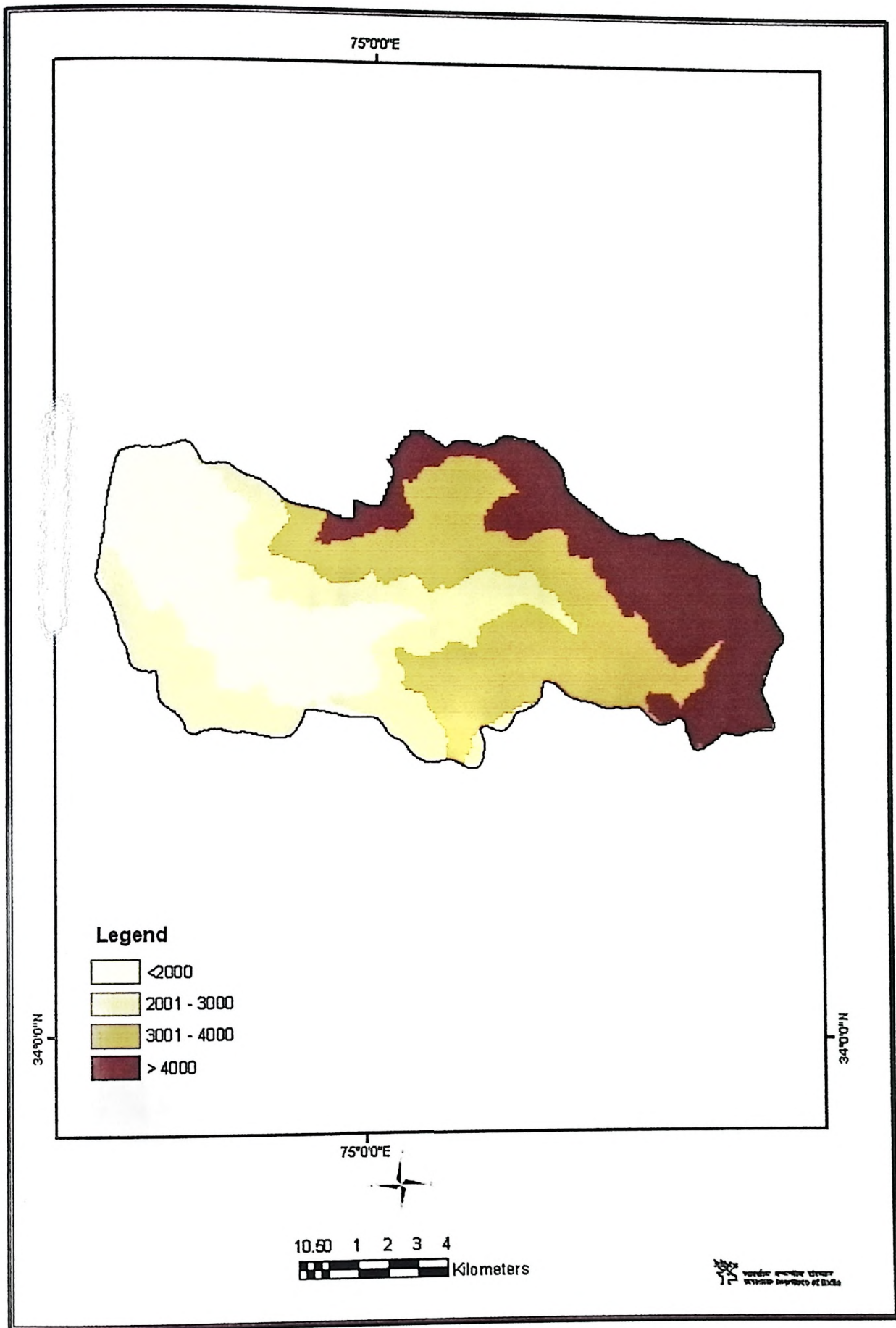
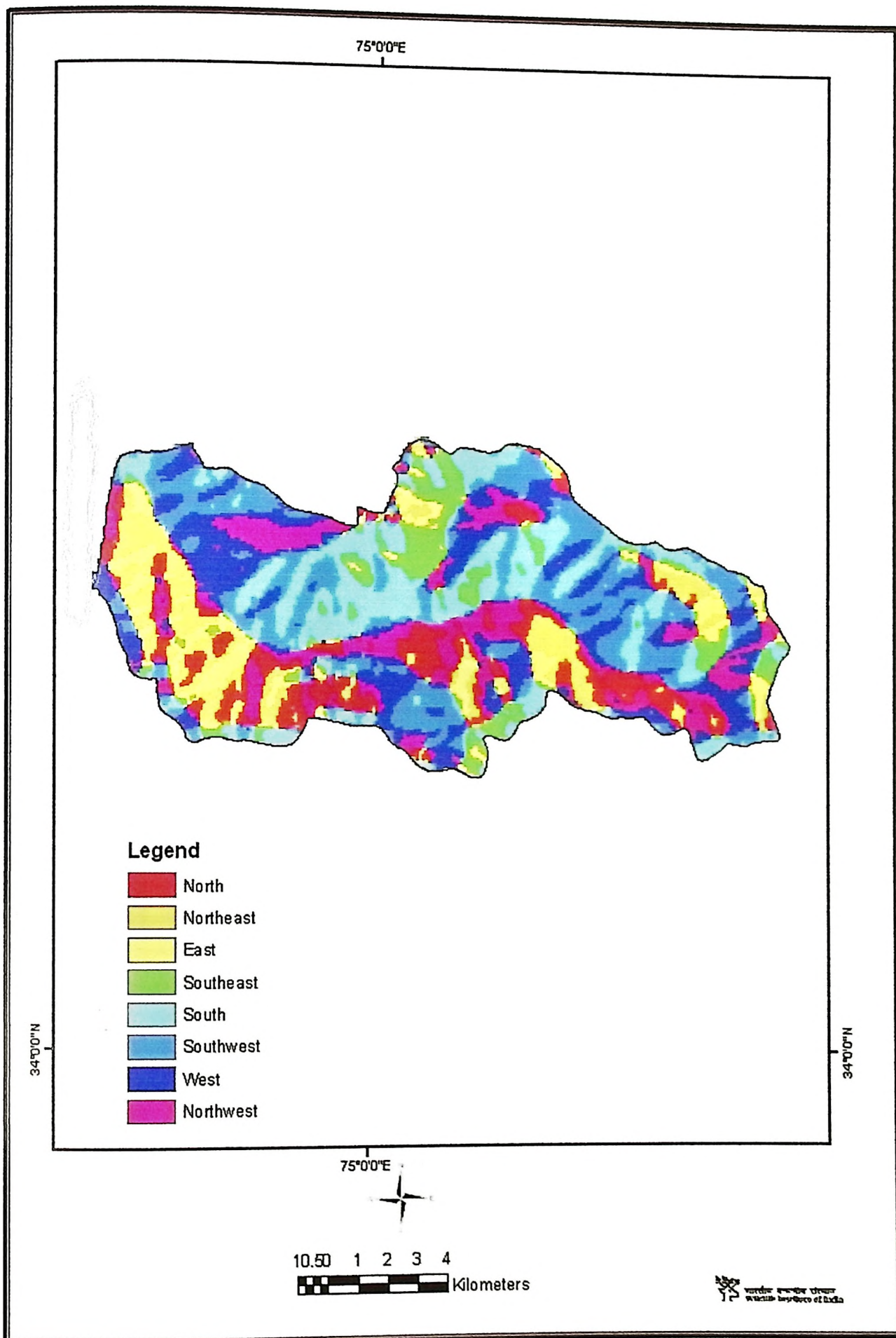


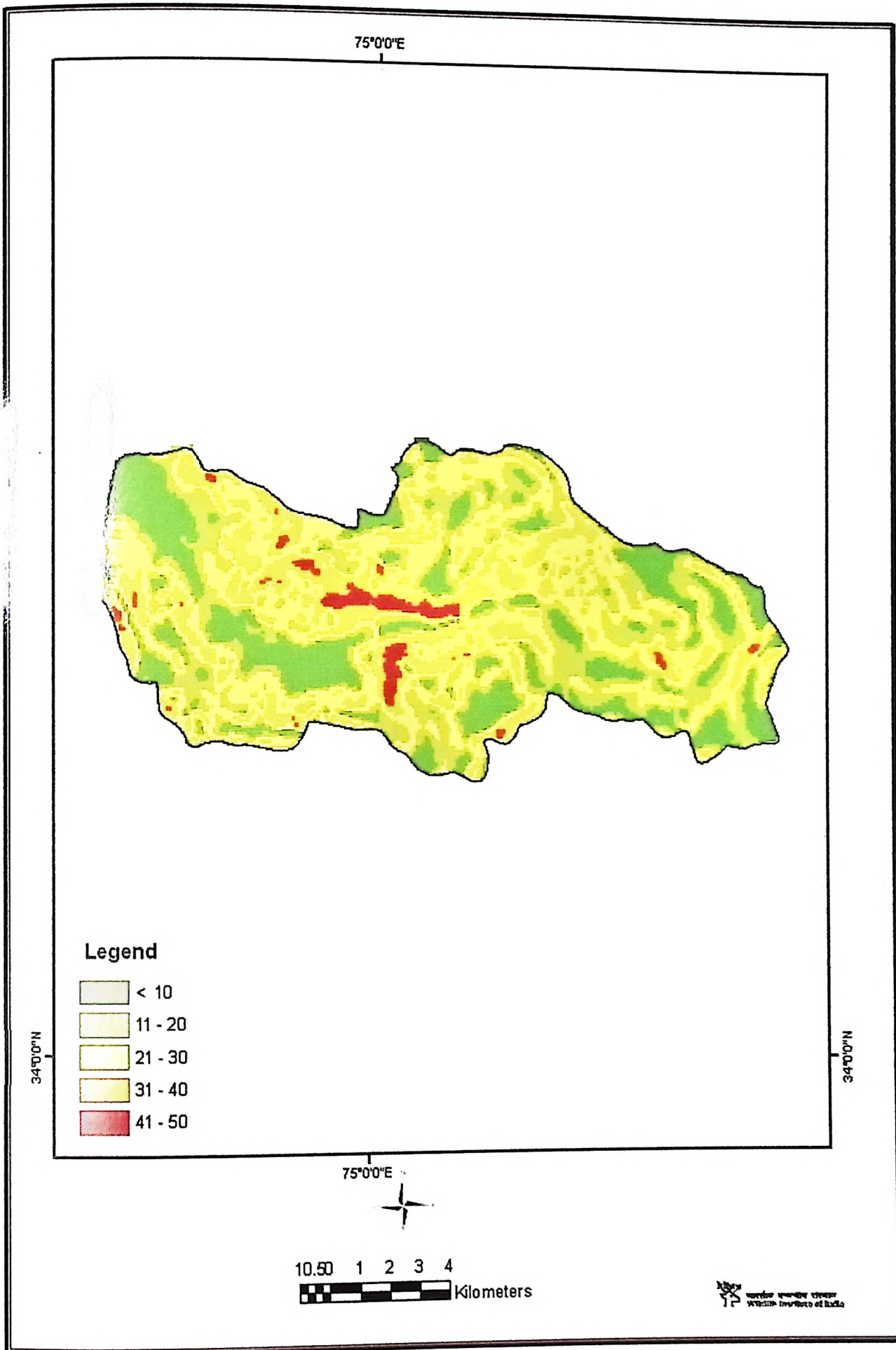
Figure 2.2. Map showing various altitudinal categories of

Dachigam National Park.

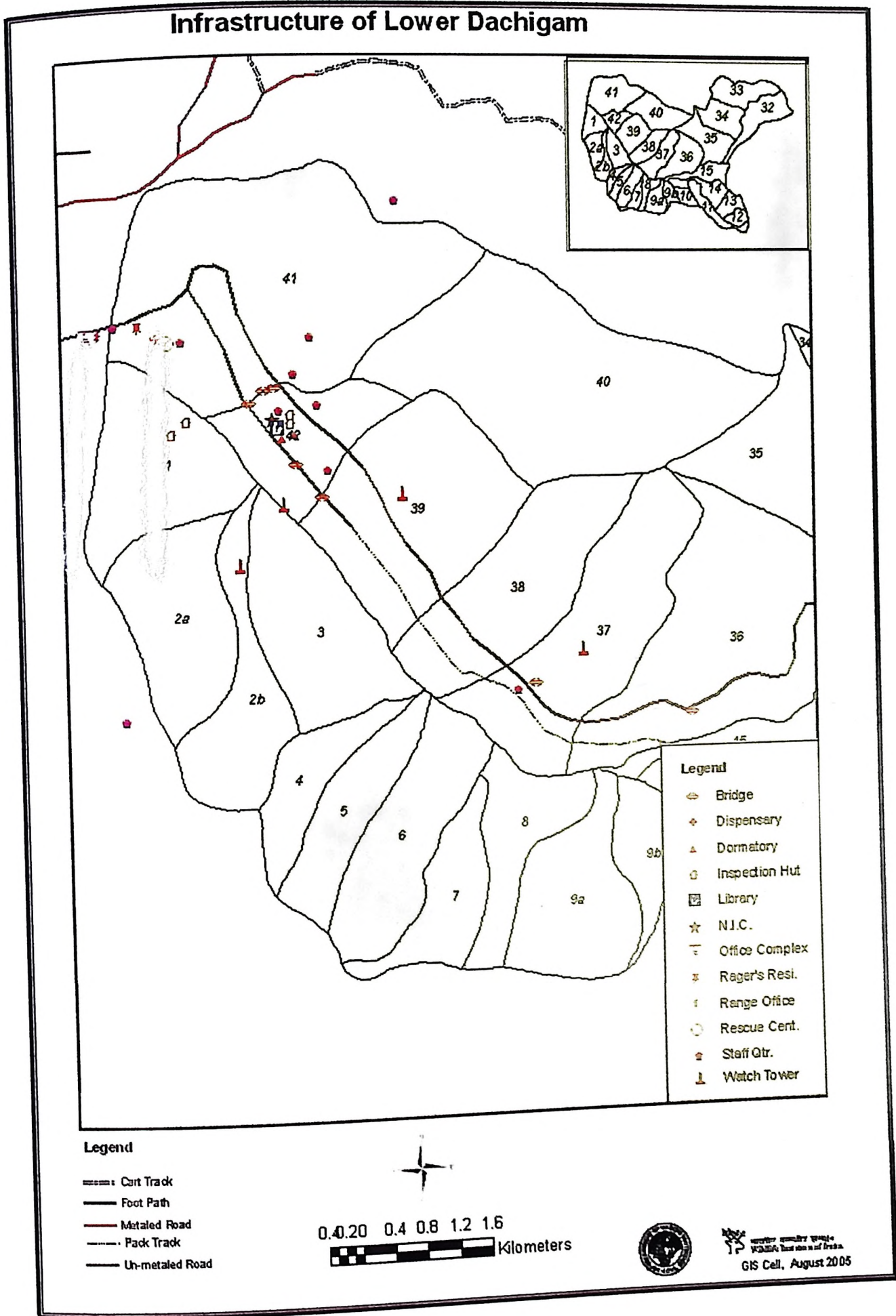
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 बतारक/Supplier  
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**Figure 2.3. Map showing various aspect categories of Dachigam National Park.**



**Figure 2.4. Map showing various slope categories of Dachigam National Park.**



**Figure 2.5. Map showing infrastructure of Lower part of Dachigam National Park.**



**Plate No. 1: Pictures showing different habitat types: (a) Pine forest (b) Oak plantation (c) Temperate grassland and scrub land (d) Mid-temperate forest in Dachigam National Park.**

## CHAPTER – 3: GENERAL METHODOLOGY

Conservation priorities and strategies are based upon understanding and assessments of general ecology of the concerned species. Mammalian carnivore study interest dates back to the origin of humans. Bears in particular have been well studied genera with methodological innovations from sign surveys (Kendall et al. 1992), satellite telemetry (Obbard et al. 2010) and genotyping studies (Wu et al. 2009). With a plentiful of literature on bear research, the present study was aimed for studying ecology of Asiatic black bears in Dachigam National Park India using modern techniques.

### **3.1. Reconnaissance and identification of the intensive and extensive study areas**

The present study was initiated in May 2007 with an aim to study abundance, habitat use patterns and black bear – human interactions in and around Dachigam National Park. The study area was surveyed for black bear signs and sightings during the reconnaissance of the study during May 2007. Based on the literature review and the field surveys, following strategy was adopted to accomplish the different objectives of this study.

First step was identification and categorization of the study area into extensive and intensive study areas (Fig. 2.1 Chapter 2). The extensive study area was defined as the peripheral areas of Dachigam landscape (~1,000 km<sup>2</sup>) that encompasses parts of Dachigam National Park, Over-Aru WS; conservation reserves (i.e., Dara, Brein Nishat, Khonmoh, Khrew, Khahgund, Shikargah, Khiram) and villages surrounding Dachigam National Park. The intensive study area was defined with much of its portion within lower part of Dachigam (as it is considered as a high density black bear area) and a minor part in upper Dachigam at Dachigam National Park. The altitudinal zones of the intensive study area ranged from 1,650 to 3,500m and this zone represented the bear habitat in the Western Himalayas (Prater 1980). The extension of this area for the intensive study was also not possible because of the logistic constraints and security concerns in the area.

### **3.2. Study design**

The most basic carnivore survey consists of surveying an area for the species occurrence. However, for population monitoring surveys have to be conducted

repeatedly (Royle and Nichols 2003). For the reliable estimates, the consistency of these surveys is a must. The information about the presence of a species is equally important as of knowing the absence of a species in an area. Regardless of the size of survey area, logic dictates that multiple sites be surveyed because the probability of detecting at least one individual will increase with the number of sites. The most conservative approach to determining the density of sites is to make sure that at least two sites are surveyed within the hypothetical home range of a species. The use of this design reduces the loss of data taking into account the inoperability of the devices/researcher bias/environmental circumstances (Long and Zielinski 2008). Considering all these, a study area was identified and the design was developed and adopted.

Most of the effort in terms of field work was carried out in the intensive study area. The intensive study area (about 90 km<sup>2</sup>) (Fig.2.1 Chapter 2) was divided into 2×2 Km grids and 23 such grids were selected for carrying out the study considering the logistic feasibility and black bear behavior. Transects/trails were laid/marked in the area representative of all the habitat types and altitudes (Fig. 3.1). For vegetation sampling circular plots (n=98) were marked after every 250 m and 23 plots along the *Dachigam Nallah* (Fig. 3.2). In each of the grids, a camera trap and a hair trap was deployed and at least one of transect was predetermined to pass through it (Fig. 3.3). Seven black bears in Dachigam National Park were captured, radio collared, released back into wild and monitored for assessing habitat use. To understand the black bear - human interaction patterns in the surrounding human habitations, semi-structured interviews were carried out in the villages surrounding Dachigam Landscape

### **3.3 Study period, logistics working schedules**

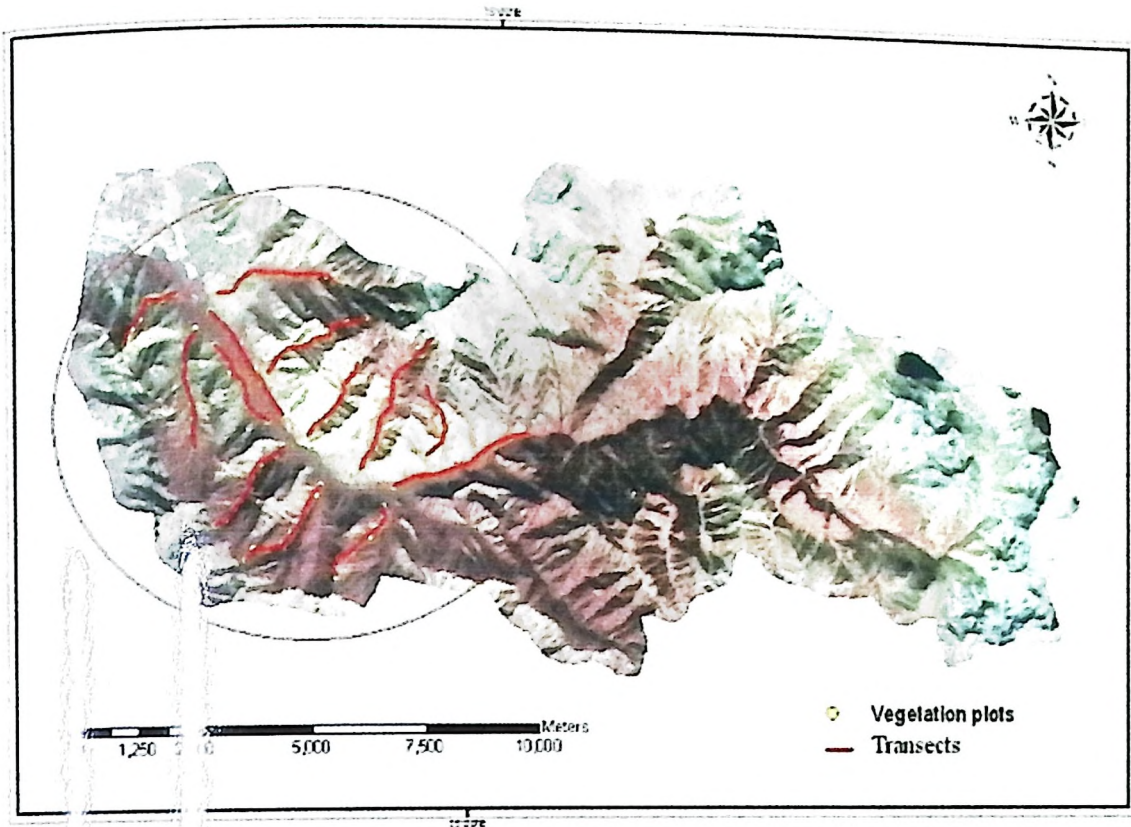
The study period extended from May 2007 to May 2011. This study was part of project, Ecology of Asiatic black bears in Dachigam National Park funded by the Wildlife Institute of India, Dehradun. The field equipments and logistic support was provided through this project. The base camp located at Harwan, about 3km from Dachigam National Park gate was hired to support the logistics during the study.

The entire (intensive) study area was systematically covered twice a month during the study period. Each transect was monitored twice a month for signs and sightings. Transect monitoring was done in the mornings. The vegetation sampling

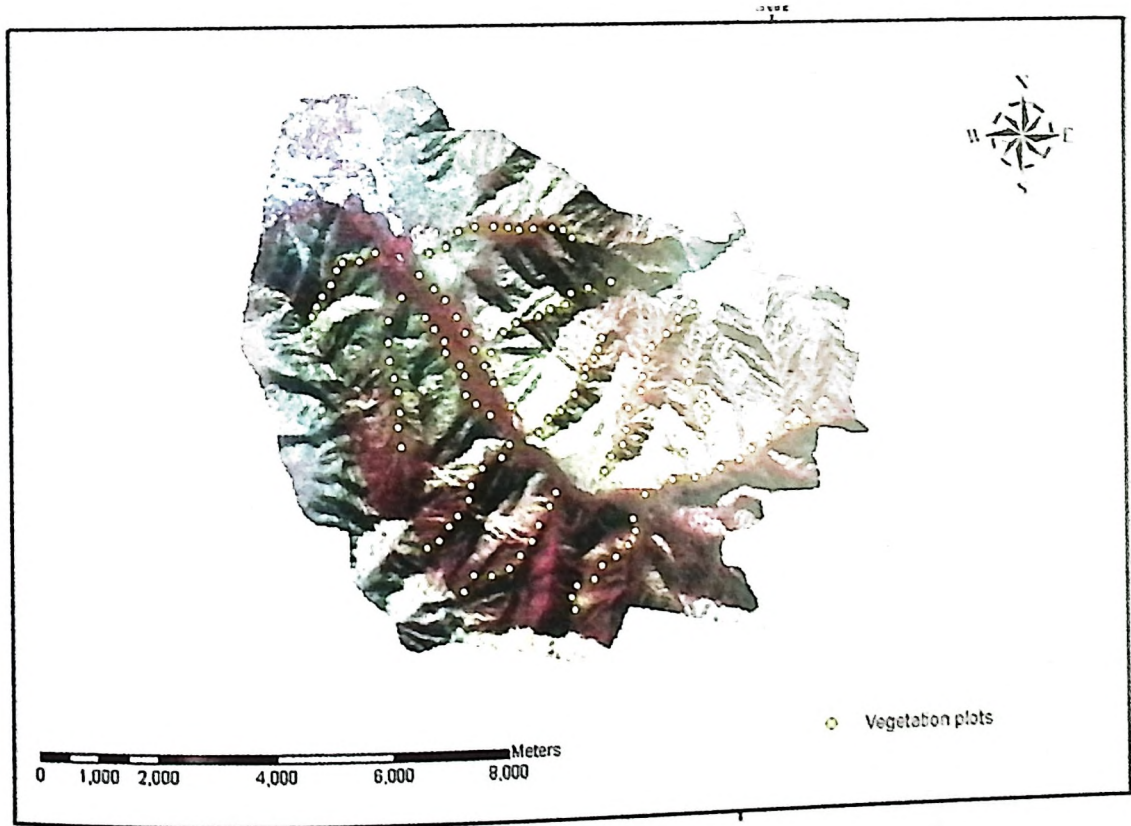
along transects and in riverine habitat was repeated twice a month. The hair traps and camera traps were checked once in three days for replacement of batteries, memory cards in camera traps, hair samples and putting in bait for hair traps. For black bear – human interaction assessment questionnaire surveys were carried out in extensive study area. For the nearby areas of the base camp 4-5 interviews per day and for areas located far from the base camp, 3-4 day were scheduled to complete interviews in 1 to 2 villages.

### **3.4 Limitations of the study**

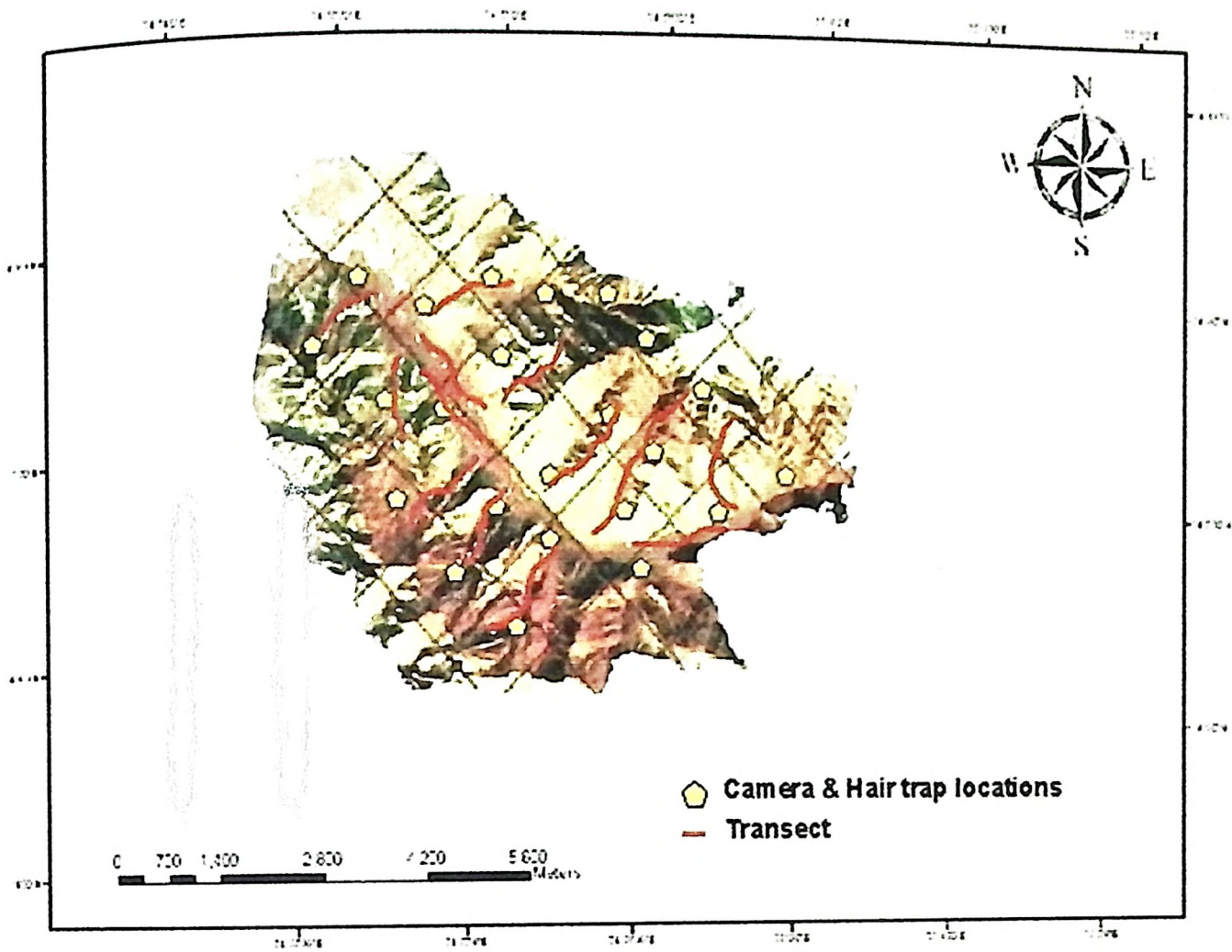
There were security concerns in the area that sometimes limited sampling and even being in the field. The security cover for VIP officials during their visit to VIP guest house located at Draphama within Dachigam National Park limited access to the field sometimes. The field work was carried out mostly trekking on foot because the motorable road only exists along the riverine valley. Some of the areas had steep slopes and rugged terrain with limited access.



**Fig. 3.1.** Map showing the locations of Transects/Trails in the intensive study area



**Figure. 3.2.** Vegetation sampling plots along transects/trails and main Dachigam *Nallah* in the study area.



**Figure. 3.3. Map showing the Camera and hair snare locations in the study area.**

# CHAPTER – 4: ABUNDANCE OF ASIATIC BLACK BEARS IN DACHIGAM NATIONAL PARK

## 4.1. Introduction

Estimating abundance and monitoring populations are important aspects of species conservation and management and a common goal in ecology (Peters 1991). The spatial and temporal patterns of abundance depict the spatio-temporal patterns of abundance and thus windows into community, ecosystem, and evolutionary processes. The information on abundance and change in abundance is important for the effective management of endangered species (Gibbs et al. 1999). A need of reliable population estimates and trends governed by effective methods to make these estimates is required for the decisions in conservation practices (Sadlier et al. 2004). This fact has been emphasized by an accelerated loss of biodiversity in recent decades which has reinforced the urgent need for monitoring programs and the necessity of studies relating habitat and species occurrence and abundance worldwide.

Large Carnivores in particular are often considered flagship, umbrella or indicator species and have been used as conservation tools for gauging and preventing loss of biodiversity (Ray 2005). Finding efficient and practical ways to acquire the information of abundance is of wide relevance and increasing urgency in view of globally declining carnivore populations (Treves and Karanth 2003) and increasing human-carnivore conflict (Charoo et al. 2011). However, this is a challenging task: carnivores are often solitary, cryptic, nocturnal, or occur at low density, making them inherently difficult and labour intensive to detect (Gompper et al. 2006; Garshelis 1999). The challenges associated with surveying carnivores necessitate methods that are effective at large spatial scales and over a broad spectrum of population densities (Zielinski 1997; Barea-Azcon et al. 2007), particularly in studies addressing landscape-scale questions such as distribution or macro-habitat associations.

Estimation of abundances for large ranging and elusive species such as bears are being explored since ages. Bear abundance is known to be difficult to estimate because of its elusive and nocturnal habits. There have been many studies involving the use of mark-recapture, most aided by telemetry, on populations of American black bears, brown bears and polar bears (*U. maritimus*) (Taylor 1994). However, such studies have been lacking for the other five species of bears due to various constraints

and perceived low densities. A number of methods have been used for abundance and density estimates of bears ranging from sign surveys (Kendall 1992), Scent station index (Lindzey et al. 1977), Capture- recapture (Hazumi 1994; Boulanger et al. 2008), direct count in post denning period (Hazumi 1994) and radio collaring (Grizzly bear inventory team 2008).

#### **4.1.1 Abundance based on sign surveys**

Bears being nocturnal and occurring at low densities, often pose difficulties in abundance estimation and population monitoring. Although various techniques are available to provide accurate estimates of abundance and density, however, logistics and funds are the main constraints that makes difficult to use these techniques. On the contrary, using of bear signs as a tool for abundance estimation has been found to be potential method (Kendall et al. 1992, Yoganand et al. 2005). Recent studies on comparative methodologies suggest sign surveys a cost effective and rapid method for estimation of animal abundance and has indicated a close fit between sign abundance and density for carnivore species (Jhala et al. 2011), despite early criticisms about accuracy (Kruuk et al. 1986). Estimates based on bear signs have been found to be related to bear densities (Garshelis et al. 1999) as well. Although quantification of bear signs is an effective tool for the monitoring of populations, however, a few assumptions need to be taken into account (Kendall et al. 1992). The studies involving comparison of recent techniques of camera capture recapture (Jhala et. 2011), spotlighting and audio playbacks (Thorn et al. 2010) have confirmed the power of sign surveys in estimating abundance for carnivores even at larger landscapes. Use of tracks to monitor and census bears has been used since long (Edwards and Green 1959). For large populations, sign and sightings are expected to provide a potential, but virtually un-tested index of bear abundance (Pelton 1972; Garshelis 1999; Yoganad et al. 2005). Signs and sightings may be used to define bear distribution (essentially presence-absence), and changes in distribution may signify changes in abundance (Rossell and Litvaitis 1991). The sightings or signs have been used to directly detect changes in bear abundance (Knight et al. 1995) or differences in bear abundance between areas (Johnson 1990).

#### 4.1.2 Non-invasive DNA technique for abundance estimation

Reliable estimates of population parameters are necessary for effective management and conservation actions. The recent advancements have led to routinely utilize genetic information in proteins and DNA to addresses questions about the behavior, ecology, life history, and evolution of bear populations. From a biological perspective, molecular genetic analyses have been utilized to uncover important characteristics of natural populations such as patterns of gene flow (Paetkau et al. 1995), reproductive success (Craighead et al. 1995), genetic diversity (Paetkau and Strobeck 1994; Paetkau et al. 1995; Waits et al. 1998), evolutionary history (Taberlet and Bouvet 1992; Waits et al. 1998) and individual identification within a population (Paetkau and Strobeck 1994; Paetkau et al. 1995).

Asiatic black bear genetics is less studied and recent. It started with a method to evaluate genetic method to study free ranging Asiatic black bears using molecular methods (Yaping 1996) and now the complete genome has been obtained (Hou et al. 2007). With the development of microsatellite markers for Asiatic black bears (Kitahara et al. 2000; Shih et al. 2009), evaluation of genetic status of Asiatic black bear population (Kim et al. 2011; Ohnishi et al. 2011) and other related aspects (Characteristic of bark stripping: Kitamura and Ohnishi 2011; Evaluation of genetic diversities: Ohnishi et al. 2007; Influence of climate on bear genetics: Ohnishi et al. 2009) has been possible.

The use of a DNA-based population census may eliminate some of the logistical barriers to estimating population numbers. The recent development of using genetic fingerprinting to estimate size of wildlife populations has provided bear biologists with a more efficient tool to estimate bear numbers than traditional mark-recapture techniques. The technique was pioneered with grizzly bears and American black bears in British Columbia (Woods et al. 1999).

Population genetics provides a finer scale perspective, requiring genetic markers of finer resolution, or greater variability, than phylogeography. Measuring levels of genetic variation is an important aspect of conservation genetics. The informativeness of such measurements is related to the variability of the genetic markers used. Microsatellites have been widespread in wildlife population genetics research (Snow and Parker 1998).

#### 4.1.3. Use of Camera trapping technique for abundance estimation

Camera-trapping has been successfully used throughout the world for studying a wide range of elusive animals when compared with more traditional methods (O'Brien et al. 2003; Sanderson and Trolle 2005; Bowkett et al. 2007; Ríos-Uzeda et al. 2007; Moruzzi et al. 2002; Carbone et al. 2001; Karanth and Nichols 1998). This technique has proven useful in providing detailed species inventories, where it has high detection efficiency and has recorded species that were otherwise undetected (Yasuda 2004; Gimán et al. 2007). Elusive species such as bears have been studied worldwide using this technique (Noyce et al. 2001). Traditional presence-absence surveys estimate the proportion of the area occupied by the species of interest within a landscape through direct field observations, often ignoring the key issues of detectability and spatial sampling and thus rendering at best a naïve estimate. A species may not be detected even when it is present and its detectability may vary from site to site. Surveys conducted over large regions are impractical to carry out unless a spatial sampling scheme is followed (Yoccoz et al. 2001).

It is not possible to identify bear individuals from photographs obtained in camera traps, so using a mark-recapture framework to determine densities, as done with tigers (Karanth and Nichols 1998), is not practical. Further, while conducting distance-sampling surveys along line Royle and Nichols (2003) have constructed a model by linking the probability of detecting presence and the abundance at a sampling unit. By using repeated detection-nondetection data gathered from occupancy surveys, they suggest a maximum likelihood approach at estimating the parameters (that includes abundance). They also emphasize that likelihood-based inference is not a small-sample procedure, and this should be considered in any study. In spite of the relative ease with which presence-absence data may be gathered, achieving large samples for analysis as suggested by Royle and Nichols (2003) for even practical estimates of the parameters might be difficult.

Bayesian approaches at parameter estimation have found themselves to be useful in a variety of ecological applications (Dennis 1996; Dixon and Ellison 1996; Ellison 1996; Hilborn and Mangel 1997) and have many strengths and limitations (Dennis 1996; Ellison 1996). Field biologists often encounter logistic difficulties that curtail them to work with very low sample sizes and yet have the need to use such information. Bayesian inferential procedures under certain circumstances better

makes use of such prior beliefs in parameter estimation. By sampling a site repeatedly for the presence-absence of a species, Royle and Nichols (2003) constructed a model that may be used to determine the abundance of a species. This is a simple model that makes use of a logical assumption that the detectability of a species is solely dependent on the abundance at that site for a given animal-specific detection probability

No rigorous population estimates exist for Asiatic black bears in India but are reported to occur in 53 protected areas (PAs) and in 62 other localities (Sathyakumar 2001). The potential range of Asiatic black bear habitat in India is estimated to be about *c.* 270,000 sq. km of which <10% is in PAs. A population of 5,400 – 6,750 individual black bears was estimated for India by extrapolating the densities of 1/40 km<sup>2</sup> and 1/50 km<sup>2</sup>. In the Indian Himalaya, the best known populations of Asiatic black bears are reported to present in the State of Jammu and Kashmir (Sathyakumar and Choudhury 2007). In the lower Dachigam area of Dachigam National Park, Saberwal (1989) reported Asiatic black bear density of 1.3 – 1.8 bears/ km<sup>2</sup>. There is no quantitative information available on abundance estimates and to indicate the changes in the population trends of Asiatic black bears in India. In the present study, the potential of using various techniques (Sign surveys, DNA based and Camera trapping) for population estimation of black bears and the effectiveness of each method was evaluated.

## **4.2 Methodology**

### **4.2.1(a) Sign surveys**

Transects and trails (n=13) were marked and monitored for signs and sightings. Transects were either routes walked along inspection trails or transects were laid through pathless areas to cover these areas. Each transect or part of transect was predetermined to pass through a sampling grid (Details in Chapter 3). The line transect method involves walking on a straight line and counting the individuals/signs on both sides of the line. It is a widely used technique for many wildlife species to get a relatively unbiased density of the population (Burnham et al. 1980; Buckland et al. 2001). In Himalayas, the straight line transects are not possible everywhere but curvilinear transects/trail sampling have been used in Himalayan terrains (Sathyakumar 1994; Ramesh 2003; Charoo et al. 2010).

Black bears leave different types of signs (Plate 2) including scats, tracks, diggings used to excavate insects, bedding sites, stone turns, bark stripping, rake marks on trees. The suitable signs which can be used as an index for bear population trend are scats, tracks and stone turns. Scats: Black bear scats are easily distinguishable by their shape, size and contents.

Tracks: these are less frequent and dependent on the substrate type and can be varying according to various habitat types.

Stone turns: are seasonal, black bears feed on insects mostly in spring and autumn seasons and are confined to areas with stones dominating in the area.

Rake marks: Bears leave rake marks on trees, particularly on pine trees. Although these rake marks can be distinguished from marks of other animals but are also seasonal in nature.

Feeding platforms: Black bears make characteristic nest or platform like stratum on tall trees to feed upon the fruits. These sites are also easily differentiated but are only active during peak fruiting season.

The marked trails and transects (n=13) were monitored for all the black bear signs and sightings twice a month and encounter rates (#/km) were calculated.

#### 4.2. 1 (b) Results

A total of 2,520 km was walked for monitoring of 13 transects from 2008 to 2010. The encounter rates of black bears varied monthly, seasonally and year wise (Fig. 4.1 and Fig. 4.2). Encounter rate was found to be highest in summer (June - August) followed by spring (March - May), autumn (September - November) and lowest during winter (December - February). The encounter rates varied across the years for each season. For spring, it was highest in 2010 ( $0.75 \pm 0.05$ ), followed by 2009 ( $0.66 \pm 0.1$ ) and least for 2008 ( $0.52 \pm 0.11$ ). For summer, year 2009 ( $1.33 \pm 0.12$ ) had maximum encounter rate followed by 2010 ( $1.06 \pm 0.09$ ) and 2008 ( $0.97 \pm 0.14$ ). In case of autumn, encounter rate was highest for 2010 ( $0.94 \pm 0.06$ ) followed by 2008 ( $0.9 \pm 0.25$ ) and 2009 ( $0.87 \pm 0.05$ ). In case of winter, it was highest in 2009 ( $0.41 \pm 0.21$ ) followed by 2008 ( $0.34 \pm 0.2$ ) and 2010 ( $0.22 \pm 0.05$ ).

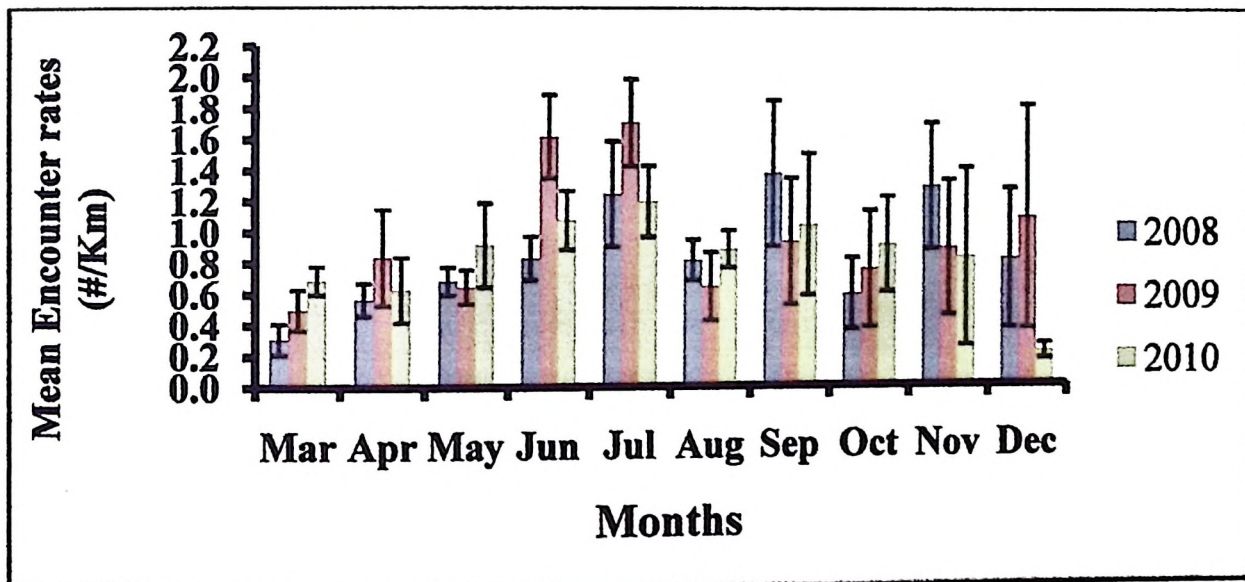


Figure. 4.1. Encounter rate (#/Km) of Asiatic black bear (month wise) based on signs and sightings in Dachigam National Park, 2007- 2010.

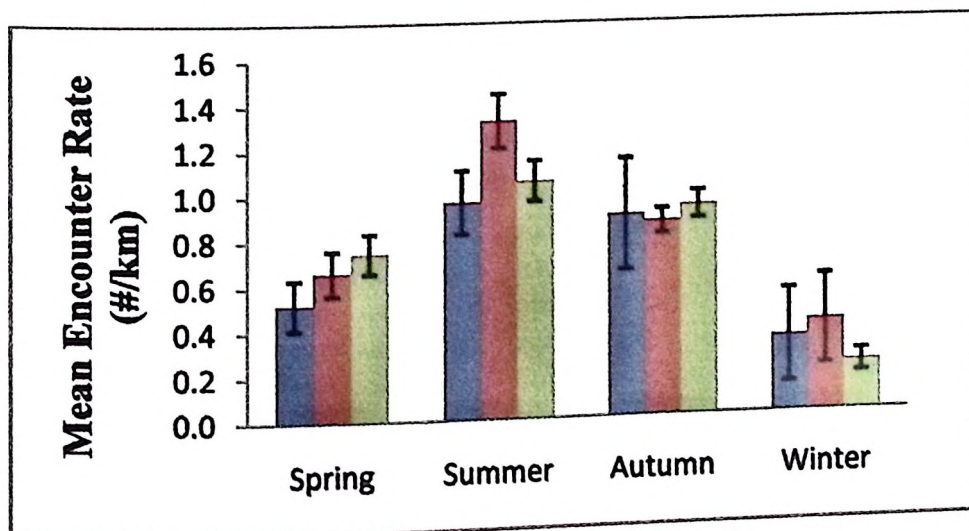


Figure. 4.2. Encounter rate (#/Km) of Asiatic black bear (season wise) based on signs and sightings in Dachigam National Park, 2007- 2010.

#### 4.2.2 DNA based

The source of DNA for population density estimation was taken in the form of black bear hair. The hair from bears was collected from hair traps placed in sampling grids systematically in Lower Dachigam National Park. The methodology involved following steps:

##### 4.2.2. a. *Field method for collection of black bear hair (DNA source):*

###### **Sample collection**

The intensive study area of 90 km<sup>2</sup> was divided into 2X2 km (n=23) grids to ensure systematic sampling. In each of these grids, a hexagonal hair trap with three layers of barbed wire tied around six poles was placed. One camera trap was placed right in front of the hair trap for monitoring. Different types of baits (maize corn, apple, fish, and rotten meat) were tried to attract bears to the trap but honey was found to be the most effective bait for black bears. The bait was kept in an earthen bowl at the center of the hair trap. Each hair trap was regularly checked after 2- 3 days for the hair captures. After sample collection the hair trap was brushed up to clear hair to avoid mixing with the new hair sample. The camera traps were run throughout spring, summer and autumn but not for winter expecting low captures because of hibernation of bears. The hair samples were collected and kept in paper envelopes separately to avoid any damage and cross contamination and then stored in 70% alcohol for further laboratory analysis.

##### 4.2.2. b. *Laboratory methods*

The laboratory process involved following steps:

###### **Isolation of DNA from hair**

The DNA isolation from the black bear hair was carried out using Qiagen DNeasy tissue kit (*Qiagen, Germany*) following the manufacturer's protocol with the recommended alterations as proposed by Thakur et al. (2011). For DNA isolation from reference blood samples, PCI protocol (Sambrook et al. 1989) was followed.

###### ***Protocol (For hair samples)***

1. The hair follicles were chopped into fine pieces and approximately 25 mg of starting material was placed in a 1.5 ml micro centrifuge tube, and an amount of 180 µl Buffer ATL was added

2. 100 mg/ml DTT solution was prepared.
3. 25  $\mu$ l DTT solution (as prepared above) and 20  $\mu$ l Proteinase - K was added and mixed by vortexing for ~15 seconds (sec.).
4. The tubes were incubated at 55°C in shaking water bath (or equivalent) until completely lysed. Lysis usually takes place in 2-3 h, but the samples were kept overnight for complete lysis.
5. The lysed samples were taken from the water bath and vortexed for 15 sec. 200  $\mu$ l Buffer AL was added to each sample and revortexed for 30 sec. The tubes were incubated at 70°C for 10 min.
6. 200  $\mu$ l EtOH (96-100%) was added to each sample, and mixed by vortexing. White precipitate may form with addition of EtOH. All the precipitate was added to a spin-column.
7. The mixture was pipette from step 6 into DNeasy spin column sitting in 2 ml collection tube and centrifuged at 8,000 rpm for 1 min. The flow-through and collection tubes were discarded.
8. DNeasy mini-columns were placed in a new 2 ml collection tube and 500  $\mu$ l buffer AW1 was added. The tubes were centrifuged at 8,000 rpm for 1 min and flow through and collection tubes were discarded.
9. DNeasy mini-columns were placed in a new 2 ml collection tube and 500  $\mu$ l buffer AW2 was added. The tubes were centrifuged at 10,000 rpm for 3 min. and flow through and collection tubes were discarded.
10. DNeasy mini-column was placed in a clean 1.5 ml microcentrifuge tube with top removed. 60- 80  $\mu$ l AE buffer was directly poured onto the membrane.
11. The tubes were incubated at room temp for 1 min and centrifuged at 10,000 rpm for 1 min to elute. The tubes were closed, labelled, and stored. If needed, a second elution was carried out using clean 1.5 ml microtube and 60  $\mu$ l buffer AE as above.

## **Quantity and quality assessment of isolated DNA**

### **Quantity assessment of isolated DNA**

DNA quantification can be done using spectrophotometric measurement of UV absorption at wavelengths 230, 260 and 280 nm. Measures of DNA purity can be determined by the  $A_{260}:A_{280}$  and  $A_{260}:A_{230}$  ratios. These ratios provide indications of

protein, and polyphenol and carbohydrate contamination, respectively. The DNA should show a clear absorbance peak at 260 nm. The  $A_{260}$  value provides a measure of concentration (roughly 1.0 reading at  $A_{260}$  is equivalent to 50 mg/ml). A pure DNA solution has an  $A_{260}:A_{280}$  ratio of  $1.8 \pm 0.1$ . The concentration of unknown double stranded DNA samples was estimated using the following formula:

---

$$\text{DNA Concentration } (\mu\text{g/ml}) = (\text{OD } 260 \times \text{dil. Factor} \times 50 \mu\text{g/ml}) / 1000$$

---

**Quality assessment of isolated DNA: It involves following steps**

**(i) Casting the gel**

1. The gel casting tray was prepared for casting the agarose gel by making it grease free using 70 % ethanol.
2. 0.8 % agarose in TBE buffer. (0.8g in 100 ml TBE buffer) was prepared and boiled in microwave oven to dissolve.
3. The agarose gel was cooled down upto  $50^{\circ}\text{C}$  and  $4\mu\text{l}/100\text{ml}$  of ethidium bromide (EtBr-20mg/ml) was added to it.
4. The comb was placed in gel casting tray and the prepared gel was poured (taking care that there is no bubble formation) into it and allowed for polymerization. The gel was 3-5 mm thick. Bubbles were removed by pocking them with the pointed end of pipette tips before the gel got polymerized.
5. After the gel had solidified, the comb was removed carefully by wriggling back and forth gently and then lifting up carefully, not rips the bottom of the well.

**(ii) Preparation and loading of samples**

6. While the gel was cooling,  $2\mu\text{l}$  of loading dye was mixed with  $2\mu\text{l}$  of each DNA sample to be loaded. Molecular size standard was also prepared by mixing  $2\mu\text{l}$  of 1 kb ladder with  $2\mu\text{l}$  of loading dye.
7. The casted gel along with the tray was inserted horizontally into the electrophoresis chamber and the top of the gel was flooded with fresh running buffer (1X TBE) to cover the gel to depth of about 1 mm.

8. The solution (DNA sample with dye) was sucked into the pipette and the tip was placed at the top of the well and gently the solution was expelled into the well.

### **(iii) Gel electrophoresis and visualization of DNA**

9. The lid and power leads were placed to the apparatus and the gel was electrophorised at 100 volts for 30-60 minutes or till the tracking dye reaches up to three-fourth of the way across the gel.
10. The DNA bands were visualized by placing the tray onto High Performance UV Transilluminator and photographed using gel documentation system.

### **Selection of microsatellite markers**

A set of 20 microsatellites were selected based on the degree of polymorphism and their wide coverage on the genome (Kitahara et al. 2000; Bellemaina et al. 2007; Shih et al. 2009) (Appendix 1). The selected primers were synthesized and forward primer of each marker was labelled with one of the fluorescent dyes (FAM, VIC, PET, NED) at the 5' end.

### **Polymerase Chain Reaction (PCR)**

Initial standardizations of PCR cycling conditions were attempted with reference samples and then the similar conditions were followed for amplification of microsatellites with DNA extracted from hair samples. The standardized combinations of microsatellite loci were pooled to get high throughput genotyping and successfully six multiplex PCRs were generated (Table 4.1).

Following Qiagen (Mainz, Germany) Multiplex PCR kit, PCR reactions were set up in a 15  $\mu\text{L}$  of reaction volume containing 7.5  $\mu\text{L}$  of 2 $\times$  Qiagen Multiplex PCR Master mix, 0.50  $\mu\text{L}$  of 10  $\mu\text{M}$  of each primer pair (3.0  $\mu\text{L}$  for six loci), 1  $\mu\text{L}$  of DNA elutant ( $\sim$  20 ng) and 3.5  $\mu\text{L}$  of RNase-free water. The amplification conditions were 15 min initial heat activation of Hot Start (Mainz, Germany) *Taq* DNA polymerase at 95°C, followed by 35 cycles of denaturation at 94°C for 30 s, annealing at specific temperature (Table 4.1) for 90 s and extension at 72°C for 60 s with a final extension at 60°C for 30 min. Amplification was checked on 2% agarose gel.

Scoring of allele was performed using Gene Mapper software (version 3.7, Applied Biosystem). All the samples were genotyped twice to get the confident allelic data. Duplicate genotyping was carried out for the samples which did not produce band and

the genotype in the first PCR and capillary electrophoresis. The duplicate genotype data was considered for further analysis to minimize the genotyping errors *i.e.* the issues of allele drop out and scoring of false alleles.

#### **4.2.2. c. Statistical analysis**

Typographic errors and frequency of the occurrence of null alleles for each locus was tested using the computer program MICROCHECKER version 2.2 (Van-Oosterhout, 2004). Multi-locus genotype data was used in identification of the unique individuals in the dataset of 56 samples using GENEALEX version 6.41 software (Peakall et al. 2006) and a unique genotype ID was given to the each identified individual. Genetic diversity estimates *i.e.* observed ( $N_a$ ) and effective number of alleles ( $N_e$ ), inbreeding coefficient, observed ( $H_o$ ) and expected heterozygosity ( $H_e$ ) were performed using GENEALEX version 6.41 software (Peakall *et al.* 2006). Polymorphic information content (PIC), a measure of marker's informativeness was calculated using CERVUS version 3.0 (Kalinowski et al. 2007). Deviation of loci from Hardy–Weinberg equilibrium (HWE) was estimated using Chi square test as implemented GENEALEX version 6.41 software (Peakall et al. 2006). The genealogical relationship between the identified individuals of unknown ancestry was estimated using maximum likelihood method as implemented in ML-RELATE computer program (Kalinowski et al. 2006).

#### **4.2.3 Results**

A total of 120 samples collected in the summer months (May- July) were used for this analysis. DNA was extracted from all of these hair samples and were tried to amplify on the 20 selected microsatellite markers. Out of 20 microsatellites, 3 loci (G10H, MSUT3 and UT 23) did not amplify and four loci showed low success rate *i.e.* UT 29 (77.78%), MSUT 5 (72.22%), UT 31 (38.89%) and UT 3 (44.44%) (Fig. 4.3). Therefore, data generated from these loci was excluded and data from those microsatellites producing high success rate (>95%) was subjected for further analysis for individual identification and density estimates.

#### **Identification of individuals through multi-locus genotyping**

Each sample was genotyped twice to minimize the genotyping errors for individual identification. Only those samples were considered for individual identification that produced identical genotypes in duplicate genotyping. Few samples were repeated as they did not produce the identical genotypes in first run. It started

with 80 hair samples and 24 samples did not amplify at all. This occurred as the starting material was low (because of less hairs or hairs without root) and seven hair samples did not produce identical genotypes even after repeating thrice. In total 49 hair samples were genotyped, that produced identical genotypes in duplicate genotyping and 18 unique genotypes were identified in a pool of 49 genotypes (Table 4.2). All the genotypes except ABB 7, ABB 11 & ABB 17 were recaptured and genotype ABB 7 was recaptured as maximum as 6 times in the genotype data of 49 samples. A graph was plotted between matching genotype verses unique genotypes with increasing locus combination and was found that a combination of five or more loci are necessary to get the unique genotype Using a single locus MSUT 2, we found that the 9 individuals were of unique genotypes while other 9 individuals were of similar genotypes. On increasing the locus combination as maximum as five (MSUT 2+MSUT 7+UT 4+UT 36+G10J), all the 18 genotypes were become unique and there was no matching genotype. No unique genotype was captured on further increasing the loci combination and therefore, we conclude a combination of 5 loci was required to identify the unique genotypes (Fig. 4.4).

#### **Genetic diversity estimates**

All the 13 loci showed enough polymorphism in the population of Asiatic black bear in Dachigam National Park and the summary of the diversity measures are presented in Table 4.3. Altogether, 85 different alleles were found across 13 loci. The number of observed alleles ranged from 3 (UT36) to 9 (MSUT 2 & G10J), with overall mean number of alleles per locus of  $6.53 (\pm 1.89)$ . The observed number of alleles for all loci exceeded the effective number of alleles, which varied from 1.55 (MSUT 1) to 6.35 (UT 38) with mean  $4.04 \pm 1.63$ . Observed ( $H_o$ ) and expected heterozygosity ( $H_e$ ) ranged from 0.188 (MSUT 1) to 0.94 (MSUT 8 & UT35) and from 0.36 (MSUT 1) and 0.84 (MSUT 2 & UT 38), respectively. The  $H_e$  values were higher than  $H_o$  values for all the 13 loci with no exception. PIC ranged from 0.34 to 0.82 with an average of 0.66. PIC value for loci UT 36 and MSUT 1 was lower than 0.5 while 11 loci showed PIC higher than 0.5 which is normally considered as informative in population genetic studies (Botstein et al. 1980) and therefore, the microsatellite markers for the present study were chosen correctly and could be employed for further genetic studies on black bears. Few loci (MSUT 7, MSUT 6, UT 1 & MSUT 1) showed considerable inbreeding estimates but the black bear

population did not show any inbreeding as mean FIS estimates (0.09) did differ significantly from zero. Seven of the 13 loci confirmed to HWE ( $P > 0.05$ ) while six loci (MSUT 7, UT 4, MSUT 6, UT 1, UT 35 and MSUT 1) deviated significantly from HWE ( $P < 0.05$ ). Out of the 6 loci that deviated from HWE, 4 loci (MSUT 7, MSUT 6, UT 1 and MSUT 1) showed significant null allele estimates, therefore, this could be one of the reasons from departure from HWE equation the

The density of black bear as proposed by capture recapture model could not be estimated because of the low sample size. Based on this study, however, it has been proven that appropriate number of samples can lead to density estimates for a species like black bear.

Table. 4.1. Six multiplex panels of twenty microsatellite markers used for analysis.

Multiplex(MP)	Loci name	Dye	Size range	Ta
MP 1	MSUT 2	FAM	77-91	50
	MSUT 5	PET	167-171	50
	MSUT 6	VIC	183-193	50
	MSUT 8	NED	106-110	50
MP 2	UT4	FAM	157-182	56
	G10J	VIC	80-88	56
	G10H	PET	241-249	56
	MSUT 1	NED	170-174	56
	UT3	NED	256-282	56
MP 3	UT29	FAM	204-236	64
	UT1	VIC	176-192	64
	UT31	PET	315-369	64
	UT23	NED	349-382	64
MP 4	MSUT 4	PET	85-101	44
	MSUT 7	FAM	114-116	44
MP 5	UT36	FAM	276-309	62
	UT35	VIC	218-247	62
	UT25	VIC	314-333	62
MP 6	MSUT 3	PET	220-222	55
	UT38	NED	196-232	55

Table 4.2. Identification of unique individuals using multi-locus genotype data

Sample ID	Unique Genotype ID	Tag
MT 229	6969110116153169289289929417117121021420621032223468999118118168168186194g	ABB 1
MT 111	697711411615316128928982921711711901902062103183228997108128168168190202g	ABB 2
MT 118	697711611615315328928988901731731861862022103183228797108114168168194194g	ABB 3
MT 231	697910811414916128928980821731732062142022103303508993108118152176182190g	ABB 4
MT 230	697910811414916128928982881731732062142022103303508993108118176176182190g	ABB 5
MT 116	698311411415316128928982901711712102142022103183468793112118168168186194g	ABB 6
MT 130	69851141181531532892938080175175178178202206318318879900168168202202g	ABB 7
MT 124	698911611615316128929780941671672142142022103183468797108120168168198210g	ABB 8
MT 129	717511611614915328928978821731731782142102103183188795108114160168182198g	ABB 9
MT 232	717710811215316129329782901712071781782062183303348791108120160170186190g	ABB 10
MT 101	717711611615716929329790921812071781782062183303308793108120168168186230g	ABB 11
MT 119	71791141141531532892898290001861862022103183468793108128168168194202g	ABB 12
MT 120	718311411415316128928982901611752142142022103303468793110128168168190230g	ABB 13
MT 123	71851161161531612892938080169207214214202210326330939310811416816800g	ABB 14
MT 115	738311411415316128928968821711711782142022103183468993110128168168230230g	ABB 15
MT 122	738311411415316128928982901711711782142022103463468793110128168168230230g	ABB 16
MT 125	73831141141571692892899294171207178214206210346346879310811000190190g	ABB 17
MT 114	83831161161531612892937480167167214214202210326330919114122168168190194g	ABB 18

Table 4.3. Genetic diversity estimates of Asiatic black bear population at Dachigam National Park

Locus	Na	Ne	Ho	He	PIC	FIS	HWE (P-value)	Null allele frequencies
MSUT 2	9.00	6.29	0.89	0.84	0.82	-0.057	0.586	0.00
MSUT 7	6.00	2.79	0.33	0.64	0.58	0.481	0.046*	0.19†
UT 4	5.00	3.00	0.83	0.67	0.61	-0.250	0.001*	0.00
UT 36	3.00	1.58	0.33	0.37	0.34	0.096	0.056	0.03
G10J	9.00	5.64	0.89	0.82	0.80	-0.081	0.571	0.00
MSUT 6	8.00	4.59	0.29	0.78	0.75	0.624	0.000*	0.36†
UT 1	6.00	3.38	0.44	0.70	0.66	0.368	0.000*	0.15†
UT 35	4.00	2.95	0.94	0.66	0.60	-0.430	0.002*	0.00
UT 25	7.00	4.60	0.72	0.78	0.75	0.077	0.313	0.03
MSUT 4	7.00	4.47	0.89	0.78	0.74	-0.145	0.315	0.00
MSUT 8	8.00	5.40	0.94	0.82	0.79	-0.155	0.093	0.07
MSUT 1	5.00	1.55	0.18	0.36	0.34	0.505	0.000*	0.27†
UT 38	8.00	6.35	0.71	0.84	0.82	0.162	0.096	0.65
Mean (SE)	6.53± 1.89	4.04±1.63	0.64±0.28	0.67±0.16	0.66±0.16	0.09		

Na- Observed number of alleles; Ne- Effective number of alleles; Ho- Observed heterozygosity; He-Expected heterozygosity; PIC-Polymorphic Information Content; HWE-Hardy-Weinberg Equilibrium; \*Departure from HWE ( $P < 0.05$ ); †null alleles present; and frequency predicted as proposed by Chakraborty et al., 1992, Brookfield 2 et al., 1996.

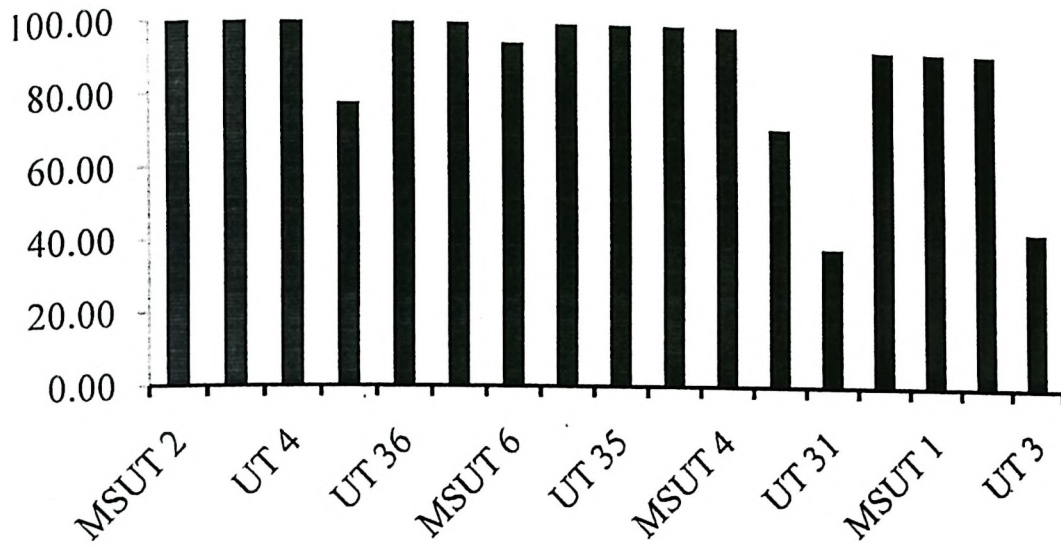


Figure 4.3. Microsatellites amplification success rate with Asiatic black bear DNA samples.

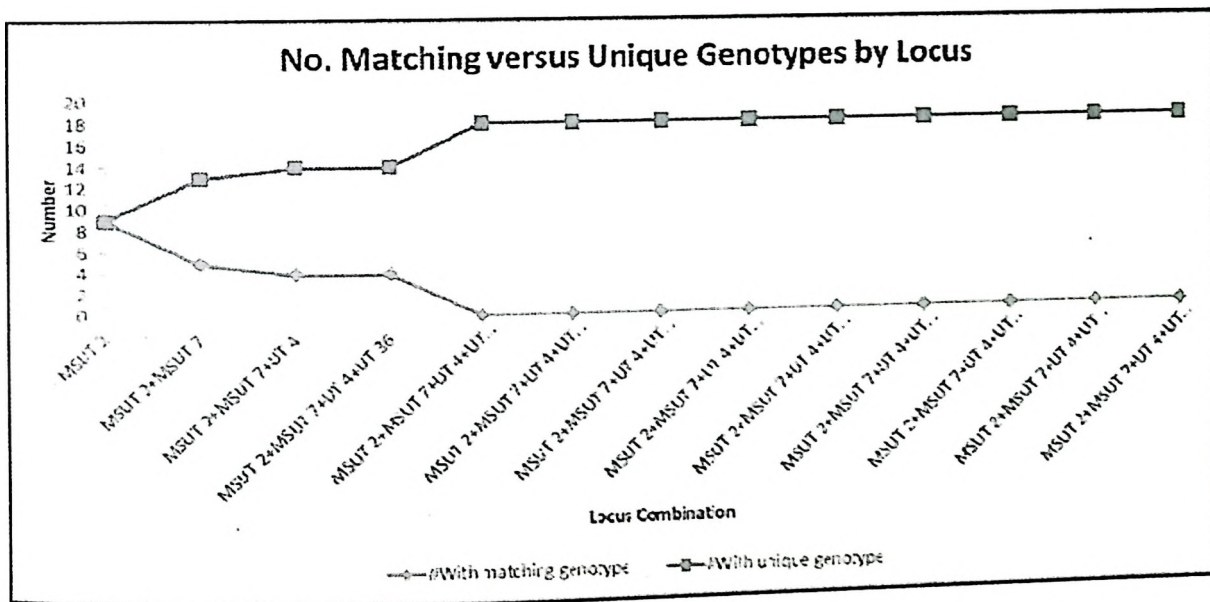


Figure 4.4. Identification of unique genotypes with increasing locus combination

### 4.3 Occupancy based abundance estimation

The study area (90 Km<sup>2</sup>) was divided into 2X2 Km grids and in each grid a camera trap was placed. The field method has been discussed in Chapter 3.

#### 4.3.1 Royle and Nichols (2003) Model Method

Occupancy surveys that are described in MacKenzie et al. (2002) and Royle and Nichols (2003) use sample units as “sites”. Implicitly, it is assumed that each site is independent and no animal will move between sites during the survey period. Unless the movement of animals is very small compared to the selected cell size, setting up a grid system and using these models for adjacent cells will violate the assumption of independence between sites. Thus, using these models for a species that ranges widely like that of black bears can provide results difficult to interpret. To minimize the size of sites based on different possibilities of home range size and to maintain the assumption of independence of abundance between sites, the two adjacent sites were joined together for analysis. The minimum home range size of black bears within the particular season in the area based on radio collaring information was estimated 8 Km<sup>2</sup> (Sharma et al. 2010).

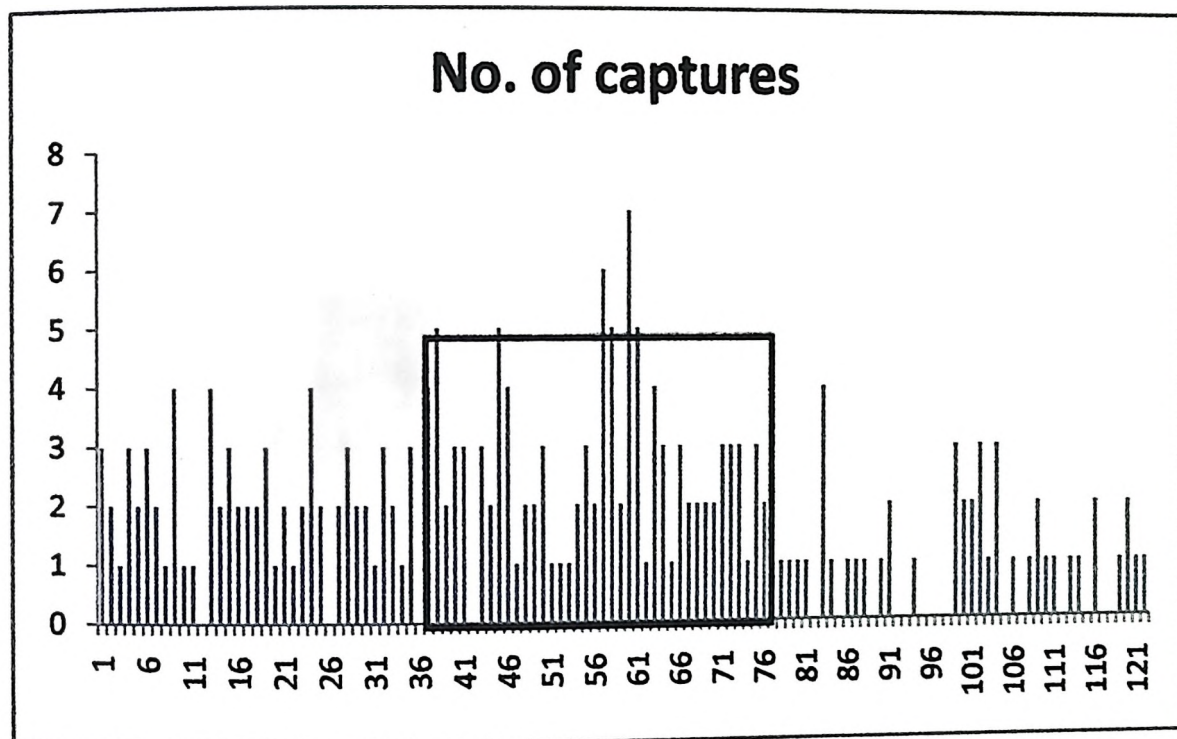
Royle and Nichols (2003) suggest building up capture histories by sites based on captures and recaptures of the species in concern on repeated visits. Since bears move widely, it is not likely that a bear captured at a given camera trap location will be caught at that same location with the same probability over subsequent camera trap nights. In the present case the temporal replicates as suggested in Royle & Nichols (2003) are substituted with spatial replicates so as to assume that all bears have an equal animal-specific detection probability.

In this arrangement, a camera-trap location is said to have detected bear presence if a bear is captured at that site on any single trap night over all the sampling nights.

A capture matrix incorporating such an arrangement built up for the analysis is as:

Sites	Captures at sites						
Site 1	0	1	0	0	0	1	1
Site 2	0	0	0	0	0	0	0
Site 3	0	0	0	1	0	0	0

The black bears in Dachigam National Park were mostly encountered in summer months. Taking into account the population closure assumption, bear population seems static in these summer months as revealed by sign survey data also (refer to earlier part of this chapter 4.1.3). The sampling record at each site was divided into five consecutive 5-day segments based on the date stamp on the photographs. A detection matrix of each species was established following the approach proposed by MacKenzie et al. (2002). The occasions where high detection of bears (high) was found was used for analysis (Fig.4.5).



**Figure 4.5. Total number of captures vs number of occasions, the highlighted part shows the duration of maximum captures.**

The data was analyzed using Program PRESENCE version 2.0 (<http://www.mbr-pwrc.usgs.gov/software/presence/>).

The Royle and Nichols (2003) model is as follows:

$$p_i = 1 - (1 - r)^{N_i} \quad (2-1)$$

Here  $p_i$  is the probability of detecting at least one animal within the site  $i$ .

$r$  is the probability of an animal being detected in site  $i$ .

$N_i$  is the actual animal abundance at site  $i$ .

To characterize the underlying estimation of abundances, the Poisson model can be a good starting point as it arises under a random distribution of animals in space (Royle and Dorazio 2006). Using this model for abundance estimation, the final

likelihood equation to estimate parameters (mean abundance at site and animal specific detection probability) is as follows:

Where,  $R$  is the number of sites,

$T$  is the number of repeated samples,

$w$  is the detection vector of the total number of detections from each site  $i$ , i.e. a vector of all the individual site-specific detections,  $w_i$  and  $\lambda$  is the expected abundance at each site, also the Poisson mean.

#### 4.3.2 Photo capture rate

Capture histories were recorded for each site. The camera traps were run on 24 hr (day - night) period and this period was considered as one trap night. The photo capture rate (#/100 trap nights) was calculated for each site (Carbone et al. 2001). The cameras were considered functional even if their position got changed because of animal movement or other factors. Change in field view of the capture did not affect the response variable estimate as it was independent on the individual identification of black bears. At some sites the cameras stopped functioning because of technical faults/drained batteries, animal movement and in some cases displaced by humans. In such cases the non- functional days were considered after the last capture at that site.

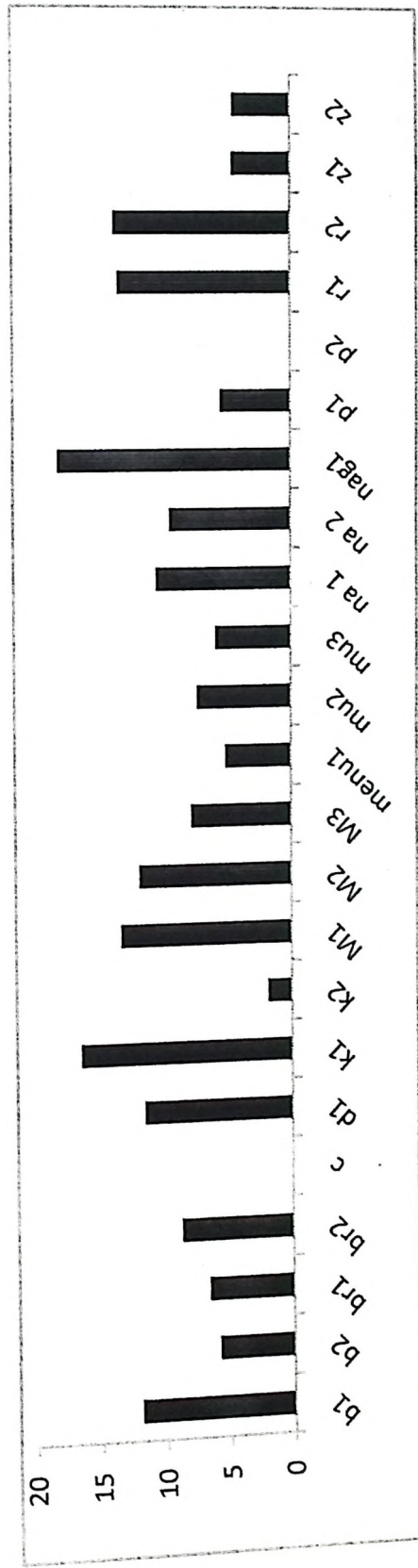
#### 4.3.3 Results

In a total effort of 6,900 camera trap nights, 389 black bear photos were captured. The site occupancy estimate was 0.97 (0.82-1.12) and based on this the abundance calculated was estimated to be 44 (23-113) (Table 4.3). The density calculated was 48/100 Km<sup>2</sup>. The capture rate (#/100 trap nights) ranged from 0 -18 across different sites (Fig. 4.6) and is shown as high, medium and low capture sites (Fig.4.7).

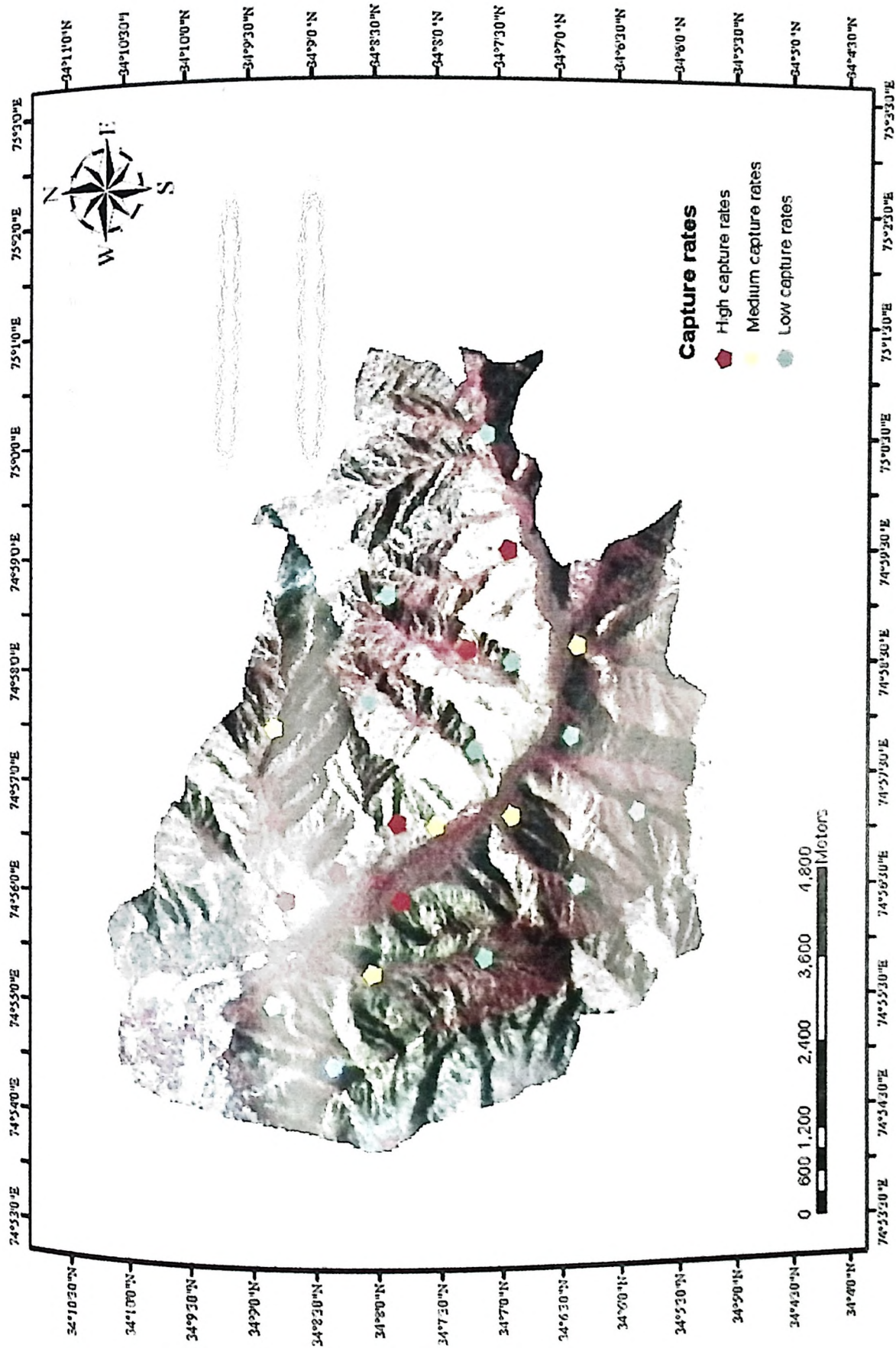
**Table 4.4. Occupancy and abundance estimates (using PRESENCE v. 2.0) of black bears based on camera trap captures in Dachigam National Park, 2008-2010.**

\* density estimated in the area of 90 Km<sup>2</sup>.

Grid size Km <sup>2</sup>	Sampling Size(#Grid)	Group abundance	SE	Mean group size	SE	Population Size (N)*	SE	Density/100 km <sup>2</sup>	SE
4X4	13	44	32	1.00	0.00	44	32	48	35



**Figure 4.6. Capture rate (#/100 trap nights) of black bears based on camera trap data at camera trap sites in Dachigam National Park, 2008 – 2010.**



**Figure 4.7. Map showing high, medium and low capture rates of black bears at Dachigam National Park, 2008-2010.**

#### 4.4 Discussion

The abundance of black bears in an area is dependent on various factors such as resource availability, physiology, and environmental conditions. The encounter rate of black bears in Dachigam National Park varied across seasons. It was highest for summer season and followed by autumn, spring and winter during the study period (Fig. 4.2). The highest encounter rates of black bears in Dachigam National Park during summer could be attributed to various factors such as: high detection rates, it is the most active season for bears as all bears including females with cubs are active and out of their dens, temperature is conducive and out of all seasons summer season has the maximum food availability. Summer is the most productive season for berries and fruits and Dachigam National Park has substantial amount of food in the form of fruiting trees for black bears to feed on. Saberwal (1989) also reported a high density of black bears (1.3 to 1.8 bears/km<sup>2</sup>) in Lower Dachigam during summer season. - Not reported to

The availability of food is a main factor in determination of bear abundance in an area. The movement of bears in search of food in and out also affects their abundance within the Dachigam National Park across seasons. The seasonal availability of natural food in Dachigam National Park in the form of herbs, berries, acorns, fruits and human cultivated food in the form of orchards, croplands in adjacent areas of Dachigam National Park results in shifting of bears in and outside the National Park and hence leads to changes in abundance. Bears go out of the national Park during summer and autumn to feed on human cultivated food. The availability of food inside the national park results in varying abundances in Dachigam National Park.

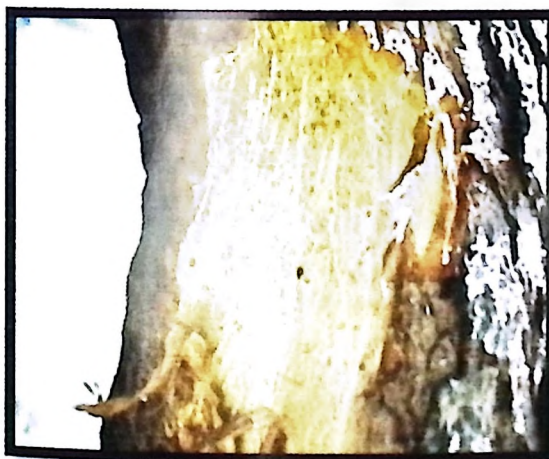
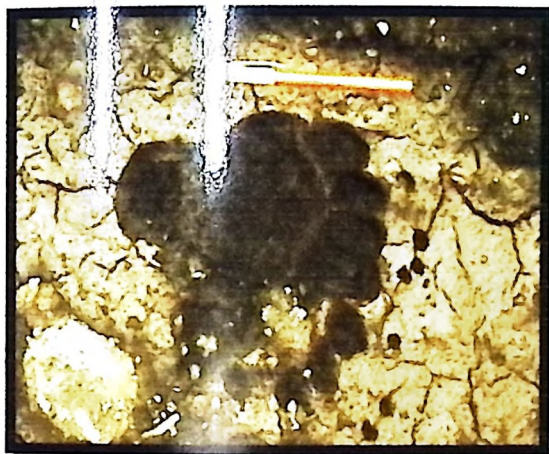
Bear behavior also determines their seasonal abundance. Black bears hibernate during winters leading to low abundance in an area. The low abundance during spring and autumn can be owed to the post and pre denning affects. Bears are less active in spring and autumn, some of the black bears come out of the hibernation late. In addition to this with the onset of autumn season the availability of food resources decreases.

The occupancy based models are being implemented to estimate the abundance of various species and has proven to be practical. The method proposed by Carbone et al. (2001) would be most easily implemented and explored in studies where camera trapping studies can be taken up and for species like that of black bears,

that cannot be identified by their markings. The abundance of black bears in Dachigam National Park as estimated by this method explains the high abundance i.e about 48/100 km<sup>2</sup>.

The use of genetic data for capture–recapture (CR) analyses has become an important tool to estimate population parameters for elusive species such as bears. Capture Mark Recapture experiments involving wildlife species have been revolutionized by at least two developments in the field of genetics. First, identification of individuals is now possible based on patterns of allelic variation at individual microsatellite loci (Mills et al. 2000; McKelvey and Schwartz 2004). Second, polymerase chain reaction allow genetic analysis to be conducted on samples containing small amounts of DNA, as is often the case with noninvasively collected hair samples (Goossens et al. 1998; Taberlet et al. 1996). The modern genetic methodology has enabled to reliably identify individual animals based on non-invasively collected biological samples containing miniscule amounts of DNA. In the present study the same concept was tried for black bears in Dachigam National Park and the genetic structure of the population was revealed. However, the low sample size limited to use the capture recapture model for population estimation. It was also understood that sufficient sample size can provide a better unbiased population estimate using this method.

The detection and location of genetic discontinuities is important to managing natural wildlife populations, and is an important first step to understand genetic patterns. The results showed that there was no inbreeding in the population of black bears in Dachigam National Park (Table 4.3). It suggests that the landscape conservation planning is likely to maintain the gene flow. As also discussed in Chapter 5, the landscape level conservation is indeed a convinced management intervention required for long term conservation of black bears. Identifying genetic patterns and correlating them with influential landscape features can provide ecological information, reveal cryptic population structure and secondary contact between previously isolated populations (Manel et al. 2003). There are many applied examples. Genetic structure has been used to infer metapopulation dynamics (Arnold 2005). Differences in spatial genetic structure related to landscape patches has been used to determine effects of anthropogenic landscape change on dispersal and gene flow (Banks et al. 2005).



**Plate No. 2: Different Black bear signs recorded during the study clock wise: (a) scat (b) digging signs (c) rake marks on tree (d) track (e) feeding platforms on tree and (f) stone turning**

# CHAPTER – 5: HABITAT OCCUPANCY BY ASIATIC BLACK BEAR

## 5.1 Introduction

Bears occupy extremely wide range of habitats including lowland tropical rain forest along the equator, coniferous and deciduous forests, prairie grasslands, desert steppe, coastal rainforest, arctic tundra and alpine talus slopes. The characteristic of bears for learning and their generally omnivorous diet have allowed each species to adapt to a variety of habitat types as they can exploit food resources across a wide range of habitat types. Many species of bears have relatively broad habitat requirements; however, bears can generally accommodate substantial human activity and some habitat alteration (Mattson 1990; McLellan 1990).

Spatial and temporal variation in latitude, climate, topography and site quality largely determine the availability of food and other resources which, in turn, influence the distribution and abundance of bear populations in various habitats. Though bears concentrate their use of the landscape in the most productive foraging landscapes, seasonal variability in food abundance and quality often result in extensive movements from one portion of their range to another leading to use of areas differentially. So bears are reported to exhibit variation in habitat use and population dynamics both within and among geographic regions (Reynolds and Beecham 1980).

Habitat reduction, combined with unsustainable levels of human exploitation, has put many populations at risk and particularly the long ranging animals for that matter are at greater risk (IUCN 2011). A narrow concept of habitat may be inapplicable for bears, which are wide ranging creatures of landscapes rather than a habitat type level. The disappearance of large, relatively uninhabited tracts of land and ensuing conflicts with human interests is the primary reason behind the decline of black bear populations in its range (Cowan 1972)

The habitat use of black bears in wide range of conditions can be attributed to its physiology and feeding habits. The process of hibernation during winters helps bears to adapt and sustain in harsh climate and food scarcity. The productivity of black bears is known to be a function of habitat quality (Rogers 1987).

Habitat use patterns often reflect the distribution of available food resources (Amstrup and Beecham 1979; Landers et al. 1979). The search for food is the ultimate reason behind many of the black bear movements and use of vegetative associations (McArthur 1981; Rogers 1987; Kozakai et al. 2011). Under natural conditions, the distribution and productivity of bear populations is nutritionally regulated by the availability of high quality food resources (Rogers 1987). In addition, annual variability in food abundance (including occasional failures in food production) may result in extensive movements outside their normal home ranges increasing the potential for interaction with humans (Beeman and Pelton 1980; Rogers 1987). The other dependent factors viz., climate, soil, and topography influence the quantity, quality, and distribution of food, which is the major determining factor of home range size; daily, seasonal, and annual movements; and use of vegetative associations (Jonkel and Cowan 1971; Amstrup and Beecham 1976; Garshelis and Pelton 1980; Reynolds and Beecham 1980; McArthur 1981; Rogers 1987).

Asiatic black bears occupy a variety of forested habitats, both broad-leaved and coniferous, from near sea level to an elevation of 4,300m. They also infrequently use open alpine meadows. Individual bears move to different habitats and elevations seasonally (Izumiyama and Shiraishi 2004), tracking changes in food abundance. Foods include succulent vegetation (shoots, forbs and leaves) in spring, turning to insects and a variety of tree and shrub-borne fruits in summer, and finally nuts in autumn (Bromlei 1965; Reid et al. 1991; Huygens et al. 2003). In some places the diet contains a sizeable portion of meat from ungulates (Hwang et al. 2002). In temperate forests, Asiatic black bears rely heavily on hard mast in autumn, in part to put on sufficient fat reserves for winter denning (hibernation). Therefore, these bears tend to focus their activities in habitats with high abundance of oak acorns, beechnuts, walnuts, chestnuts, hazelnuts, or stone pine seeds (Schaller et al. 1989; Hashimoto et al. 2003; Sharma 2012 Unpublished). In northern latitudes, where food becomes unavailable in winter, bears hibernate and tend to use habitats with potential den sites (rock crevices, hollow trees or stumps, under upturned trees, dug-out earthen dens, or ground nests). In Russia, Asiatic black bears have been reported to select flat river bottoms for denning (Seryodkin et al. 2003), whereas in central China they move to high elevation rocky outcrops on steep slopes (Reid et al. 1991).

### **5.1.1 Radio telemetry to study habitat use of bears**

Radio telemetry has proven to be instrumental in providing information on habitat use patterns in particular to elusive, cryptic and long ranging wild animal species such as bears. In case of family Ursidae, American black bear and brown bear toll to the highest number of studies using telemetry (Garshelis 2004). Even good information based on radio telemetry exists on polar bears, although there are constraints in studying this species inhabiting harsh environments (Parks et al. 2006). The other five bear species are comparatively less studied. There have been a few studies on Asiatic black bear using radio telemetry (Kostyria et al. 2002; Izumiyama and Shiraishi 2004; Hwang et al. 2010) but there was no information available for Asiatic black bears in Indian Himalaya. Of the four bear species present in India, only sloth bears (Chauhan et al. 2004; Yoganand et al. 2005) have been studied using this technique. Prior to this study, black bear that were rehabilitated back into the wild were radio collared and tracked (Ashraf et al. 2008)

### **5.1.2 Use of Camera traps to study habitat use of bears**

Camera trapping is a new emerging technique to evaluate habitat use of a species. The use of camera traps in its early years of establishment focused on surveys of elusive species. Gradually, this technique was modified and improved to answer many ecological questions including density and habitat preference. Camera-trapping has been successfully used throughout the world for studying a wide range of elusive animals when compared with more traditional methods (O'Brien et al. 2003; Sanderson and Trolle 2005; Bowkett et al. 2007; Ríos-Uzeda et al. 2007) and has proven useful in providing detailed species inventories in parks and forests, where it has a high detection efficiency and has recorded species that were otherwise undetected (Yasuda 2004; Gimán et al. 2007; Charoo et al. 2010). The elusive species such as bears has been studied worldwide using this technique. A few studies describe the carnivores' activity patterns with camera trapping (Maffei et al. 2002; Te Wong et al. 2004; Maffei et al. 2005) and a few analyze the habitat use (Foster et al. 2010). This tool was applied successfully in Asia to evaluate the presence, habitat use and activity of different species (Azlan and Sharma 2006). Camera trapping has been used to study the habitat use and occupancy patterns of many animals in different habitats. Habitat use of species such as Bare-nosed wombats (Bochard and Wright 2010), antelopes (Bowkett et al. 2007; Krishna et al. 2008), small carnivores (Chen et al.

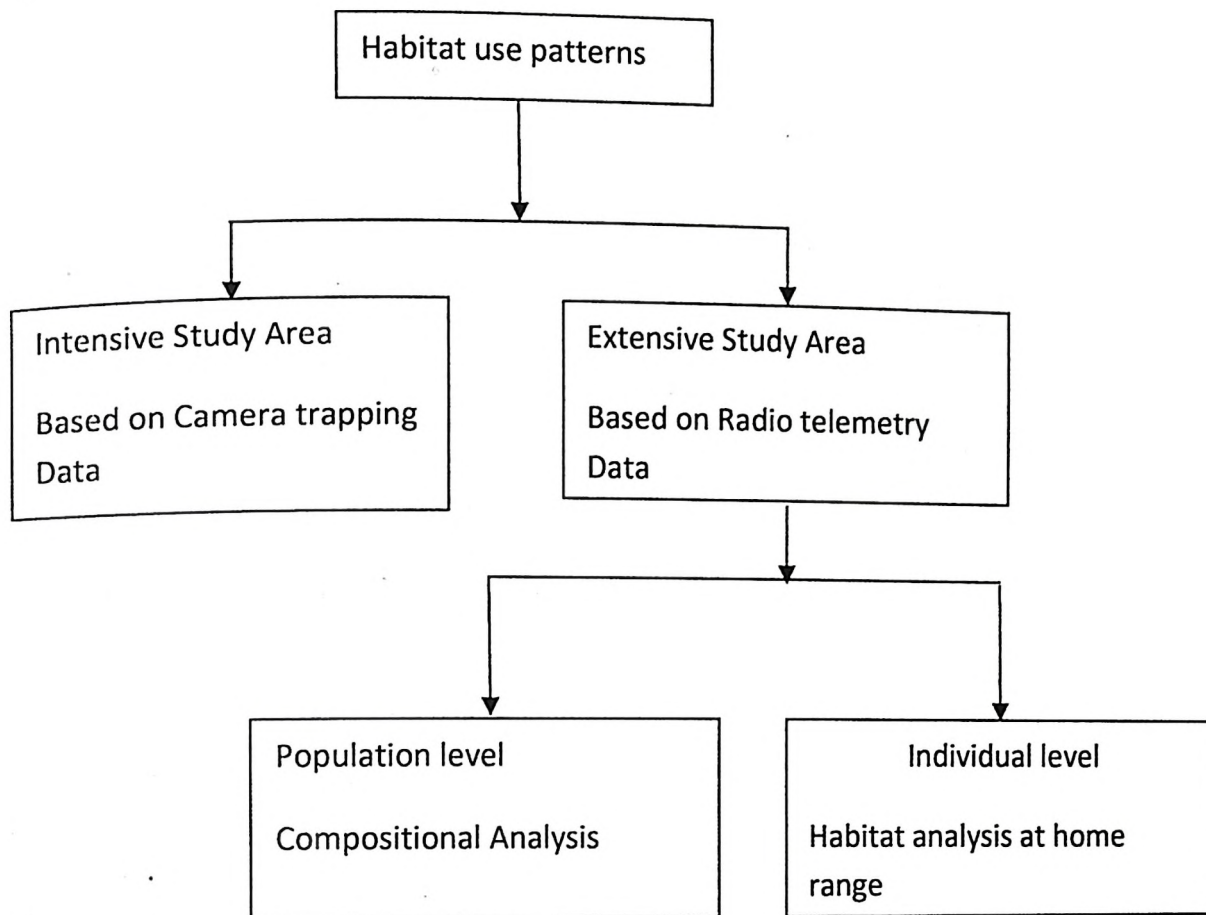
2009) and small mammals (Jimenez et al. 2010) have been studied successfully using camera traps. Linkie et al. (2007) investigated habitat use of sun bears in Sumatra using camera traps and environmental covariates for occupancy estimation and provided significant conservation implications. For bear species, however, camera trapping has been used to assess occupancy or abundance (Uzeda et al. 2007; Gopaldaswamy 2006; Dusit and Gale 2011) and a few studies account for the habitat use assessment (Zug 2009; Jones et al. 2010).

A series of methods have been used to assess habitat use of carnivores, particularly bears being secretive and generally nocturnal. Camera trapping is turning out to be a new technique to take into account these considerations.

Studies of habitat selection patterns of animals are important to identify areas and resources that contribute to the fitness of individuals and viability of populations (Fretwell and Lucas 1970). The understanding of use of different habitats by bears is an essential part for their long term sustenance and conservation. Bears use a wide range of habitats because of their adaptability and the availability of their natural habitats will always be an important requirement. Habitat use of black bears has been studied across their geographic range and a great deal of variation exists in the specific habitats that are selected and avoided by individuals in different populations (Hellgren et al. 1991; Vander Heyden and Meslow 1999; Pelton 2000; Lyons et al. 2002). A few studies on habitat use also account for Asiatic black bear (Hazumi and Maruyama 1986; Ohsako 1995; Carr et al. 2002; Izumiyama and Shiraishi 2004) in its distributional ranges. The present study was aimed to understand the habitat occupancy patterns of Asiatic black bear in Dachigam National Park and human dominated and a high density area for black bears- Dachigam landscape.

## 5.2 Methods

Habitat use of black bears was assessed at intensive study area (Dachigam National Park) using camera traps and at extensive scale (Dachigam landscape) using information from radio collared animals and at individual level by considering each radio collared black bear (Fig. 5.1).



**Figure 5.1. Pictorial representation of methodology adopted to study Asiatic black bear habitat use patterns in Dachigam landscape.**

## 5.2.1. Asiatic black bear occupancy pattern in intensive study area: Dachigam National Park

### 5.2.1. (a) *Field method*

The intensive study area of 90 km<sup>2</sup> was divided into 23, 2X2 km grids and in each grid a camera trap was placed to make sure that at least one camera is representative of a sampling unit (grid in the present study) (Royle and Nichols 2003). *Wildview* camera traps were used in the field to investigate the habitat use patterns. In each grid the placement of the camera was selected based on the literature and the field surveys such that they have the best chance of being visited by the black bears. The camera trap stations were baited as the primary objective of placing camera traps was to monitor hair traps (Details in Chapter 4). At each camera trap station a 10 m circular plot was laid to collect data for habitat parameters such as shrub density, tree density, herb density, distance from nearest water source, ground cover and canopy cover. The vegetation sampling plot was laid at a distance of 200 m from the camera trap, as the surrounding vegetation had to be cleared for open view of camera and to place a hair snare. Tree density was measured in 10m plot and within this shrub density estimated in a 5m circular plot. Herb density was estimated using four 1X1m quadrat on four corners of the circular plot. Canopy cover for each circular plot was ocular estimated and recorded as percentage values. Distance to nearest water source was estimated using Arc GIS 9.3. The habitat type for each trap station was recorded. The habitat parameters such as elevation, aspect and slope were also recorded for each station using GPS.

The camera trap stations were checked after every three days for camera trap captures and batteries. The camera traps were run for the three seasons of spring (March - May), summer (June to September) and autumn (October and November).

### 5.2.1. (b) *Analytical method for occupancy patterns*

The data was collected for both the response variable (Capture and no capture for bears) and the predictors (habitat factors) for each camera site. For each site the camera traps were run on 24 hr (day- night) period and capture histories were recorded. Occupancy surveys entail repeat visits to sampling sites. At each visit, an effort is made to detect the species of interest, producing a detection history of whether or not the species was detected at each of the visits to the site. The observed presence-absence at each visit is a binary random variable defined as follows: 1 if

detected at site and 0 if not detected. The key element of this problem is that observed non-detection is ambiguous, in the sense that there may be non-detection at sites that are, in fact, occupied (sampling zeros) and non-detection as a result of a site being unoccupied (fixed zeros). The important estimation problem is the separation of these two types of zeros by parameterizes a model that allows estimation of both detection probability and occupancy rate (Royle and Nichols 2003).

The data set presented here is for three years viz., 2008, 2009 and 2010. Cameras were run intensively for three seasons (Spring, Summer and Autumn) for nine months (March to November). The functional period of each site was based on 24 hr. The cameras were considered functional even if their position got changed because of animal movement or other factors. Change in field view of the capture did not affect the response variable estimate as it was independent on the individual identification of black bears. At some sites the cameras stopped functioning because of technical faults/drained batteries, animal movement and in some cases displaced by humans. In such cases the non- functional days were considered after the last capture at that site.

Occupancy based models using program PRESENCE, v.2.2 (MacKenzie et al. 2006; Hines 2006) were run to estimate the site occupancy rate relative to the sampling variables such as elevation, aspect, slope, canopy cover, ground cover, habitat type, distance from water and disturbance. Akaike Information Criterion (AIC; Akaike 1973) values were used to rank the occupancy model (or to select the best fit model).

### **5.2.2. Habitat use patterns in extensive study area (Dachigam Landscape)**

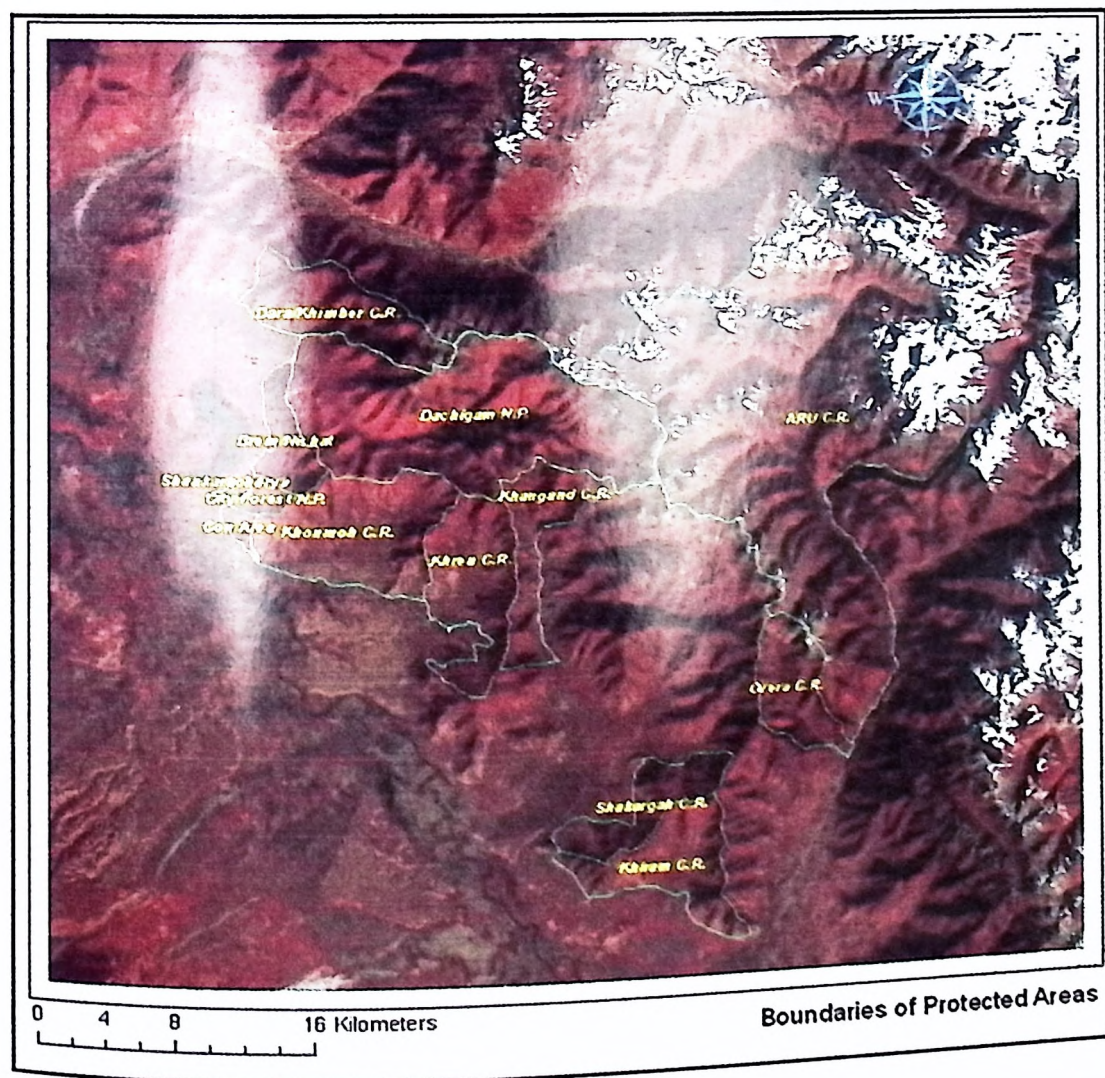
#### **5.2.2. (a) *Habitat mapping of forest cover***

The forest cover in Dachigam National Park and surrounding areas was classified using the Landsat data downloaded from GLCF (June 2009). The information was provided in four spectral bands in the visible and infrared regions with spatial resolution of 23.5 meters. The pre-processing of the image was carried out by following the standard methodology (Singh et al. 2002) which includes geometric and radiometric correction followed by geo-referencing of the scene at 1:50,000 scale using ancillary data and GPS locations. The image obtained through unsupervised classification was processed with the vegetation data for the supervised classification using the signature file containing the plant community data. The field

knowledge was subsequently incorporated to improve the accuracy of the classification. Hybrid classification was carried out which have the advantage of both the procedure (unsupervised and supervised) and the field information generated during surveys (Singh et al. 2002). The vegetation classes were delineated on the basis of spectral value of FCC. The spectral bands 3, 2, 1 (RBG) of Landsat data were also important for the vegetation class separation with different spectral (DN) values of different vegetation classes, though infrared (NIR) band was most important for the vegetation classification.

In the present study the topographic maps of Survey of India (SOI) with 1:50,000 scale and the Landsat data (LISS III) August 2009 downloaded from GLCF were used. The study area was covered in two scenes.

The satellite data was processed by using ERDAS-Image 8.4 and the ArcInfo 9.3 software. The two scenes covering the study area were mosaiced to delineate the study area. The satellite images covering the study area were geo-rectified with the help of topographic maps and the geo-rectified data was having root mean square (RMS) error of 2.58%.



**Figure. 5.2. Satellite imagery of Dachigam Landscape (with protected area boundaries) used for the land cover classification.**

### *5.2.2. (b) Habitat use analysis of radio-collared black bear in Dachigam landscape*

#### **Capturing and radio telemetry**

The collaring exercise started with the habituation of black bears towards traps using different kinds of baits. The baits used for habituation included fallen oak acorns, wild fruits, honey, sprouted maize and rotten meat. The traps were camouflaged with the broken branches of oak and grasses to avoid trap shyness of bears. Seven Asiatic black bears were captured, radio collared and tracked. The collared animals included four males (02 M, 08 M, 10 M and 100 M) and three females (00 F, 04 F and 06 F) (Details in Sharma 2012 unpublished).

In total, 967 use locations from 7 black bears was used for the analysis. For the habitat selection analysis, both VHF locations and ARGOS based locations (2-3 locations/week) were used. Due to the inaccessibility of tracking animals regularly, satellite data was used for filling up of the information gaps.

### *5.2.2. (c) Compositional analysis for habitat use of radio-collared black bear in Dachigam landscape*

The composition analysis was performed to understand the habitat use by black bear in Dachigam landscape for which 7 black bear were radio collared in the study area. The overall 100% MCP (Minimum Convex Polygon) home ranges for all the radio collared was generated. For availability the composite home ranges was generated after the combinations of all the MCPs of seven animals. The composite home ranges were selected as the area of analysis or the available area for the habitat use analysis. Habitats were classed into six groups. These were: Riverine, Mixed forest, Pine forest, Grassland and scrubland, Human habitation and Orchard. The choice of MCP as home ranges estimator was based on its widespread use (Harris et al. 1990). It is not an absolute measure of the habitat available to the animal, nor is any other home range estimator; rather, it is a more sensitive procedure than an arbitrarily defined study area. The habitat compositions in the total study areas and in each animals MCP home ranges, and the proportion of radio locations from each animal within each habitat type were calculated using the HRT tool of ArcGIS 9.1 software. In the present study composition analysis was carried out to understand overall habitat use by Asiatic black bears (Aebischer et al. 1993). The serial correlation between radio locations was irrelevant because sampling intensity was

uniform throughout the period (Aebischer et al. 1993; Stratman 2001). For each bear, habitat composition was weighted by the square root of the number of locations, because the number of radiolocations was not consistent for all the seven radio collared black bears. According to Aebischer et al. (1993) the 0% use value corresponds to the non-utilized habitat type but available habitat type was replaced by 0.01%, an order of magnitude less than the smallest recorded nonzero percentage.

### **5.2.3. Predicting habitat factors responsible for habitat use by black bear in Dachigam landscape**

#### **5.2.3. (a) Data extraction**

The habitat selection was based on Euclidean distance based approach (EDA) to estimate the patterns of black bear habitat use (Conner and Plowman 2001; Conner et al. 2003). For habitat analysis, distances from estimated bear locations were compared with distances from random points generated throughout each home range (Conner et al. 2003; Perkins and Conner 2004). The number of random points falling in each home range varied depending on size of home ranges (Fig. 5.4). To ensure an adequate number of random points for high precision, 1000 random points were generated from a uniform distribution within the population range and then calculated mean distances for increasing number of points for the representative habitat types. Mean distances from the representative habitats were stabilized and a selection of 250 random numbers of points within each home range was decided to be adequate for the analysis. Distances were calculated from random points and bear locations to each habitat type using the Hawth's tool (Beyers 2004) Arc GIS 9.3. For each individual bear, a vector of 8 distances was created for the analysis (Table 5.1). The designation of study areas for free-ranging animals is generally subjective, a problem in virtually all studies comparing habitat use with availability within a study area. Given that each animal's home ranges determined habitat availability for the analyses, these analyses are not subject to a similar potential bias. Euclidean distance habitat selection analyses do not require explicit telemetry error handling or modelling because this technique does not rely on classifying telemetry locations by habitat.

The resource characteristics for bear locations and random locations were extracted within the home ranges of each bear from digital data layers using GIS. All topographic variables in raster format (30m resolution) and the linear variables were extracted from digitized topo maps, using ArcMap. The linear factors included

euclidean distances to water (streams), road, human habitation, trails, resource (food) patch. The topographic indices included elevation, slope and aspect. Landsat III image was used to classify forest types.

### *5.2.3. (b) Habitat selection function analysis for black bear in Dachigam landscape*

A binary logistic regression was run to understand the differences between the bear and random location of different habitat parameters using SPSS 16.0 (Norusis 2008). For binary logistic regression data including eight variables extracted from vector layers for both animal and random locations was used for model prediction. A cross-correlation matrix was prepared initially to see if the variables were highly correlated to one another. Variables with correlation coefficients  $> 0.60$  were removed from the analysis. Enter elimination processes were applied to identify and remove redundant variables and those variables that did not contribute significantly in detecting presence of any species in the study area.

Overall prediction efficiency of the variables was assessed based on Nagelkerke- $R^2$  and  $- \text{Log Likelihood}$  values. Influence of individual variables including categorical variables was assessed using Wald statistics. Hosmer and Lemeshow goodness-of-fit test (chi square test) and concordance analysis (classification tables) were done to understand the fit of the model (Hosmer and Lemeshow, 1989). The  $\beta$  coefficients indicate the selection or avoidance of a resource and were used to evaluate the response of covariates on the habitat selection of black bears in the landscape.

**Table. 5.1. Variables used for the habitat use analysis for black bears in Dachigam landscape, 2009-2011.**

Habitat variable	Data Source
Elevation	Digital Elevation model using ERDAS 9.2
Aspect	Digital Elevation model using ERDAS 9.2
Slope	Digital Elevation model using ERDAS 9.2
Proximity to water source	Vector layer
Proximity to food patch	Food patches were marked by the ground data and the vector layer was generated by generating polygons of food resources in the field
Proximity to road	Vector layer was generated by digitizing the trail and road from the toposheet of the study area
Proximity to trail	Vector layer was generated by digitizing the trail and road from the toposheet of the study area
Proximity to human habitation	Vector layer was generated by digitizing the trail and road from the toposheet of the study area

### 5.3. Results

#### 5.3.1. Occupancy pattern of black bear in Dachigam National Park

The camera trapping was analyzed for three seasons: spring, summer and autumn only. Due to some logistic and technical problems, the winter data was not incorporated in the results. A total effort of 6900 number of capture days (24 hr) for 23 camera sites was achieved for 2008, 2009 and 2010. The detection of black bears varied significantly across seasons and was highest in summer. The detection variables considered for analysis were canopy cover (cc), grass cover (gc), elevation (el), shrub density (sd), slope (sl), aspect (a) and different habitat types: Grassland (g), scub (s), temperate (tmp), riverine (r), mixed forest (mf). The estimated site occupancy rates of black bear in the three seasons varied. It was slightly higher than the naive estimates (i.e. the proportion of sites where the species was detected at least once) for summer and autumn and lower for spring.

The occupancy models for spring take various habitat variables into consideration but the best fit model based on the AIC ranking considered ground

cover and elevation only. The site occupancy ( $\psi$ ) is comparatively low in spring (0.54), the camera sites at lower elevations got less captures.

Summer had the highest site occupancy (0.78) compared to all the three seasons as the black bears were photo captured at almost all the sites. The best positive predictors of black bear occupancy during summer were canopy cover, ground cover and shrub density.

During autumn, the best fit occupancy model considered tree density, elevation and slope as the predictors of black bear occupancy. The site occupancy for autumn season was 0.61.

Table 5.2. The models for predicting site occupancy and detection probability of black bear in (a) spring, (b) summer and (c) winter seasons at Dachigam National Park, 2008 – 2010.

(a)

Model	AIC Weight	Delta AIC	Model Likelihood	No of Parameters	-2LL	$\psi$	C-hat
psi(gc+el). p(s)	0.61	0	1	4	425.21	0.54	0.89
psi(sd+el+tmp).p(s)	0.48	0.30	0.64	5	443.07	0.46	0.75
psi(sl+cc). p(s)	0.40	0.41	0.091	6	421.47	0.44	0.66
psi(el+sl). p(s)	0.37	0.38	0.082	6	465.05	0.31	0.62

(b)

Model	AIC	Delta AIC	Model Likelihood	No of Parameters	-2LL	$\psi$	C-hat
psi(cc+gc+sd). p(s)	420.65	0	1	4	631.02	0.78	0.76
psi(sd+el+tmp).p (s)	448.7	3.09	0.53	6	601.54	0.7	0.66
psi(sl+cc). p(s)	385.03	4.10	0.45	7	534.09	0.62	0.58
psi(el+sl). P(s)	377.1	3.8	0.082	7	712.9	0.6	0.52

(c)

Model	AIC	Delta AIC	Model Likelihood	No of Parameters	-2LL	$\psi$	C-hat
psi(td+el+sl). p(s)	319.9	0	1	5	425.21	0.32	0.54
psi(cc+sd).p (s)	367.2	3.09	0.24	7	443.07	0.22	0.43
psi(sd+el+d).p(s)	439.5	4.10	0.091	7	421.47	0.16	0.32

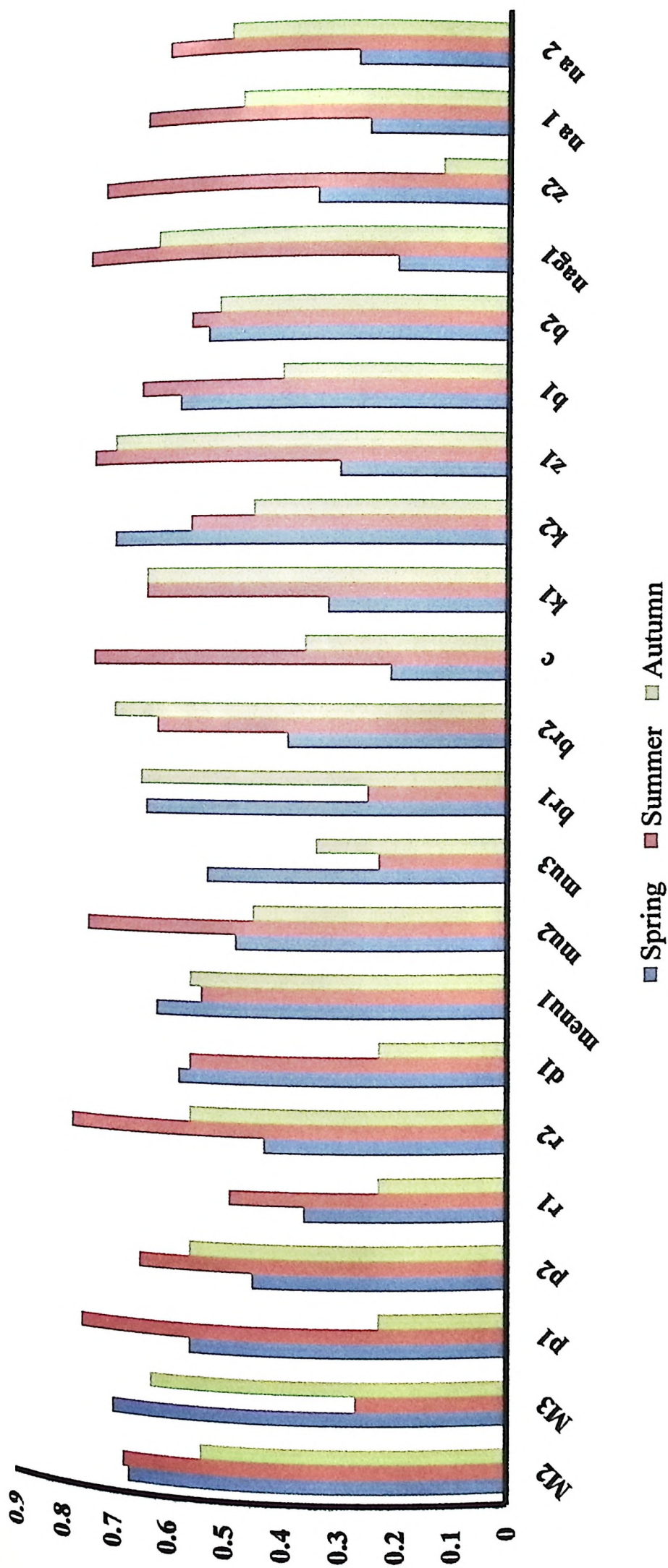


Figure 5.3. Site occupancy of Asiatic black bears at various camera sites, Dachigam National Park 2008 – 2010.

### 5.3.2. Habitat characterization

#### 5.3.2. (a). Land cover/Land use mapping: Land cover/Land use (LULC) in Dachigam National Park

The total area of Dachigam National Park was 141 km<sup>2</sup> calculated using GIS (Fig. 5.2). The Dachigam National Park is administratively divided into two: Lower and Upper Dachigam. Lower Dachigam National Park was selected as our intensive study area with an area of approximately 90 km<sup>2</sup>. The area under forest cover in lower Dachigam is 91% and rest 9% includes non forest areas which are rocky clefts, water bodies, human-agriculture and snow covered area. The spatial distribution of different land cover types was generated after hybrid classification method. The vegetation of Lower Dachigam is represented by 34 tree species, 21 shrubs, 96 herbs, 8 climbers belonging to 65 families.

#### A. Forest cover

Following are the forest types in Dachigam National Park: -

##### I. Riverine forest

Riverine forest is mainly confined along the main Dachigam *nallah*. It is basically a succession vegetation type which is mainly dictated by the local edapho-climatic conditions. The plant community of this forest type was represented by following broad leaved tree species *Morus alba*, *Morus nigra*, *Salix babylonica*, *Populus alba*, *Acer caesium*, *Juglans regia*, *Ulmas lavigata*, *Rhus sp.*, *Corylus sp.*. The dominant shrub species in this forest type are *Rosa brunonii*, *Roubinia sp*, *Indigofera heterantha*, *Viburnum sp*, *Berberis sp*. The under growth comprised of *Arenaria serpyllifolia*, *Viola odorate*, *Geranium sp.*, *Solenanthus cereinatus*, *Climatis grate*, *Vitisvinifera*. This forest type lies in the elevation gradients of 1600m to 1900m and it covered almost 30% of the total area of intensive study area.

##### II. Low Temperate Pine mixed forest

Pine forest grows on the slopes along the north and north east aspects between Harwan water reservoir and Pehlipora. This land use/ land cover type contributes to 48 % of total intensive study area. *Pinus wallichiana* is the dominant conifer that sometimes reaches up to the open scrubs and forms patches. In the lower zones the *Pinus wallichiana* has very little undergrowth and has the following shrub species such as *Lonicera quinquelocularis*, *Viburnum continifolium*, *Berberis lyceum*, *Rosa webbiana*, *Stipa sibirica*, *Artemisia vestita*, *Polygonum amplexicaule*, *Geranium wallichianum*, *Origanum normal* and other species. In many places, pine was found to

be in association with other shrubs such as *Rosa brunonii*, *Rhus succedanea*, *Parrotiopsis jacquemontiana*, *Rosa webbiana*, *Prunus cerasifera*, *Crataegus monogyna*, *Berberis lycium*. Pine forest is distributed mainly in the elevation range of 1,800m to 3,400m throughout the Dachigam National Park in small patches.

### III. Low Temperate forest

The low temperate forest is distributed in the elevation zone of 1,700m to 2,100m. This forest type is composed of various tree species and the dominant tree species were *Pinus wallichiana*, *Aesculus indica*, *Rhus sp.* and *Lonicera quinquelocularis* the dominant shrub species were *Rosa webbiana*, *Rosa brunonii*, and *Berberis lyceum*. This forest type shares large number of species with riverine and mid- temperate forest and is distributed between riverine and the mid-temperate forests covering the north facing slopes starting from the Raznar area in Dachigam block up to the Gratnar in Pehlipora block. Low temperate forest type covers 15% of the total forest area of Lower Dachigam (Fig. 3.4).

### IV. Mid- Temperate forest

Mid temperate mixed forest is distributed in the elevation gradient of 1,800m to 2,400m. In this forest type the dominant tree species were *Juglans regia*, *Aesculus indica*, *Rhus sp.*, *Populus ciliata*, *Corylus colurna*, *Padus cornuta*, *Fraxinus sp.*, *Taxus wallichiana*. The dominant shrub species in this forest type are *Prunus sp.*, *Berberis sp.*, *Viburnum sp.*, *Rosa webbiana*, etc. This forest type is very much important for Black bear and *Hangul* throughout the year. It comprises almost 20% of the total area of Lower Dachigam.

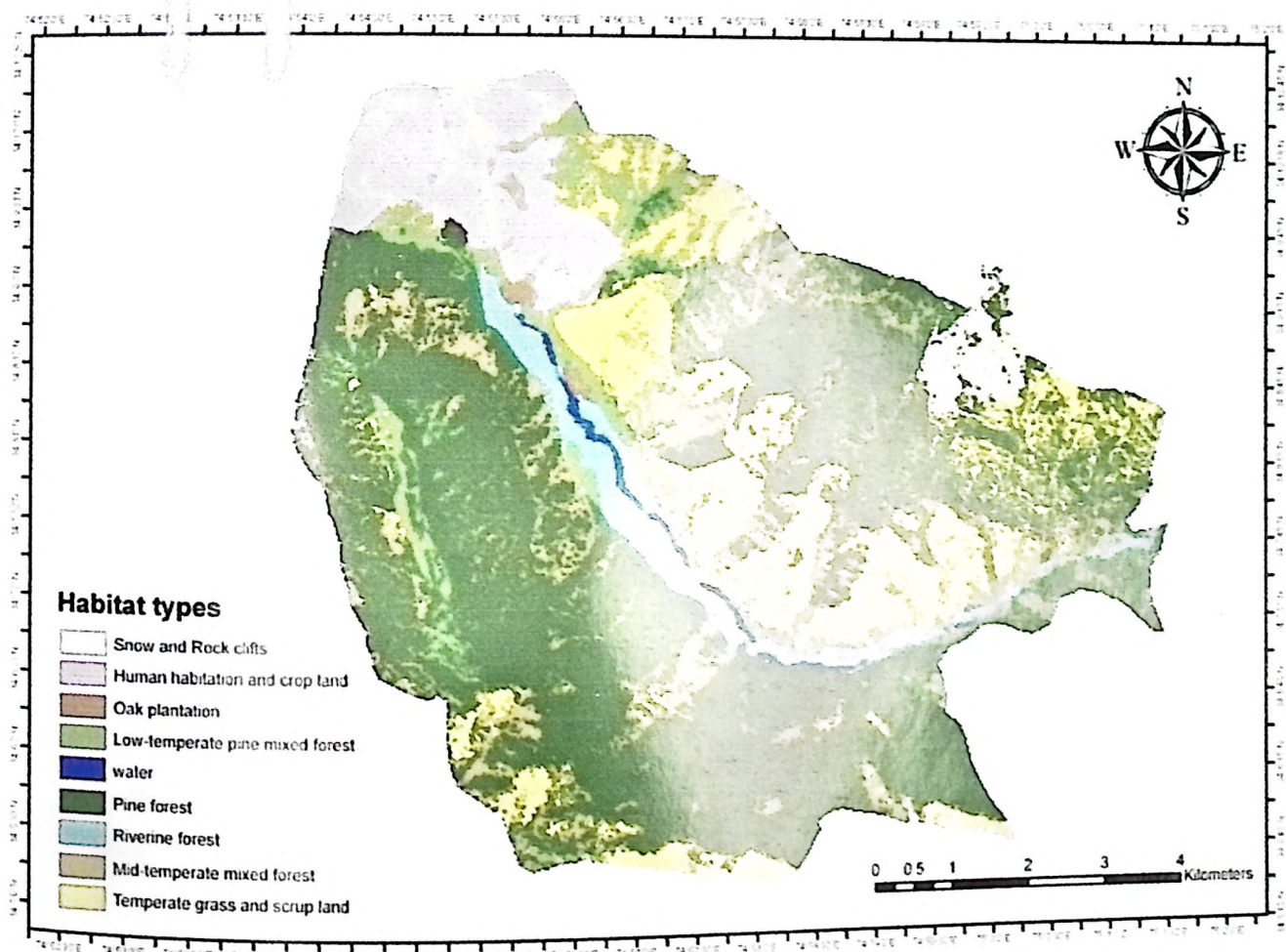
### V. Temperate grassland/scrubland

These are vast stretches of open lands particularly on slopes facing South – west between 1,800m to 2,700m. These open stretches are sparsely covered by thickets of broad leaved deciduous scrub comprising, *Parrotiopsis jacquemontiana*, and *Prunus armeniaca*. This vegetation type has large number of xerophytic species which makes scrubland patched. These species include *Indiofera heterantha*, *Rosa brunonii*, *Rosa webbiana*, *Lonicera quinquelocularis*, *Geranium nepalensis*, *Dipsacus mitis*, *Dactylis glomerata*, *Colochicum laetum*, *Stipa sibirica*, *Zizyphus anathema*, *Fragaria vesca*, *Kocuria cristata*. This vegetation type is very much important for

*Hangul*. The temperate grass and scrubland habitat forms 30% of the total intensive study area.

## VI. Oak Plantation

It is a plantation of white oak (English oak) (*Quercus robur*) planted by Maharaja of Kashmir. White oak is an exotic species and is now one of the most important habitats for species such as Asiatic black bear and *Hangul*. Oak plantation is a small patch in riverine forest with around 18 hectare area. Oak acorn is the most important food of black bear in autumn season (Sharma et al. 2010). Asiatic black bears feed extensively in this patch before going into hibernation or winter sleep. The other tree species in this patch are *Aesculus indica*, and *Morus alba*.



**Figure 5.4. Map showing different forest/habitat types of black bear in intensive study area of Dachigam National Park.**

## B. Non-forest

Forest areas include barren rocky clefts, and water bodies.

## **I. Snow and Barren/ Rock cliffs**

The area of barren/ rock cliffs in Dachigam National Park is negligible in both intensive area and contributes 2% (1.2km<sup>2</sup>) of the area. This land use type represents rock cliffs and areas which are covered by snow during most of the months of the year and is mostly barren.

## **II. Water bodies**

In Dachigam National Park there are many perennial streams and lakes. The area covered in this class is small but they are well distributed in Dachigam and which are fulfilling the water needs of the wildlife. The image which was used for the analysis could only represent perennial lakes and did not include seasonal streams and other water sources. This class of LULC represents 0.5% (0.38km<sup>2</sup>) of intensive study area.

### **5.3.2 (b) Land use/land cover types in greater Dachigam Landscape.**

The total area of the part of Greater Dachigam landscape (Fig. 5.3) used for the ecological study in the landscape (area of analysis) was 550 km<sup>2</sup> calculated using GIS. This area of analysis selected for this study comprised of human habitation, crop lands, five conservation reserves and Lower to middle part of Dachigam National Park which is administratively falls under Central Wildlife Division. The total area under forest cover was (230 km<sup>2</sup>) which was 42 % of the total area. The non-forest LULC includes human settlements, croplands, rocky clefts, water bodies and snow covered area. The spatial distribution of different land cover types was assessed after hybrid classification method. The crop lands in the landscape represent horticulture and agriculture crops

#### **A. Forest areas**

The forested area was classified into three major classes which includes Conifer forest, Broadleaf mixed forest, and temperate grassland and scrubland.

##### **1. Conifer forest type (Pine dominated forest).**

The pine forest is located mostly in the middle and upper elevation ranges in the landscape. The area covered by Pine forest was highest and largely falling in Protected Areas (PA) and this forest type was mostly devoid of disturbance. *Pinus wallichiana* was the dominant tree species in this forest type and the other conifer

tree species were *Abies pindrow*, and *Taxus wallichiana*. The total area under pine forest cover was 168 km<sup>2</sup> and comprises 30.4 % of the total area in the landscape.

## 2. Broadleaf mixed forest type.

The mixed forest type is the second type forest cover in the landscape after pine forest and it is located in the middle to lower elevation zones of the landscape. The mixed forest represented by large number of species which includes *Asculuas indica*, *Juglans regia*, *Populus sp.*, *Salix sp.* and others. This forest type comprises of 10% of the total area and the total area was 58km<sup>2</sup>. The mixed forest occupying areas between conifer forest and other LULC in the landscape.

## 3. Riverine forest.

The Riverine forest type is located only in Dachigam National Park. This forest type holds highest diversity in the form of large number of plant species (tree, shrub etc) and it is the most important type of LULC for large number of wild animal species such as Hangul, black bear and leopard. The riverine forest comprises 0.5 % of the total areas in the landscape. Riverine forest type runs all along the main Dachigam *nallah*.

## 4. Temperate grassland and scrubland.

The grassland and scrubland areas are located in the open areas mostly on the west facing slopes in the landscape. The grassland and scrublands in Dachigam National Park provides important habitat for species such as *Hangul* and black bear. This land use type occupies areas in the middle elevation zones and was in the form of patches in the landscape. The Temperate grassland and scrubland forest comprises 8.8% (48.8km<sup>2</sup>) of the total areas in the landscape.

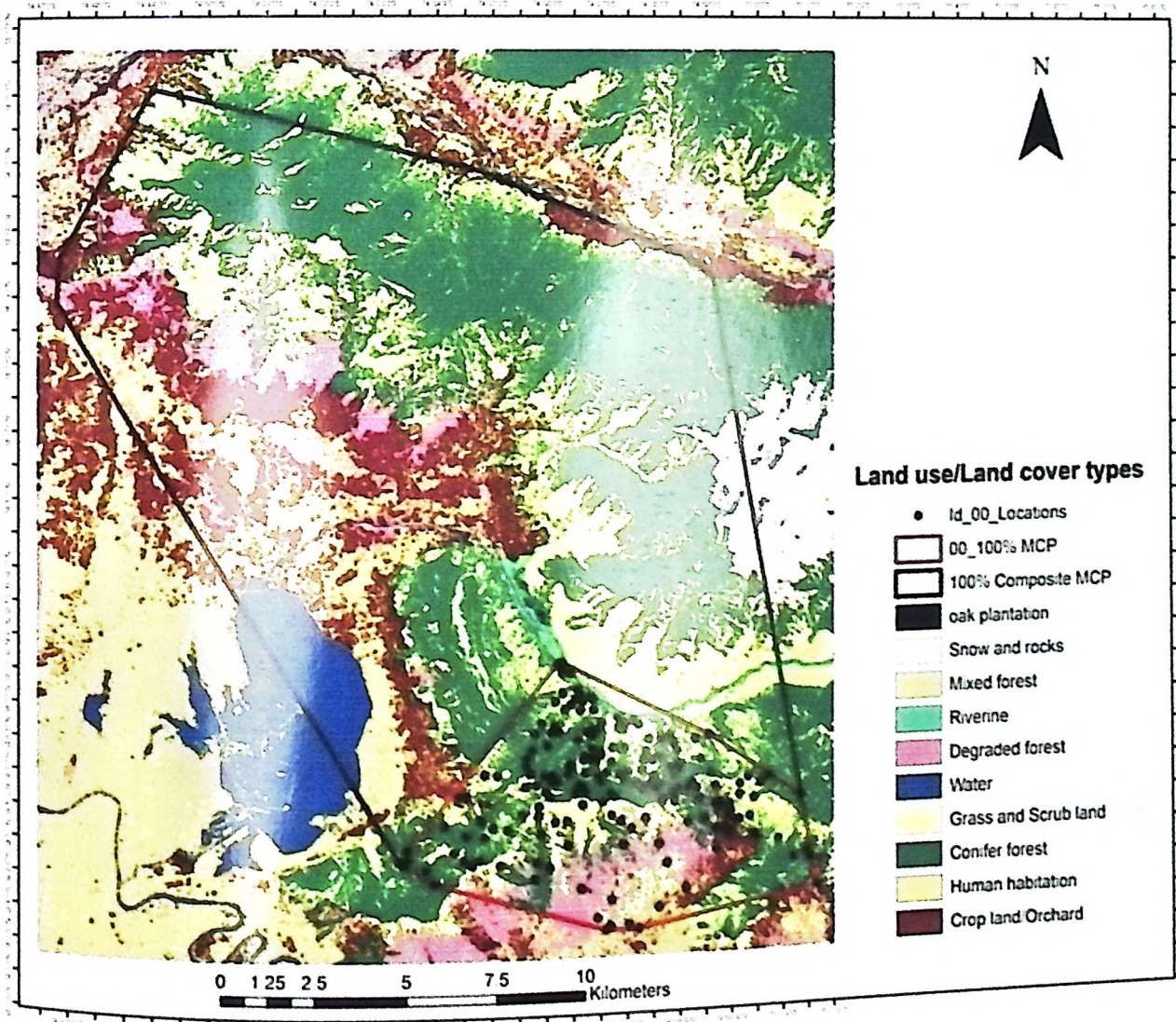
## B. Non-Forest areas

The non-forest areas cover degraded / barren areas, snow, human settlement and croplands.

1. **Degraded/barren areas.** The degraded area are mostly located in Dara/Khimber conservation reserve towards North-East of the Dachigam National Park and this land use type cover large amount of area in Khunmoh and Khrew conservation reserve. The total area of degraded forest type land use was 45.4 km<sup>2</sup> and forms 8.1% of total areas in the landscape.

2. **Human settlements.** The human settlements were mostly located towards Dal lake on the North-Western side in the landscape. The total area covered by this land use type was 118 km<sup>2</sup> and about 21.3% of the total area.

3. **Crop lands.** In Dachigam landscape this land cover type is located on the fringe areas of the protected areas and the other forested habitats. This land cover type comprises about 66.2% of the total areas in the landscape and is one of the major land use type in the landscape. The cropland cover composed of horticulture crops and the agriculture crops.
4. **Snow and rocky clefts.** The area of barren/ rock cliffs was negligible in the landscape and contributes 2.9% (16km<sup>2</sup>). This land use type shown in the map represents rock cliffs and areas which are covered by snow in most of the months of the year. This land use type support very few species of plants and mostly barren.
5. **Water.** Dachigam landscape is the catchment area of Dal lake and covers 5.2% of the total area of the landscape.



**Figure 5.5. Land cover/ land use types (areas of analysis) with 95% minimum Convex Polygon (MCP) based on all locations of collared black bears (Seven) and an example of an individual home range 95% MCP in Dachigam Landscape, 2009-2011.**

Habitat use of black bear was recorded to be affected by various habitat parameters. The use of habitats varied across gender. The use of habitat selection was assessed at Johson's (1980) second level order.

**5.3.3. (a) Habitat Use by black bear in Dachigam landscape**

The overall habitat use by black bears was not random ( $\lambda = 0.0395$ ,  $\chi^2 = 22.62$ ,  $df = 5$ ,  $P < 0.001$ ,  $n = 7$ ) and differed significantly across various habitats. Riverine habitat type ranked highest among all the six different types of habitat associations followed by mixed forest type and it was lowest for the human habitation habitat type. Black bear use of different cover types was disproportional to availability within the composite home ranges or the area of analysis. Compositional analysis of second order selection resulted in ranking matrices that ordered habitats from the most to least use during the study period. The simplified matrix ranks the habitat use in the order: Riverine > Mixed forest > Pine forest > Grassland & Scrubland > Cropland > Human habitation (Table 5.12).

**Table 5.3. Matrix of habitat use rankings for Asiatic black bear based on comparing proportion of habitat use within minimum convex polygon (MCP) home ranges with proportions of total available habitat types in Dachigam Landscape, 2009- 2011.**

+ Preference, - avoidance

Each mean element in the matrix was replaced by its sign and triple sign represents significant deviation from random at  $P < 0.5$ .

(R= Riverine, MF= Mixed forest, GS= Grassland and Scrubland, PF=Pine forest, HH= Human habitation, C=Cropland).

Matrix of habitat use rankings							
Habitat type	R	MF	GS	PF	HH	C	Rank
Riverine	0	+++	+++	+++	+++	+++	5
Mixed forest	---	0	+++	+++	+++	+	4
Grassland and scrubland	---	---	0	-	+++	+	2
Pine forest	---	---	+	0	+++	+	3
Human habitation	---	---	---	---	0	---	0
Cropland	---	-	-	-	+++	0	1

### 5.3.3. (b) *Habitat selection factors in Dachigam landscape*

Seven radio collared black bears (4 male and 3 females) were used to assess habitat use patterns. The affect of various habitat parameters varied across different individuals

#### *Animal 06 F*

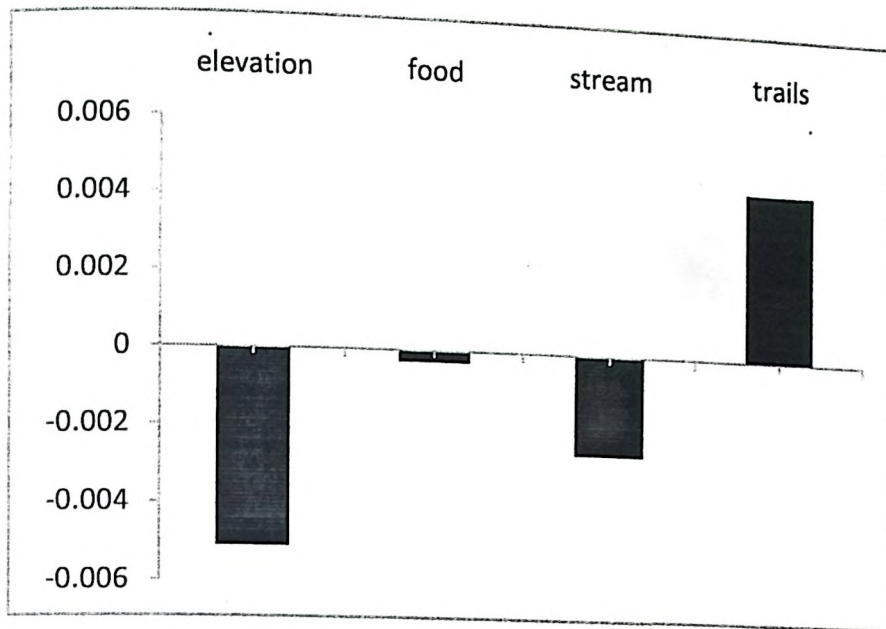
This female bear largely used areas closer to road, trail and village (Fig. 5.8) (Table 5.2). The negative predictors included proximity to wild food, stream and areas with higher elevations. Estimated -2 Log Likelihood (Cox and Snell  $R^2$ ) and Nagelkerke  $R^2$  in the model obtained was 222.9 (0.357) and 0.49 respectively was found significant with the model prediction values. Hosmer and Lemeshow goodness-of-fit test revealed better model fit ( $\chi^2=13.52$ ,  $p=0.09$ ). Overall correct classification rate of the model was 85.6%. The best cut-off point optimizing sensitivity and specificity was found to be at 0.5.

#### *Animal 04 F*

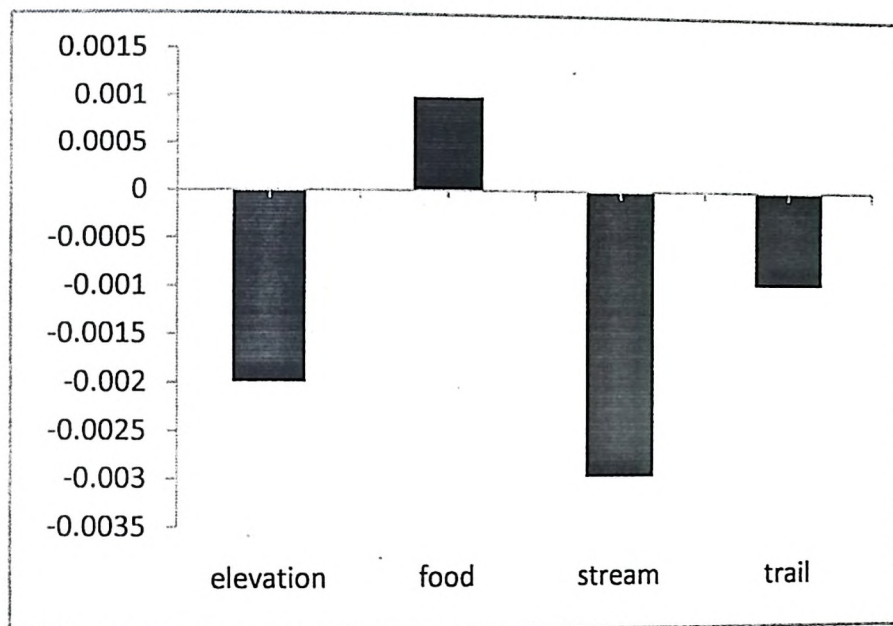
This female bear largely used areas closer to trails (Fig. 5.9) (Table 5.3). The negative predictors included steep proximity to stream, food and areas with higher elevations. Estimated -2 Log Likelihood (Cox and Snell  $R^2$ ) and Nagelkerke  $R^2$  in the model obtained was 313.8 (0.169) and 0.23 respectively was found significant with the model prediction values. Hosmer and Lemeshow goodness-of-fit test revealed better model fit ( $\chi^2=16.12$ ,  $p=0.03$ ). Overall correct classification rate of the model was 75.4%. The best cut-off point optimizing sensitivity and specificity was found to be at 0.5.

#### *Animal 00 F*

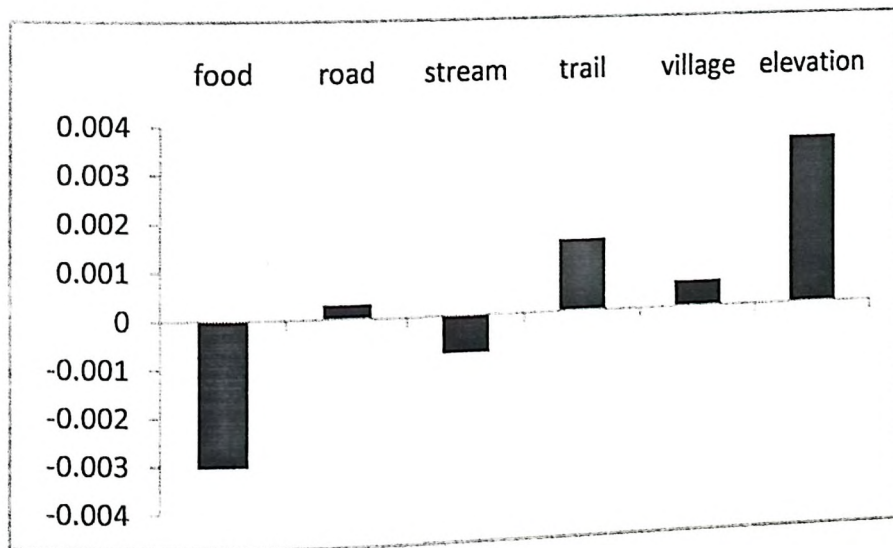
This female bear used areas at higher elevations and with close proximity to trail, road and village. The negative predictors included close proximity to stream and wild food (Fig.5.14) (Table 5.8). Estimated -2 Log Likelihood (Cox and Snell  $R^2$ ) and Nagelkerke  $R^2$  in the model obtained was 271.6 (0.53) and 0.7 respectively was found significant with the model prediction values. Hosmer and Lemeshow goodness-of-fit test revealed better model fit ( $\chi^2=23.6$ ,  $p=0.03$ ). Overall correct classification rate of the model was 90%. The best cut-off point optimizing sensitivity and specificity was found to be at 0.5.



Id 04



Id 02



Id 00

Figure 5.6. Effect of various habitat parameters on the habitat use of black bear (id) 04, 02 and 00 radio collared bears in Dachigam Landscape, 2009-2011.

**Table 5.4. . Logistic regression coefficients, standard errors, and Wald statistic for various habitat parameters of black bear ( id) 04, 02 and 00 radio collared bears in Dachigam Landscape, 2009-2011.**

Covariate	$\beta$ Coefficient	S.E.	Wald	Sig.
Elevation	-0.005	0.002	4.445	0.51
Food	0.000	0.001	0.077	0.04
Stream	-0.003	0.001	5.575	0.02
Trails	0.004	0.002	8.859	0.00

**Id 04**

Covariate	$\beta$ Coefficient	S.E.	Wald	Sig.
Elevation	-0.002	0.001	5.523	0.019
Food	0.001	0	52.658	0
Slope	0.063	0.018	11.614	0.001
Stream	-0.003	0.001	29.25	0

**Id 02**

Covariate	$\beta$ Coefficient	S.E.	Wald	Sig.
Food	-0.003	0.000	15.046	0.000
Road	0.000	0.000	0.952	0.329
Stream	-0.001	0.000	4.409	0.036
Trail	0.001	0.001	6.868	0.009
Village	0.001	0.000	3.375	0.066
Elevation	0.004	0.001	12.625	0.000

**Id 00**

#### *Animal 02 M*

This male bear used areas with closer proximity to wild food. The negative predictors included elevation, proximity to stream and trail (Fig.5.10) (Table 5.4). Estimated -2 Log Likelihood (Cox and Snell  $R^2$ ) and Nagelkerke  $R^2$  in the model obtained was 231.4 (0.5) and 0.76 respectively was found significant with the model prediction values. Hosmer and Lemeshow goodness-of-fit test revealed better model fit ( $\chi^2=5.97$ ,  $p=0.65$ ). Overall correct classification rate of the model was 87.8%. The best cut-off point optimizing sensitivity and specificity was found to be at 0.5.

#### *Animal 08 M*

This male bear used areas with higher elevations, closer proximity to wild food. The negative predictors included proximity to stream, trail and village (Fig.5.11) (Table 5.5). Estimated -2 Log Likelihood (Cox and Snell  $R^2$ ) and Nagelkerke  $R^2$  in the model obtained was 131.11 (0.09) and 0.13 respectively was found significant with the model prediction values. Hosmer and Lemeshow goodness-of-fit test revealed better model fit ( $\chi^2=10.36$ ,  $p=0.24$ ). Overall correct classification rate of the model was 64.1%. The best cut-off point optimizing sensitivity and specificity was found to be at 0.5.

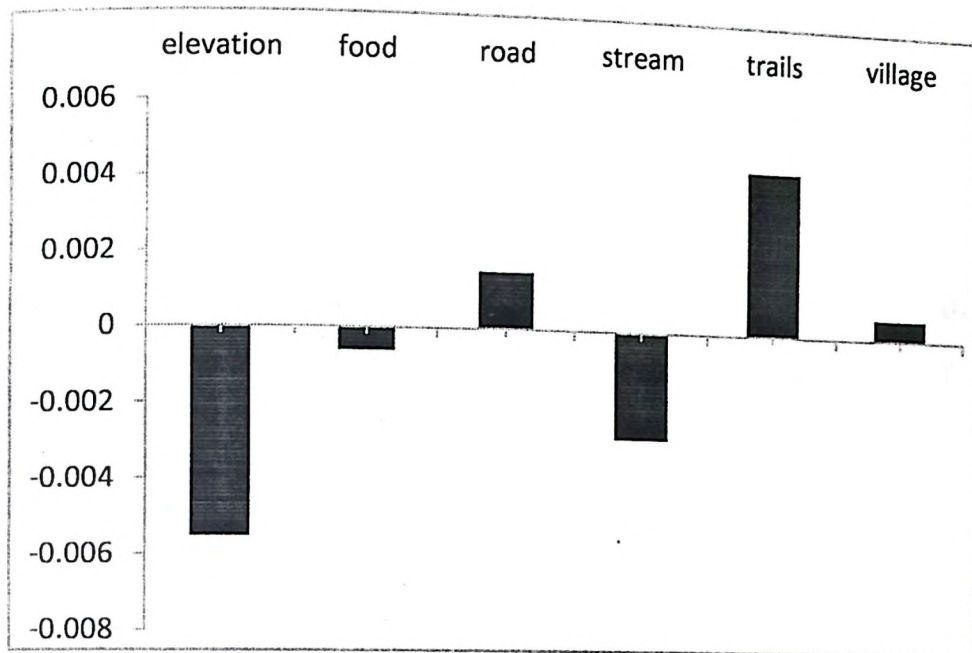
#### *Animal 10 M*

This male bear used areas with closer proximity to food, stream and areas with higher elevations. The negative predictors included proximity to trails (Fig.5.12) (Table 5.6). Estimated -2 Log Likelihood (Cox and Snell  $R^2$ ) and Nagelkerke  $R^2$  in the model obtained was 149.9 (0.026) and 0.35 respectively was found significant with the model prediction values. Hosmer and Lemeshow goodness-of-fit test revealed better model fit ( $\chi^2=7.92$ ,  $p=0.44$ ). Overall correct classification rate of the model was 75.5%. The best cut-off point optimizing sensitivity and specificity was found to be at 0.5.

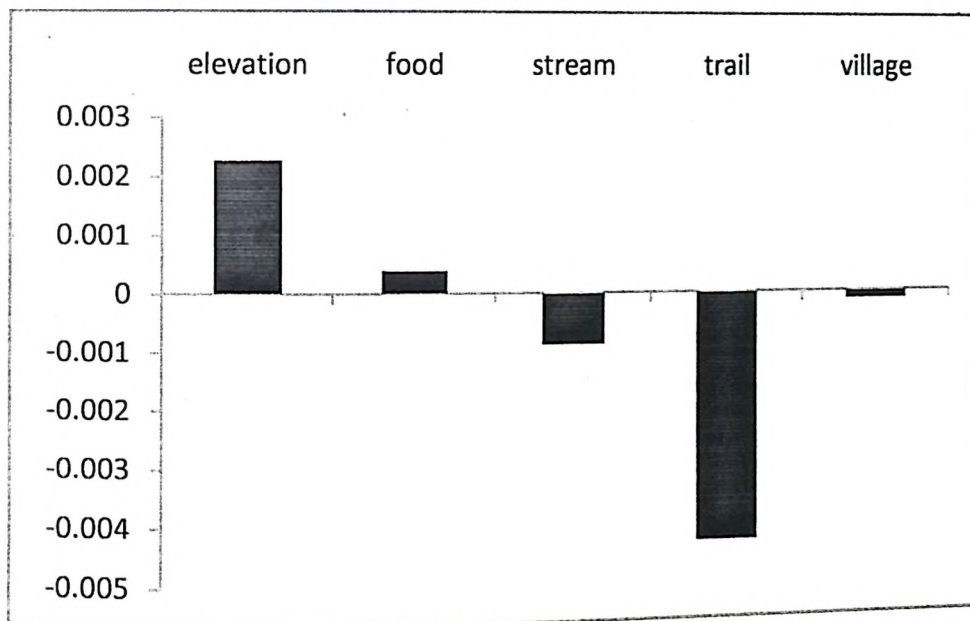
#### *Animal 100 M*

This male bear used areas with closer proximity to wild food and stream. The negative predictors proximity to trail and higher elevations (Fig.5.13) (Table 5.7). Estimated -2 Log Likelihood (Cox and Snell  $R^2$ ) and Nagelkerke  $R^2$  in the model obtained was 166.9 (0.023) and 0.31 respectively was found significant with the model prediction values. Hosmer and Lemeshow goodness-of-fit test revealed better

model fit ( $\chi^2=15.1$ ,  $p=0.56$ ). Overall correct classification rate of the model was 73.3%. The best cut-off point optimizing sensitivity and specificity was found to be at 0.5.



Id 06



Id 08

Figure 5.7. Effect of various habitat parameters on the habitat use of black bear (id), 06 and 08 radio collared bears in Dachigam Landscape, 2009-2011.

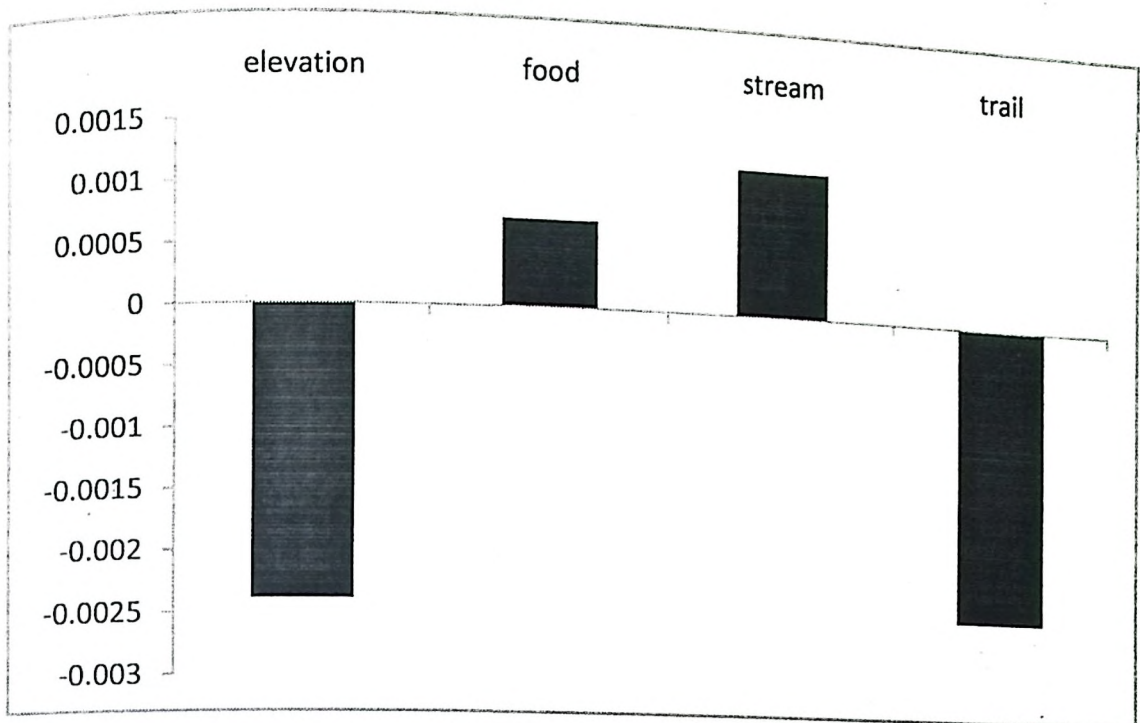
Table 5.5. Logistic regression coefficients, standard errors, and Wald statistic for various habitat parameters of female (id), 06 and 08 radio collared bears in Dachigam Landscape, 2009-2011.

Covariate	$\beta$ Coefficient	S.E.	Wald	Sig.
Elevation	-0.006	0.002	5.521	0.019
Food	-0.001	0.001	0.372	0.542
Road	0.002	0.001	4.123	0.042
Stream	-0.003	0.001	6.805	0.009
Trails	0.004	0.002	8.524	0.004
Village	0.001	0.000	3.047	0.081

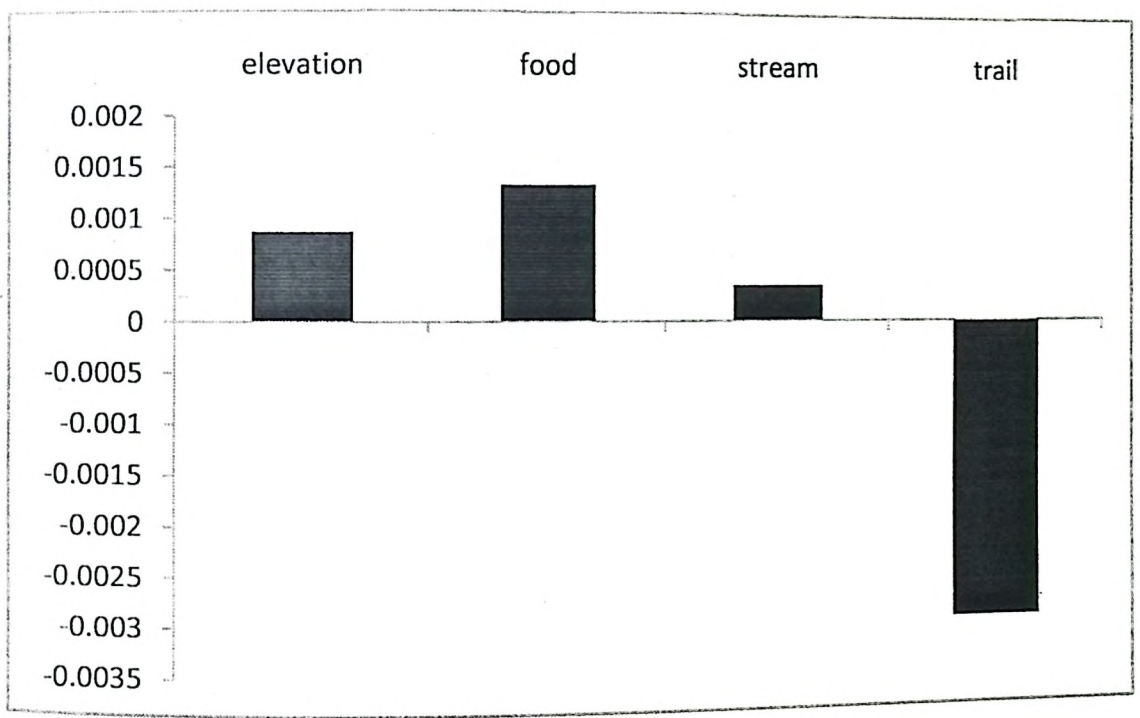
Id 06

Covariate	$\beta$ Coefficient	S.E.	Wald	Sig.
Elevation	0.002287	0.001462	2.44569	0.117848
Food	0.000405	0.001381	0.085936	0.769408
Stream	-0.00089	0.001701	0.272781	0.601472
Trail	-0.0043	0.002752	2.444901	0.117907
Village	-0.00014	0.000334	0.178857	0.672357

Id 06



**Id 100**



**Id 10**

**Figure 5.8. Effect of various habitat parameters on the habitat use of black bear (id) 100 and 10 radio collared bears in Dachigam Landscape, 2009-2011.**

Table 5.6. . Logistic regression coefficients, standard errors, and Wald statistic for various habitat parameters of female (id), 100 and 10 radio collared bears in Dachigam Landscape, 2009-2011.

Covariate	$\beta$ Coefficient	S.E.	Wald	Sig.
Elevation	-0.002	0.002	2.202	0.138
Food	0.001	0.001	1.093	0.296
Stream	0.001	0.001	1.569	0.210
Trail	-0.002	0.002	2.549	0.110

Id 100

Covariate	$\beta$ Coefficient	S.E.	Wald	Sig.
elevation	0.0009	0.0012	0.5612	0.4538
food	0.0013	0.0007	3.9253	0.0476
stream	0.0004	0.0009	0.1492	0.6993
trail	-0.0030	0.0015	4.0522	0.0441

Id 10

## 5.4 Discussion

Habitat selection by individuals reflects availability of basic necessities, such as food, water, and cover. The behavior and physiology of bears help them to inhabit a variety of habitats. The habitat use of black bears in wide range of conditions can be attributed to its physiology and feeding habits. Black bears in Western Himalayas go under hibernation to avoid harsh winters and this adaptation along with other ecological factors results in their use of different kinds of habitats differentially.

### 5.4.1. Habitat occupancy based on Camera trapping

The detection probability of a species is dependent on various factors and it changed across seasons in the present study. Seasonal changes in black bear habitat use have been widely documented and are primarily attributed to variation in food availability (Lindzey and Meslow 1977; Landers et al. 1979; Hugie 1982; Novick and Stewart 1982; Elowe 1984; Grenfell and Brody 1986; Pelchat and Ruff 1986; Young and Beecham 1986; Unsworth et al. 1989; Hellgren et al. 1991). The use of higher elevations by black bears in the spring season (based on the camera trap data) clearly depict the use of grasslands and other areas with new sprouted saplings/grasses and herbs. Black bears generally den at high elevations to avoid predators and during spring season the bears come out of the hibernation but are less active and especially females associated with the new cubs restrict their movements mostly at higher elevations. The other possible reason for bears using higher elevations with more ground cover is that higher elevation areas get herb and grass sprouts early compared to the lower elevations. As observed during the present study, black bears mostly feed on herbs during spring. Bears were found to feed on *Dipiscus mitis*, a herb abundant in the grassland at higher altitudes in the study area during spring season. The use of fresh sprouted grasses during spring has been documented for Asiatic black bears in other studies also (Hwang et al. 2002).

Summer proves to be the best season to detect the black bears in Dachigam National Park as highest encounter rates of both signs and sightings was recorded in this season (Discussed in Chapter 4). The best positive predictors for summer based on the best fit occupancy model of black bears were canopy cover, ground cover and shrub density. The areas with good proportion of canopy cover and shrub density are a measure of good food indicator. In summer, the food available to bears is mostly in the form of berries and fruits in the wild (Hashimota and Takatsuki 1997; Hwang et

al. 2002; Sathyakumar and Viswanath 2003). In the field bears were found feeding on berries and fruits of *Morus*, *Prunus*, *viburnum sp.*

In hyperphagia and soon after, black bears prepare themselves for hibernation. The onset of autumn, bears are busy in feeding on nuts/acorns of oak, walnut to store fat rich food. This season also experiences the bears going in higher altitudes in search of den sites. The use of higher elevations mostly to feed on oak acorns has been found common among the American and Asiatic black bears (Mattson 1998; Vaughan 2002; Costello et al. 2003; Hashimoto et al. 2003).

#### 5.4.2 Habitat use at Landscape level

In the present study, bears used the landscape wherein the forested habitats along with the agricultural lands, forested habitats were used by bears (Table 5.12). Bears moved out of the protected areas in search of food in agricultural lands. The use of agricultural land by Asiatic black bears has been documented in other earlier studies also (Huygens and Hayashi 1999). The complex topography in Japan similar to that of the present study area with agricultural lands and developed areas immediately adjacent to the bear habitats results in exploitation of human food sources by bears (Carr et al. 2002). Human-induced changes to the landscape such as forest management and clearing of land for agriculture or development, also affect the habitat use of bears (Hellgren and Maehr 1992; Mitchell and Powell 2003). The forested habitats were preferred over human dominated areas. Riverine habitat was significantly used by black bears in the area. This habitat provides resources in the form of food, water with appropriate canopy cover to avoid predators. The riverine habitat is abundant in the shrub species and provides a source of food for black bears in the area. Moreover, the presence of oak plantation in close vicinity of the riverine habitat also provides an attraction of black bears in the area. Black bears congregate in this oak patch during the autumn season to feed on the oak acorns. Although surrounding crop fields of Dachigam landscape also provided a source of food for black bears and bears utilize this resource by crop depredation but the natural food and forested habitats were a preferred over human food. The habitat types such as mixed forest and grasslands are also used by black bears. In addition to the food resources provided by these habitats habitat in the form of fruiting trees (*Juglans regia*, *Ulmus wallichiana*) and herbs also provide resting places, denning sites (Sharma 2012 unpublished). Human habitations were avoided by black bears.

Dachigam Landscape is a mosaic of forested habitats interspersed with human habitations. These habitations are a source of discontinuity between forested habitats. Forest fragmentation is known to have negative effects on the maintenance of viable populations of black bears (Hellgren and Maehr 1992; Hellgren and Vaughan 1994; Rudis and Tansey 1995).

#### 5.4.3 Habitat selection at individual scale

The selection of various habitat characteristics was unique to all the radio collared bears. A common pattern of habitat selection by all the bears did not come out in the results and can be attributed to the capture site where bears were trapped for collaring and clumped information of different seasons. Although bears are not territorial in behaviour but in the present study the radio collared bears preferred to move back into the areas where from they were captured for the first time. The collaring of rescued bears from the surrounding areas mostly near human habitations provided an opportunity to understand their behaviour after their release in to the forested habitats.

**Table 5.7. Details of Collared black bears: Sex, Site of capture and last location in Dachigam landscape, 2009-2011**

Animal (ID)	Sex	Site of Capture	Last detection site
04 F	Female with cub	Dachigam National Park	Dachigam National Park
08 M	Male	Dachigam National Park	Dachigam National Park
100 M	Male	Dachigam National Park	Dachigam National Park
02 M	Male	Outside Dachigam National Park	Outside Dachigam National Park
00 F	Female	Outside Dachigam National Park	Outside Dachigam National Park
06 F	Female	Dachigam National Park	Outside Dachigam National Park
10 M	Male	Outside Dachigam National Park	Dead in den

The habitat use pattern of Dachigam landscape by bears indicated that conservation planning of bear habitats should be at the landscape level, the approach of protected area conservation is not sufficient for long ranging species like bears. The data was not sufficient to analyse and understand the pattern across various seasons. As season plays an important role in habitat selection for bears, the present results based on the radio locations may not be justifiable with their selection of habitat characteristics in the landscape. The preference of various habitat factors by Asiatic black bears can be detrimental to the site and individual as has been documented earlier also (Honda et al. 2009; Liu et al. 2009).

04F: This female with a cub of the year was captured, collared and released back in the Dachigam National Park. The areas at high elevation were avoided by this female as the trails were used by the female to move between areas for easy and safe access. The areas close to food patches and streams were also avoided by this animal probably to avoid confrontation with other bears and predators.

02M: This animal was rescued from a nearby area (1 km from the boundary of National Park) and radio collared and released back in Dachigam National Park. The animal stayed in for some time and went back on other side of the boundary of to the human habitation connected to Dachigam National Park. It avoided areas with higher elevation, stream and trails. The areas close to the food patches in Dachigam (riverine habitat) were used by this bear.

00F: This animal was rescued from Aulstang, a nearby area, radio collared and released in Dachigam National Park. The animal was in Dachigam National Park for some time and went back to the same place it was rescued. The animal avoided areas close to wild food and streams and used resources close to villages

06F: This bear was captured from Dachigam National Park, radio collared and released back and it spent most of the time outside. This animal moved to a nearby place Dara and hibernated in Kangan. This animal was back to Dachigam National Park in autumn and then went back to Kangan for hibernation. This animal may have come to Dachigam National Park to feed on oak acorns before going in hibernation.

08M: This male bear resided in Dachigam National Park. The animal preferred the areas with higher elevations and close to wild food. It avoided human dominated areas and preferred to be in forested habitats with natural food.

100M: This male was captured and stayed within the Dachigam National Park. With the presence of food in the forested habitats, the bear did not go out to the human habitats. It used the riverine area of the national park mostly, the area with sufficient food resources and did not prefer high elevation areas.

10M: This male was captured within the national park and was found to use areas within the national park. The bear did go outside but before the onset of the winters came back to the Dachigam National Park. The animal used areas with high elevation with sufficient food abundance. The animal was found dead in a den in spring.

The opportunity of using various methods in understanding habitat use patterns of Asiatic black bears was helpful. The use of radio tracking data provided an insight of the movement and use of various habitat types in Dachigam Landscape. The patterns of habitat use by black bears in the landscape can be base line information for land use management in the landscape. The use of an appropriate technique can be useful in devising management strategies. The sampling scheme should be considered before taking into consideration because improper sampling may lead to misleading ecological inferences and biased conservation actions.



Plate No. 3: Camera trap picture of Asiatic black bear at Dachigam National Park during 2009-11.

## CHAPTER – 6: BLACK BEAR – HUMAN CONFLICTS.

### 6.1. Introduction

The interaction of humans with wild animals especially large ranging carnivores lead to conflicts worldwide. Conflicts between humans and wildlife in India are escalating due to increasing human population, loss of natural habitats, and in some regions, increasing wildlife populations as a result of successful conservation programs (Rodgers 1989; Saberwal et al. 1994). The intimate interspersed of people in protected areas often results in conflicts between humans and wildlife (Rodgers 1989). Most wildlife protected areas in India support various forms of land use, such as agriculture, livestock grazing, and collection of minor forest produce. Human-wildlife conflicts are acute when the species involved is highly imperiled while its presence in an area poses a serious threat to human welfare (Saberwal et al. 1994). Although humans and carnivores have co-existed for a long time but the frequency of conflicts have increased in recent decades as a result of increased human activities in wildlife areas or on natural habitats (Graham et al. 2005; Bulte and Rondeau 2005).

Multiple studies have shown that carnivore populations are limited by human interventions. The species with conflicts with humans are more prone to extinction. Conflicts with people have lead to extinction and eradication of certain wild species (Woodroffe et al. 2005). In certain cases where local extinctions are not any how possible, the local decline suppressed populations and restricted distribution are the secondary outcomes. Brown bears, lynx and wolves had disappeared from most of Western Europe by the end of the nineteenth century (Woodroffe 2001). Such human-induced mortality affects not only the population viability of some of the most endangered species, but also has broader environmental impacts on ecosystem equilibrium and biodiversity preservation.

Black bear - Human interactions are not a local, small-phenomenon, but an issue that spans diverse arrays of geographic and human demographic contexts. Bears typically compete directly with humans for resources such as space, food, security and cover and are reported to be involved in interaction with humans throughout their distributional ranges (Garshelis 1989; Huygens and Hayashi 1999; Sathyakumar 2003; Bargali et al. 2005; Fredriksson 2005; Smith et al. 2005; Mordo et al. 2008;

Yadav et al. 2009; Charoo et al. 2011). Bears have the highest brain to body mass ratio of all carnivores (Gittleman 1986), and bear behavior is highly influenced by learning (Herrero 2002). Positive interactions in which bears gain rewards from human food sources can lead them to adapt and utilize human food sources. This behavior has the potential to perpetuate through generations, often resulting in conflicts with humans (Gilbert 1989; Beckmann and Berger 2003). Black bear-human interactions bear long existence as humans and black bears overlap much in resource sharing. Almost all bear species kill or injure livestock, damage agricultural or horticulture crops, or otherwise directly compete with people (Herrero et al. 1999).

Asiatic black bear – human interactions are known to exist throughout its distributional ranges (Stubblefield and Shrestha 2007; Choudhury et al. 2008; Charoo et al. 2011; Honda et al. 2009; Yadav et al. 2009). Asiatic black bear is known to cause damage to agriculture and horticulture crops, apiaries, fish farms, livestock and human beings throughout its distributional range (Hazumi 1994; Huygens and Hayashi 1999; Chauhan 2003). In the Himalaya, black bear – human interactions have been reported in past (Prater 1980), but the intensity of such reports have increased in the recent years (Sathyakumar and Choudhury 2007). Increase in human population and recent developments are associated with the increase in bear- human interactions (Beckman and Berger 2003). The changes in land use patterns (extending agricultural/horticultural farmlands, encroachments and disturbances in bear habitats) and developments due to increase in human population around bear habitats have led to an increase in black bear - human interactions in the Himalayan landscape (Sathyakumar 2001; Sathyakumar and Choudhury 2007). The Himalayan region and the hills of northeast India cover *ca.* 591,800 km<sup>2</sup> (18% of India) and probably holds one of the largest population of black bears in Asia (Sathyakumar 2001; Sathyakumar and Choudhury 2007). In the Indian Himalaya the best known populations of Asiatic black bears are reported to be present in the State of Jammu and Kashmir. Although no authentic population estimates exist but Dachigam National Park and its adjoining protected areas are reported to hold good number of Asiatic black bears (Sathyakumar 2001). These high density black bear areas pose a serious bear- human interaction management problem. The movements of bears and humans in natural and man-made habitats for resource use have led to increased incidences of bear-human encounters. The present study was initiated with the following objectives in mind: to estimate

these interactions in the landscape at a finer scale in a high density black bear area, to understand the possible reasons for these intense black bear – human interactions and to provide recommendations measures to mitigate the conflict in the landscape.

## **6.2. Methods**

Informal interviews using semi-structured questionnaires were conducted in the villages located at the periphery of Dachigam National Park (Fig. 5.1). Interviews were mostly interaction based; however, the information was recorded in the pre-designed formats. In each village, a stratified sample of households was selected by compiling census data of village households and by adopting participatory rural appraisal (PRA) techniques (Richards et al. 1999). Based on economic status, the government of India has classified households into 2 groups: below poverty line (BPL) families have annual incomes <20,000 Indian rupees (INR) and above poverty line (APL) families have annual incomes >20,000 INR (Planning Commission of India 2008). In villages adjoining Dachigam landscape, families were categorized as either APL or BPL, and they were generally equal in proportions. Because only 5 families (households) were sampled in each village, 3 families were selected from whichever group exceeded 50% of the population in that village. Information on black bear encounters (number, place, and time), cropping pattern, crop damage, livestock depredation, attacks on humans, protection measures, forest dependency (fuel wood/fodder collection and livestock grazing) and reaction during close encounters, was collected from each family interviewed. We conducted field investigations (n = 87) on crop depredations, attacks on humans, and livestock depredations.

Black bear–human interactions were categorized as

- (1) Crop damage, (2) Attacks on humans, or (3) Livestock depredation.

### **6.2.1. Crop damage**

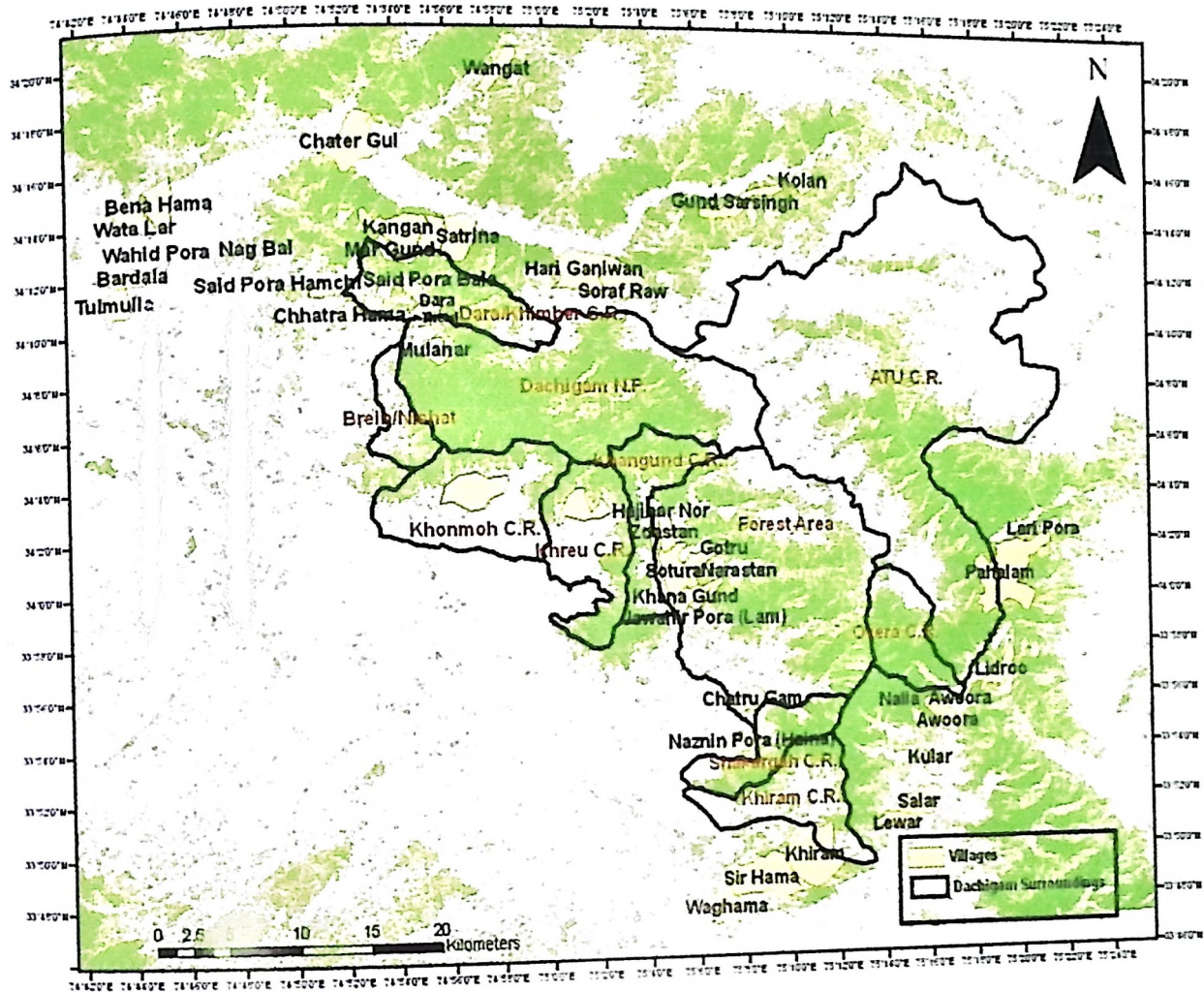
Information on crop damage (crop type, part eaten, month), GPS location, elevation, and approximate distance from the nearest bear habitat was recorded for each crop damage case.

The type of protection measures used to scare off bears was also recorded.

### **6.2.2. Attacks on humans**

For bear attacks on humans, month, time, and location as reported by the victim, family members of the victim, or a witness were recorded. The location of the

bear attack, altitude, and distance from the nearest forest was recorded by visiting the site of encounter. Each of the respondents was asked to provide information on the reaction and precaution during close encounter with bears.



**Figure. 6.1.** Area surveyed for assessment of Black bear – human interactions in Dachigam Landscape, 2007-2009.

### 6.2.3. Livestock depredation

In case of livestock depredation, the number of livestock depredated, location, distance from nearest bear habitat, time, month and number of bears involved in the depredation was recorded.

In addition to the above information on forest dependency in the form of livestock grazing, going in to forest for minor forest produces was collected. The number of bears visiting the place, sex if possible or unidentified incase the respondent was not sure about the identification was recorded from each of the household interviewed.

To understand the spatial distribution of bear-human interactions, the GPS locations of the conflict cases recorded during the conflict survey were plotted on the imagery of the Landscape using Arc GIS 9.3 (ESRI 2006) after converting geographic

locations into Universal Transverse Mercator (UTM) projection in 43 UTM zone and WGS48 datum. According to Walden Tabler's (1970) "First law of geography" states that "everything is related to everything else, but the near things are more related (spatially autocorrelated) than distant things". The Getis-Ord clustering statistics (Hotspot analysis) has been used to study such spatial clustering in studies related to social science and medical studies (e.g., Glavankov et al. 2001; Burra et al. 2002; Vazquez-Prokopec et al. 2005) but in the recent past it have been used in wildlife science studies also (Mordo 2007). In the present study, bear human conflict was mapped using the Getis-Ord  $G_i^*$  hotspot statistics method in ArcMap 9.3 using spatial statistics tool (ESRI) defined as :

$$G_i^* = \frac{\sum_j W_{ij}(d)X_j}{\sum_j X_j} \quad j \text{ may equal } i$$

Where  $G_i^*$  measures the degree of association in variables  $X$  for  $j$  points located within distance  $d$  of the focal point  $i$ , including  $i$ , as compared to the total value of all  $j$  points across the study area (Getis and Ord 1992). The binary weight matrix  $W_{ij}$ , equals 1 if  $j$  is within distance  $d$  of  $i$  and 0 otherwise. Once  $G_i^*$  is calculated for each point, it is redefined as a standard deviate value for each point by subtracting the mean, or expected  $G_i^*$ , and dividing it by the standard deviation (Getis and Ord 1996). The resulting  $G_i^*$  statistic will assume positive or negative values when clustering is higher or lower than expected, and  $G_i^*$  values can be defined as significant if they are within more than  $\pm 2$  SD of the mean (the two-sigma rule) (Anselin 1995).

The selection of the grid cell size in the present study was decided by considering the average home range of black bear in the landscape i.e., 4x4 Km as revealed by the radio collaring data. The clustering pattern of conflict cases in the landscape was used to represent the intensity of conflict such as high, medium and low conflict pattern.

### 6.3. Results

A total of 227 respondents were interviewed around Dachigam landscape. Black bear- human interactions were more frequent on the northern region of Dachigam National Park. About 72% of the villagers interviewed claimed to be

dependent on the forest produces and about 56% were below poverty line status. A spatial pattern of bear- human interactions is indicated in Fig. 6.1. The bear- human interactions were more intense in close vicinity of bear habitats (Fig. 6.2) at the altitudinal ranges of 1800- 2200m (Fig. 6.3). The bear – human interactions span from May to December (Fig. 6. 4). Crop damage turned out to be the most common form of bear – human interaction in the area. We plotted the three types of human-black bear interactions (i.e. crop depredation, bear attacks on human, and livestock depredation) on the map of Dachigam Landscape.

### 6.3.1. Cropping pattern and damage

The cropping period in Dachigam Landscape spans from May to December with the peak production of crops and fruits during summer (i.e. production of cherry May-July, maize August - October, apple production is from October -December). The most common type of conflict recorded was crop depredation by black bear. About 85% of the villagers interviewed reported crop depredation by black bear. The areas close to the bear habitats were more prone to raiding by black bear. Crop damage varied in different months (Fig. 4). Summer being the most productive season for most of the agricultural and horticultural crops in the area, had maximum number of crop damage cases (87%) followed by autumn (9%) and the remaining in winter. Most of the crop depredations occurred in August and September (70%) that coincides with the production of maize and apple, followed by June and July (12%) for cherry. During October and November, there were fewer cases (9%) and the instances of crop depredation declined as autumn progressed, with only 3% of cases reported in December (winter).

The various crop protection measures adopted by the villagers to scare off bears included: drumming empty tin or metal containers, putting up scare crows, keeping guard dogs, barbed wire fencing and animal-proof walls. Drumming empty tin/metal containers was the most commonly used protection measure, as 74% respondents reported using this technique, followed by use of barbed wire fencing (17%), scare crows (29%), guard dog (7%) and animal-proof wall (4.8%).

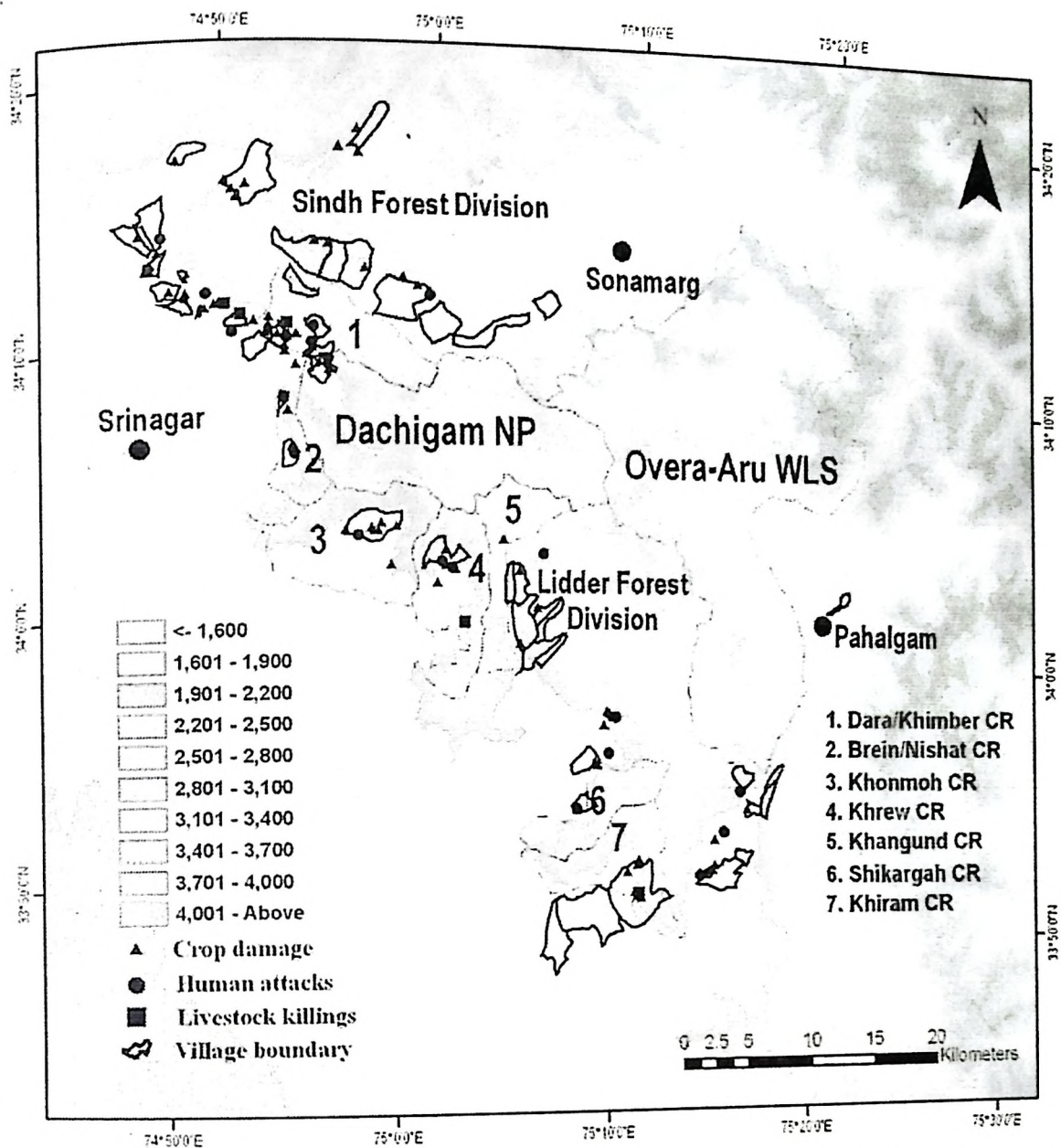
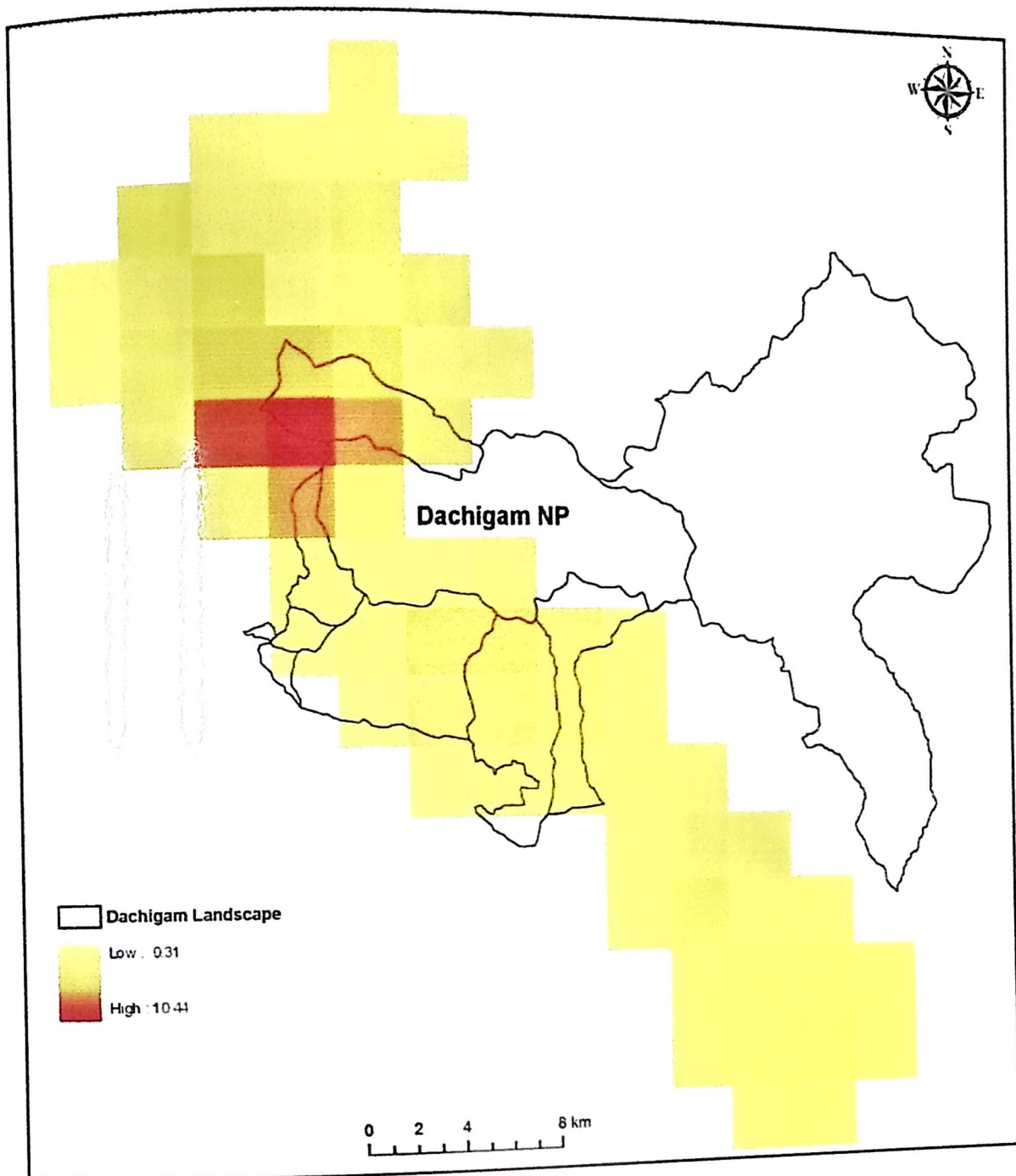


Figure. 6.2. Map of the Dachigam landscape in Kashmir, India, with conflict locations and human habitations. (NP – National Park; WLS – Wildlife Sanctuary; CR – Conservation Reserve).



**Figure. 6.3. Map showing the intensity of black bear- human conflicts in Dachigam Landscape, 2007-2009.**



**Plate No. 4. Crop protection measures adopted by villagers (Clock wise from top left) barbed wire fencing, human watch, cemented wall, watchtower, drumming of empty tin/metal containers.**

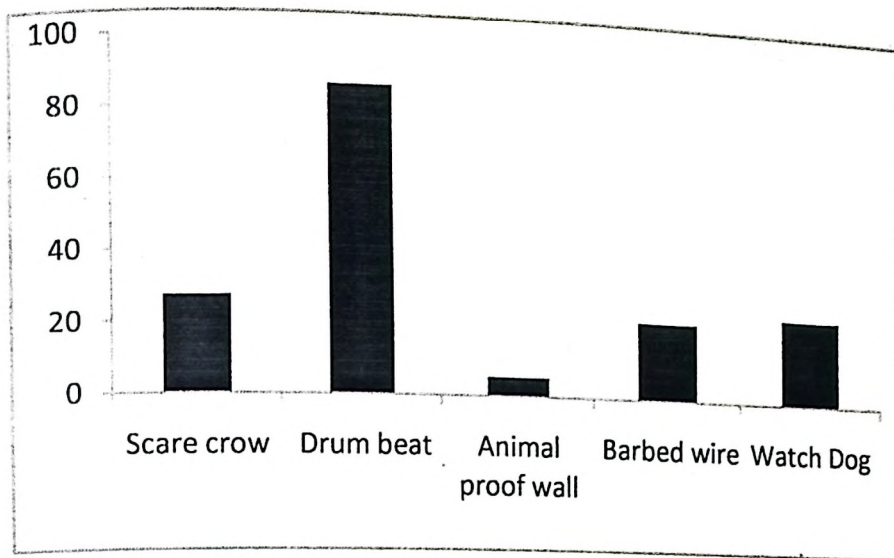
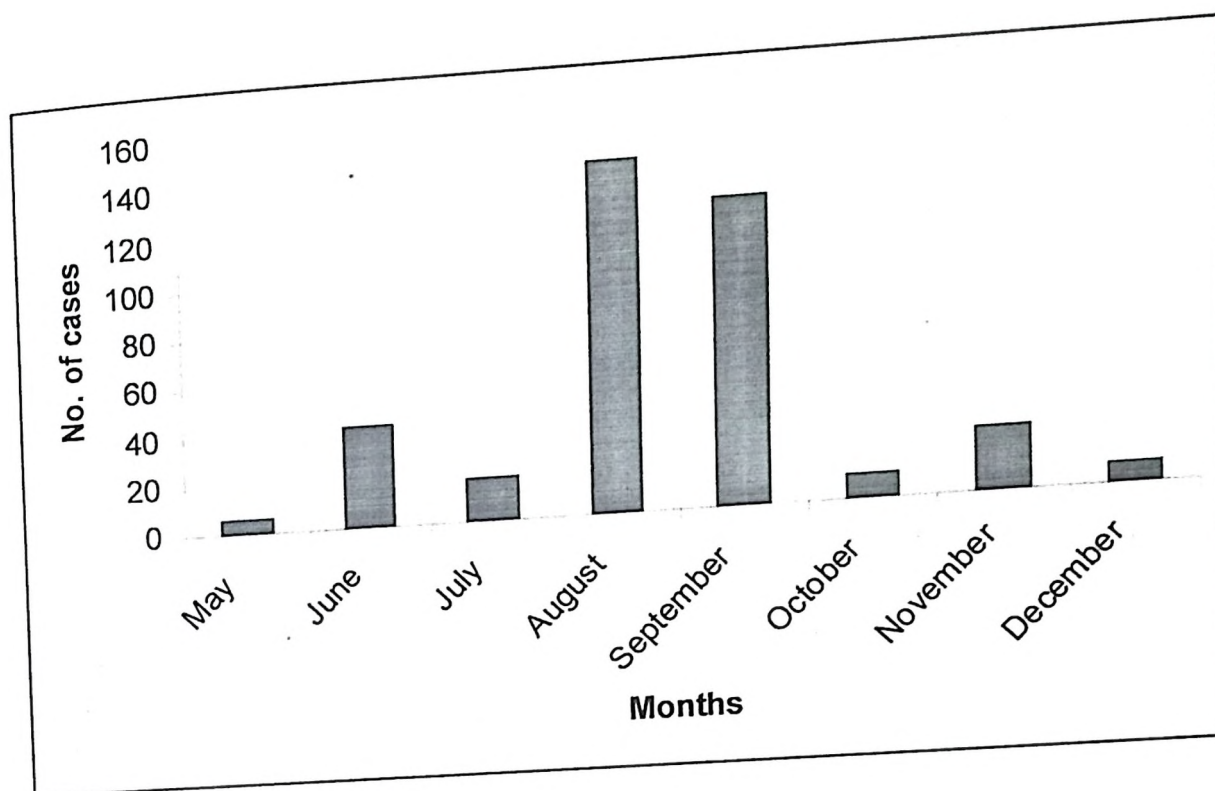


Figure. 6.4. Graph showing the percentage use of different protection measures by locals to minimize crop depredation

Table. 6.1. Crop damage patterns of common crops depredated (monthwise) by black bears in Dachigam Landscape.

Crop	J	F	M	A	M	J	J	A	S	O	N	D
Apple										■	■	■
Almond						■	■					
Cherry					■	■						
Maize								■	■			
Walnut								■	■	■		



**Figure. 6.7. Black bear- human interactions in different months around Dachigam Landscape, India, as reported by respondents to a questionnaire survey (n= 227), May 2007- April 2009.**

### 6.3.2. Attacks on humans

A total of 19 attacks on humans were recorded during the survey (May 2007- April 2009). Most of the bear attacks were on people working in crop fields [n=13; (68%)] followed by people working in forests for resource use [n=4; (21%)] and about 10% of cases (n=2) occurred in villages. Bear attacks occurred during the period May to November. Most of the cases (61%) occurred in summer followed by autumn (22%), spring (8%) and winter (9%). Over 60% of the attacks occurred during crepuscular period, 25% during day time, and 15% during night. The intensive periods of bear-human interaction corresponds well to the periods of increased human activity. Major cultivation activities in the area between May – December, increases human movement in summer and autumn and probably makes humans vulnerable to bear attacks. During the interviews local people claimed black bears more active in the crop lands during crepuscular time resulting in more number of casualties during these hours.

Bear attacks were mostly in crop fields and orchards (63%) followed by in forests (22%) and in villages (15%). Over 59% of the attacks occurred during crepuscular period (dawn & dusk), 26% during day time, and 15% cases occurred during night (Fig.). Most of the cases (52%) occurred during summer followed by

autumn (26%), spring (11%) and winter (11%). The low number of cases during winter may be due to less human activity in the croplands and bears are also either hibernating or were less active.

The number of bear-human conflict cases was high at crepuscular periods and during summer and autumn seasons as human activity is also high in agricultural fields and orchards during these periods when people are either going for work or returning after work.

### **6.3.3. Livestock depredation**

The number of livestock killed by black bears within the surveyed localities during 2007-09 was 28 in 7 incidences. Of these, 19 livestock were killed by black bears during nights in cattle sheds or night shelters and three were killed in forest. Livestock depredation by black bear in cattle sheds or night shelters have been reported from Nepal also (Yadav et al. 2009). Most of the livestock killings (n=21) occurred in winter, possibly due to non-availability of food. Of the 21 number of livestock killed in winter, 11 were killed by a black bear in a single incidence.

### **6.3.4. Spatial pattern of Black bear – human interactions in Dachigam Landscape**

The intensity of black bear – human interactions in the landscape was more intense in the areas around northeast and southern boundary of Dachigam Landscape. Southern part of the landscape had less intense conflict compared to the northern part of the landscape.

## **6.4. Discussion**

Black bear-human interactions have been reported to be on an increase in the recent past in Kashmir. Choudhury et al. (2008) also indicated the same pattern and recognized Dachigam landscape as a high conflict zone. As like other parts of the Kashmir Valley, in Dachigam landscape the expansion of habitations towards the forest fringes have increased the frequency of encounters between humans and bears. There are reports of such high levels of bear-human interactions at the interface of wild and developed areas (Beckman and Berger 2003) and are expected to be at more risk for these interactions (Honda et al. 2009). The developmental activities by humans at edges or interfaces in suburban landscapes make them more prone to bear-human conflicts (Morodo et al. 2008). The active sharing of resources between

humans and bears as revealed in present study is leading to the close human- bear interactions. Attraction for food resources is claimed to be the primary reason for bear- human interactions (Bargali et al. 2005; Honda et al. 2009). Crop lands adjacent to the forested areas provide unintentional attraction to high quality food for bears. Crop damage was reported to be the most common type of bear-human interaction in Dachigam Landscape. Almost all the agricultural lands and orchards at the fringes of Dachigam landscape were raided by black bears. The fragmented habitats with adjacent human habitations and croplands/orchards increase the close interactions between humans and bears (Bargali et al. 2005). Crop raiding by black bears in this landscape has been documented in earlier studies (Prater 1980; Chakarborty 1983). The recent changes in agricultural practices from low crops to orchards adjacent to these high density bear habitats (Choudhury et al. 2008) have compounded the problem of crop depredation leading to high economic losses to the farmers. Summer being the most productive season for orchards and croplands in Kashmir Valley and the most active season for black bears, crop damage was at its peak. The secondary effects of attraction of bears towards human food (agricultural lands/dump sites) are attacks on humans. Black bears are known to be involved in livestock depredations in their distributional ranges (Chauhan 2003; Yadav 2009) in cattle sheds or during grazing. The economic losses in the form of livestock depredation or crop damage have always been negative to conservation for bears. The attacks on humans by bears are the most serious concern of all the types of bear- human interactions. The determination of local people towards bear conservation becomes difficult. The management of bear – human interactions is an issue for the future and particularly for the wild habitat- human developing landscapes.

### **6.5. Management recommendations**

Based on the interview data and field surveys carried out around Dachigam Landscape during 2007-09, some basic understanding of the black bear-human interactions in this region has been obtained. Some patterns have been observed and these need to be monitored in future to guide management interventions that reduce human-bear conflicts. Some measures/improvements based on the current study and after the evaluation of some conflict situations by visiting the rescue operations. These suggestions were categorized into three types based on the situation and evaluation:-

### **6.5.1. Incident response**

#### *Strengthening of Conflict Management Team*

A fully equipped, well trained and motivated 'Conflict Management Team' comprising of wildlife staff, veterinarians, staff of related line departments or institutions and wildlife NGOs has been formed at the Wildlife Division Level to respond to conflict situations, including bear rescue, treatment (if required), translocation and monitoring. Efficient and effective response to complaints is now more feasible when rapid communication is possible from and to the interaction site and between the personnel of the Conflict Management Team and when duties are shared amongst the members of the Team.

### **6.5.2. Monitoring**

#### *Black Bear-Human Interactions Database Development and Maintenance*

The patterns of black bear-human interactions in a large landscape both in spatial and temporal scales will be extremely important to understand underlying causes and to plan a strategy for mitigating close bear-human interactions. For instance, in the State of Alaska, U.S.A, a century (1901-2000) of bear-human conflict database has been maintained (Smith and Herrero 2008) based on which analysis, management actions and awareness education have been proposed and implemented. It is extremely important for the Department of Wildlife Protection, Jammu and Kashmir State to develop and maintain a database on conflicts for its different regions using GIS. It would be necessary to distinguish causes and symptoms of bear-human interactions.

### **6.5.3. Resident behavior**

#### *1. Awareness Creation*

Awareness creation in the form of do's and don'ts through elected bodies at the village or block levels, religious or educational establishments, and other government or non-governmental agencies are already in practice and should be continued. Restricted movements during crepuscular periods in farm lands and forests during summer and autumn may be help in reducing bear attacks on humans as revealed by present study. During rescue operations, a need was felt to make people aware of providing safe passage or escape route to stranded bears and not to involve themselves in man handling with bears.

## *2. Reducing livestock depredation by Black Bear*

As most of the livestock depredations had taken place at the night shelters in the villages, we realized the necessity of strengthening the doors, windows and other vulnerable portions of these night shelters to reduce loss due to predation by black bear and leopards. Some villagers who adopted our suggestion to replace the wooden doors of livestock night shelters with metal doors succeeded in not losing any livestock to black bear or leopard. Also use of guard dogs (Andelt and Hopper 2000) and supervised livestock grazing has been recommended to reduce livestock depredations (Chauhan 2003) when taken for grazing in bear habitats.

## *3. Strengthening of local and traditional black bear deterrent methods*

We suggest a village level cooperative effort for guarding of crop fields and orchards on a rotational basis using the effective means of scaring bears such as drumming empty tin/metal containers. Proper lighting in the corners or boundaries of crop fields and orchards particularly the vulnerable points lying close to forest fringes may be another option that may help to reduce crop depredation as observed in a few cases during the survey. The traditional methods as already in practice may be helpful when used in combinations. The traditional method of burning red chillies mixed in cow dung practiced in Uttarakhand State was experimented in many orchards of the villages at the periphery of Dachigam National Park. This traditional method was found to be effective in preventing bears from entering fields and therefore recommended for the use by local villagers.



**Plate No. 5: (a) Black bear near a crop field in Tulmul village near Dachigam National Park and (b) Problem Black Bear tranquilized by Wildlife Department personnel for capture and translocation**

## CHAPTER 7: CONCLUSION AND MANAGEMENT IMPLICATIONS

### 7.1 Conclusion

Bears are known to adapt to the environmental conditions and more or less to the human impacts on their habitats. The adaptability of black bears in particular as they share the resources with humans compared to other species appears to allow for flexibility in their behavioral responses to variation in landscape and habitat at multiple spatial scales. However, the unavoidable circumstances have led to conflicts with humans in much of their distributional ranges. The results of the present study provide a basic understanding of the resource needs in the form of sustaining habitats for this species.

The results are useful for beginning to understand the effects of fragmentation and habitat management on diet, space-use, and habitat selection, and for developing a sound conservation strategy for the black bears in Dachigam Landscape. The presence of food resources believed to be the main attraction of black bears in an area was well documented by this study also. The radio collared bears provided an insight that they tried to be in an area with sufficient food and preferred it to be the natural wild food. However, it was also clear by the results that availability of the secure and close resources of human food may also lead them to utilize it. Further the congregation of black bears in the autumn in the oak patch within Dachigam National Park also suggests that bears prefer natural food over human food with a condition to its availability within forested habitats. Habitat differences at a finer scale also may be important in modifying space use, habitat selection, and diet. For a long ranging species such as the black bear the conservation strategies have to be prioritized at the landscape level rather than at the protected area level. The current and future forest management practices in the study areas have to be focused on habitat improvement in the form of food availability and less human interference at the landscape level.

Dachigam landscape is known for a highly dense population of black bears and the results showed the same. It is the combination of superabundant food in adjacent agricultural fields and a diversity of abundant soft and hard mast within the forests that allows for the unique situation in this area. Abundant food resources are often negatively correlated with home range size in mammals (Litvaitis et al. 1986),

including black bears (Powell et al. 1997). It has been found that a combination of natural and human-induced forest fragmentation leads to increased home range size and movements of bears to locate suitable habitat. However, if food is abundant and diverse, then fragmentation may have the opposite effect and lead to smaller home ranges and increased population density even in areas with very little remaining habitat (Mollohan and LeCount 1989). This could explain the space use patterns and high density of bears observed in Dachigam National Park, with food as the mitigating factor. This phenomenon may allow bears to persist on with the involvement of current and future habitat restoration efforts are successful in substantially increasing the amount of forested land in the area. The future management practices need to protect and restore large, contiguous forested habitat for black bears in the landscape and elsewhere in the distributional range of black bears that may provide a strategy for managing bears in areas where habitats are already highly fragmented. The contiguity of forested tracts with the forested habitat interspersed with agricultural fields will allow increased movement and successful dispersal of bears, while maintaining abundant food resources. The isolated populations should be connected as it appears that movement of bears between the subpopulations is relatively rare and can have an impact on the gene flow between the populations.

Conflicts with humans have become an increasing priority in management and conservation of large carnivores including bears. Consequently, a greater understanding of spatiotemporal trends of conflicts and their predictors is warranted in order to efficiently allocate resources and apply targeted management. Based on the present study following observations and recommendations are suggested for conflict mitigation in Dachigam Landscape.

## **7.2 Black Bear-Human Conflicts Database Development and Maintenance**

The basic step towards understanding and developing mitigation strategies for reducing black bear-human conflicts in this landscape and elsewhere in the State would be the development and maintenance of a database. The patterns of black bear-human conflicts in a large landscape both in spatial and temporal scales will be extremely important to understand underlying causes and preventing conflicts. For

instance, in the State of Alaska, U.S.A, a century (1901-2000) of bear-human conflict database has been maintained (Smith and Herrero, 2008) based on which analysis, management actions and awareness education have been proposed and implemented. It is extremely important for the Department of Wildlife Protection, J & K State to develop and maintain a database on conflicts for its different regions using GIS. It would be necessary to distinguish causes and symptoms of bear-human conflicts. Changing land use patterns, development and use of black bear habitats by humans are the causes, while un-natural behavior, human habituation are the symptoms.

Database on number of conflict cases reported during 2007 and 2008 has been developed through this study and the same is being suggested to be adopted by the Department of Wildlife Protection J&K Govt.

### **7.3 Creation of Conflict Management Team**

The Department of Wildlife Protection, J & K State, has recently, initiated some management activities to deal with black bear-human conflicts. These include: payment of *ex gratia* to the victim's family who suffered loss due to black bear; and capture and translocation of bears from affected areas into the wild. In some cases, injured bears were captured, treated and then released back into the wild. A fully equipped, well trained and motivated 'Conflict Management Team' comprising of wildlife staff, veterinarians, staff of related line departments or institutions, and wildlife NGOs has to be formed at the Wildlife Division Level to respond to conflict situations, including bear rescue, treatment (if required), translocation and monitoring. Efficient and effective response to complaints is more feasible when rapid communication is possible from and to the conflict site and between the personnel of the Conflict Management Team and when duties are shared amongst the members of the Team. Control rooms have been established at district level and conflict management teams are established by the department at divisional level for handling wildlife-Human conflict cases. In addition to that the state government has constituted a committee to deal with Man-Animal Conflict cases under the Chairmanship of Commissioner/ Secretary. A coordination committee headed by Principal Chief Conservator of Forests has also been constituted for the better coordination with the Forest Department to handle problem in forested areas outside PAs. The assistance of Police is also taken by the department to tackle the problem. The better co ordination

of these teams and organizations can help in mitigating the loss of human and bear lives and thus mitigate the conflict.

#### **7.4 Awareness Creation**

Knowledge on black bear behavior is essential for the villagers who live near bear habitats and suffer crop losses and are also vulnerable to bear attacks. Awareness creation through elected bodies at the village or block levels, religious or educational establishments, and other government or non-governmental agencies needs to be explored. Simple precautionary measures such as avoiding moving singly during dawns and dusks in crop fields or orchards or forests during summer and autumn could greatly reduce bear attacks on humans. Avoiding potential denning areas and sites with high bear food abundance in different seasons by the people would minimize bear-human encounters in bear habitats. Another crucial factor that can reduce bear attacks is providing a safe passage or escape route for a stranded bear, particularly in the villages. These 'dos' and 'don'ts' were widely circulated through posters in local language. T.V and print media were also used for awareness creation for villagers in study area. During the study, pamphlets and posters were distributed in the villages that were affected by black bear-human conflicts. Students were educated about wildlife through seminars, and other activities organized at Nature Interpretation Center in Dachigam National Park. Such conservation education activities if continued in future as well can be useful.

#### **7.5 Reducing livestock depredation by Black Bear**

As most of the livestock killings have taken place at the night shelters in the villages, it would be necessary to strengthen the doors, windows and other vulnerable portions of these night shelters to reduce loss by predation to black bear and common leopard. Supervised livestock grazing by at least 3-4 villagers will reduce livestock depredation by black bear and leopard. Villagers who were affected by livestock depredation by black bear and leopards were advised to use iron doors and proper lighting at their cattle sheds or night shelters. More than a dozen villagers replaced wooden doors with iron doors and have strengthened the walls of cattle sheds and both have been found to be very effective in reducing livestock loss.

## **7.6 Guarding of crop/orchards from black bear damage**

A Village level cooperative effort for guarding of crop fields and orchards on rotational basis could be tried as an option using the effective means of scaring bears such as noise by drumming empty tin/metal containers. Using guard dogs while patrolling and keeping them in villages would be of added advantage. Proper lighting in the corners or boundaries of crop fields and orchards particularly the vulnerable points lying close to forest fringes may be another option that may help to reduce crop depredation as observed in a few cases during the survey. Animal-proof walls seems to very effective in reducing crop raiding by bears, but many villagers may not be able to afford it due to its high cost. The Department of Wildlife Protection, Rural Welfare, Horticulture and other line Departments of J & K Govt. in consultation with the village communities could evolve strategies to raise financial resources for building animal-proof walls around the vulnerable portions of a few seriously affected villages on a trial basis to assess its utility and sustainability.

Change in local cropping patterns can significantly influence Black bear-Human conflict intensity. Villagers growing Cherry in the vicinity of Dachigam National Park are vulnerable to losses due to bear. If such villagers change to other crop or stop growing cherry then there is a likelihood of minimizing the Black bear-Human conflicts. Similarly, changing animal husbandry practices by keeping a few high-yielding breeds and stall feeding animals in proper shelters instead of large number of local breeds that are less productive in terms of meat and milk, could be an alternative that can reduce conflicts.

## **7.7 Monitoring of Conflict areas**

Use of passive and preventive actions is an important step in conflict management. There should be proper monitoring of black bear-human conflict areas where at least one of the employees is present at the problem site until the situation is resolved. While monitoring the bear, information such as number, age, location, bear behaviour and the direction of the movement of the conflicting animal has to be recorded and reported. Movement of the people should be restricted to give safe passage to the problem bear.

## **7.8 Translocation and Marking of problem bear**

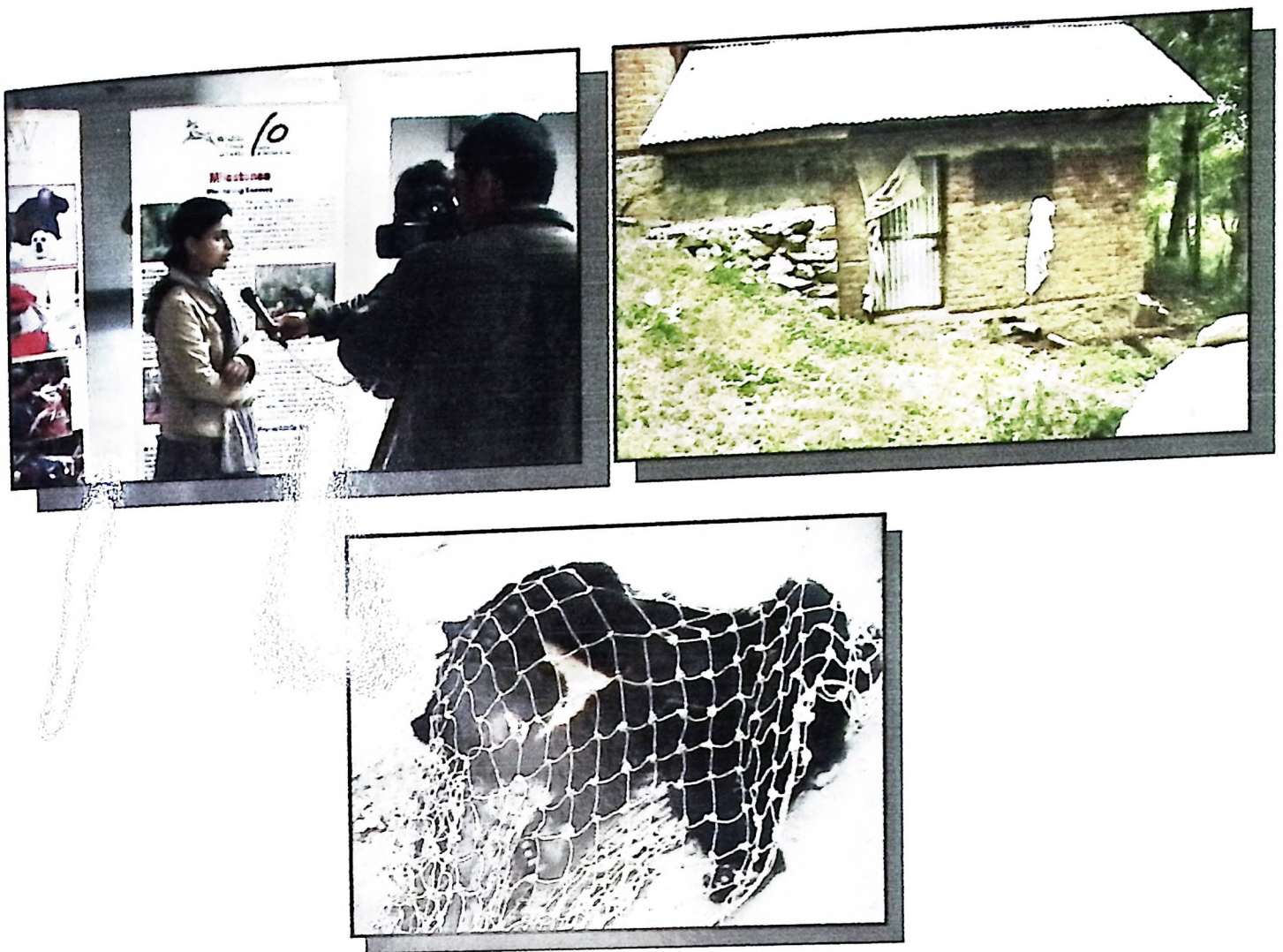
The problem bears that are captured and translocated from the conflict areas should be marked by radio collar, florescent collar or, by ear tags prior to their release back into the wild so that the movement and the ranging patterns of these animals could be studied. This will be very helpful in better understanding of problem bears and ultimately help in mitigating the problem.

## **7.9 Aversive Conditioning of problem bears**

Aversive conditioning of a problem bear (habituated to people or raiding crops) is very much essential so that the problem bear learns to associate 'undesirable activities' such as entering a village, crop field or orchard with 'negative events'. Such problem bears could be subjected to one or more of the following treatments prior to release back into the wild. The treatments include: being hit with bear pepper sprays or rubber bullets, loud noise by bursting of crackers, and barking and/or chased by specially trained dogs. During this study, rescued black bears were subjected to aversive conditioning before releasing them into the wild.

## **7.10 Strengthening of local and traditional black bear deterrent methods**

The traditional methods of burning red chilies mixed in cow dung was experimented for many orchards in villages which were located in the periphery of Dachigam National Park such as Dara, Saidpora in Cherry production season. This traditional method was found to be effective in preventing bears from entering fields and therefore recommended for the use by local villagers.



**Plate No. 6. Awareness creation through media ; Changing Agricultural and Animal Husbandry Practices, A picture of a cattle shed in Saidpora, a village near Dachigam National Park where the wooden door was replaced with iron door; A rescued black bear.**

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Appendix I:

Microsatellite markers selected for the study of Population genetics of Asiatic Black Bear in Dachigam landscape, Kashmir, India

Marker ID	Loci Name	Repeat Motifs	Primer Sequence		TA	GenBank Accs.	Allele range
			Forward	Reverse			
ABB 1	MSUT 2	(AC) <sup>20</sup>	AGTGAATCCTAAACAGGTTA	TAATATGAATATGGTGTGCT	50	(AB040107)	77-91
ABB 2	MSUT 7	(CA) <sup>3</sup> + (CA) <sup>3</sup> + (CA) <sup>13</sup>	TGGAANAATATCTCATTC	TTGTAGGTACTGGTTAC	43	(AB040112)	114-116
ABB 3	UT4	(GAAA) <sup>6</sup> GAGA(GAAA) <sup>11</sup>	GGAAACAGCTATGACCAT -GAGTTATTGGCACTAAAATCTAATG	CTGCAAAATCCCTGCTCAACTTTC	56	FJ640078	157-182
ABB 4	UT29	(GAAA) <sup>2</sup> AA(GAAA) <sup>17</sup>	TCGGGGCTCATCA -GACATTGCCCTTTTACAGAGCAG	GGGCAGATCTCAACCACCATAAAGC	64	FJ640081	204-236
ABB 5	UT36	(GAAA) <sup>16</sup>	TCGGGGCTCATCA -AGACTCAGGAAAGTCTGGAGTGGGA	CTTTCGGCTCAGGGATCGAGC	62	FJ640084	276-309
ABB 6	G10J		GCTTTTGTGTGTGTTTIGC	GGTATAACCCCTCACACTCC			80-88
ABB 7	MSUT 6	(TG) <sup>20</sup>	CATATGGTGACTAAGATAAC	AAGAGATGATTTCTGTCTC	49	(AB040111)	183-193
ABB 8	UT1	(GAAA) <sup>9</sup> GGGA(GAAA) <sup>10</sup>	TCGGGGCTCATCA -AGCAACTCTTCTCAGATGTTTCACAAA	CCCAGGTCAGCACTTGGCATAAC	64	FJ640076	176-192
ABB 9	UT35	(GAAA) <sup>15</sup>	TCGGGGCTCATCA -ACTCCCTAGTAAGTAGAAAAGCACAC	CCCACAGGATGGGCTCAAGAA	64	FJ640083	218-247
ABB 10	UT25	(GAAA) <sup>2</sup> (GA) <sup>12</sup> (GAAA) <sup>16</sup>	GGAAACAGCTATGACCAT -GCTCAGGGCGTGTATCCCAGAG	GGCTCCCCTGCACCTAGAGATTTAAC	62	FJ640080	314-333
ABB 11	MSUT 4	(TG) <sup>14</sup>	GTGTCCCAACTGTAGATGA	TGAGTAATATTTCTTTCTCT	44	(AB040109)	85-101
ABB 12	MSUT 5	(TC) <sup>15</sup>	GGGACTGAGCCTCTCATC	TCCAAATATTTTGTCTGAGTG	50	(AB040110)	167-171
ABB 13	G10H		GGAGGAAGAAAGATGGAAAAC	AAAAGGCTAAGCTACATCG			241-249
ABB 14	MSUT 3	(TG) <sup>13</sup>	TCCACAAATACTGACTGAAT	AGCATTCAGCTCTTATGAGG	53	(AB040108)	220-222
ABB 15	UT31	(GAAA) <sup>17</sup> GG(GAAA) <sup>3</sup>	TCGGGGCTCATCA -AATAAACTGTATGCAGCCATACTAG	CTGCCACTGAAATCTTCTGATCTTAG	64	FJ640082	315-369
ABB 16	MSUT 8	(TC) <sup>3</sup> + (TC) <sup>5</sup> + (GT) <sup>11</sup>	GATCCTGGGACTTCTCAG	TCCAGAGAAAAGAGGACTG	48	(AB040113)	106-110
ABB 17	MSUT 1	(TC) <sup>5</sup> + (TC) <sup>14</sup>	CCTTGGGATTCGGGATTGT	AGTCCTCACCCCTCCCTTTT	58	(AB040106)	170-174
ABB 18	UT38	(GAAA) <sup>24</sup>	GGAAACAGCTATGACCAT -ATTATTGATGAGCAGGGACAG	CTAAAAGCAACAACATGTGAATG	56	FJ640085	196-232
ABB 19	UT3	(GAAA) <sup>18</sup>	TCGGGGCTCATCA -AAGACATACAGAAAGCCAAAGACTAG	TACTCAATTACAAAGGATAACTATA	56	FJ640077	256-282
ABB 20	UT23	(GAAA) <sup>10</sup> GA(GAAA) <sup>22</sup>	GGAAACAGCTATGACCAT -GCTGGATACATCATCTCTGGCTC	GGAATCAAGTTCGGCATCGGG	62	FJ640079	349-382

## Appendix – II

### Format used for Black Bear – Human Conflict Survey in , Kashmir during 2007-09.

S.No.		Date:		GPS location
Name:		Address:		

Crop:

Name of crop	Land	Seed used for	Yeild	Damage	Distance from

Month of damage:

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

Plant part eaten:

Leaves	Fruits	Stem	Flower	Stage of crop:	Pre-mature	Mature
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Number of Livestock:  Livestock killing:

Orchard damage:

Crop name	Number of trees	Production in (kg)	Damage in(kg)	Cost per/Kg

Income source:

	Agriculture	Job/Government	Private/shop
Income sources			

Human-attack:(     )

Attack by	Place	Activity	Type	Time/place
Black bear				
Leopard				