1. INTRODUCTION

1.1 Background

Sloth Bear (*Melursus ursinus,* Shaw 1791) belongs to family ursidae of order carnivora. Out of eight species of bears found in the world (Servheen 1990), only three species viz: Asiatic Black Bear *(Ursus thibetanus*), Sloth Bear (*Melursus ursinus*) and Brown Bear (*Ursus arctos*) are found in Nepal (Shrestha 1997). Asiatic Black Bear and Brown Bear are found in higher elevation than Sloth Bear which is distributed in the lowland Terai and Siwalik Hills.

Sloth Bears are restricted to the Indian subcontinent: Nepal, Bhutan, India and Sri Lanka. Sloth Bears are basically a lowland species, although they are distributed up to elevation of 1700 meter in India from the southern tip of the Western Ghat Mountains to the foothills of the Himalayas (Yogananda et al. 2005, Dharaiya 2011). In Sri Lanka, Sloth Bear are distributed in the remaining forests of dry lowlands below 300m, where human densities and disturbance are low (Ratnayeke et al. 2007a,b). Sloth Bear were found historically in the Sal forest of central Bangladesh but none have been seen since 1968 (Servheen 1990) and are now considered extinct from the country (Islam et al. 2013). In Bhutan, Sloth Bear occur in much restricted habitat of lowland of subtropical forests (Wangchuk 2012). Distribution of Sloth Bear range in Nepal is restricted mainly to the Terai region and Siwalik hill stretches. They were formerly reported to exist across the Terai but have been extirpated in some part of the region (Garshelis et al. 1999a) and limited to eight districts of Terai region including Chitwan National Park, Parsa WildLife Reserve and Bardia National Park.

Sloth Bears are the only myrmecophagous ursid and are uniquely adapted to feed on insects (Laurie and Seidensticker 1977, Joshi et al. 1997). Morphological distinctions include lacking of first pair of upper incisors, a raised and elongated palate, especially mobile lips, a mobile snout and nostrils which can be closed voluntarily for efficient feeding on insects (Laurie and Seidensticker 1977, Joshi et al. 1995, Christiansen 2007). The front claws of Sloth Bears are long (6-8cm) and slightly curved where as hind legs are shorter, adapted for efficient digging of insect colonies (Garshelies et al. 1999a). Sloth Bear posses several adaptations to cope with subtropical and tropical environment such as having low metabolic rate and high thermal conductance which help to reduce heat production and facilitate heat loss (MacNab 1992). They are generally nocturnal but females with cubs and sub adults become more active during day and rest at night to avoid nocturnal predators and intra-specific encounters (Joshi et al. 1999, Yoganand et al. 2005, Bargali et al. 2012). The most notable behavioural distinction of the Sloth Bear from other ursids is the female carrying the cubs on its back (Laurie and Seidensticker 1977, Joshi et al. 1999).

Habitat use, distribution and ranging patterns of Sloth Bear are influenced by the availability of food resources. Being mobile and opportunistic, bears shift their habitat in accordance with availability, abundance and distribution of foods (Joshi et al. 1995, Gondalia et al. 2012). They occupy wide range of habitat including wet and dry tropical riverine forest, Sal forest, savannas and grasslands. In Nepal, Sloth Bears generally move to upland Sal forest in wet season because monsoon rains hamper foraging in low lands whereas they concentrate in lower grassland areas in dry season where ants and termites are readily available (Joshi et al. 1995).

Sloth Bear is listed as “Vulnerable” species by the World Conservation Union (IUCN 1996) and is included in Appendix I of CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) 1995. Major threats to this species are habitat loss and poaching (Johnsingh 2003). Depletion and fragmentation of natural cover (Santiapillai and Santiapillai 1990, Rajpurohit and Krausman 2000), trade in body parts (Laurie & seidensticker 1977, Servheen 1990, Garshelies et al. 1999a), stealing of cubs for dancing (D’Cruze et al. 2011, Satyanarayn et al. 2012) and increased conflict with humans (Bargali et al. 2005, Pragash et al. 2012, Reddy et al. 2012) have posed serious threats to the Sloth Bear populations in its entire range (Bagali et al. 2012). Sloth Bears rarely enter into the village, damage property or raid the crops (Joshi et al. 1995), human- bear conflicts mostly happen due to the encounter in forests (Pragash et al. 2012). The only natural threats to Sloth Bear are tigers (*Panthera tigris)* and possibly leopards (*Panthera paradus)*. Sloth Bears have been observed fending off approaches by tigers (Joshi et al. 1999) but have occasionally been observed as a prey item of tigers (Gopal 1991).

1.2 Detection Probability and Occupancy

Occupancy is the probability that a randomly selected sampling unit in an area is occupied by a target species (MacKenzie et al. 2002). Traditional approaches to estimate occupancy assumed perfect detection; means the species is either present or absolutely absent (Rota et al. 2009). Few species are so conspicuous that they will always be detected at a sampling unit when present but the case is not always true for nocturnal, elusive and rare species (MacKenzie et al. 2002). Such species may go undetected even present at a site and recorded as 'False absent'. Without correcting this fact, simply count of the number of units where the species is detected will underestimate the true level of occupancy. To overcome this error, MacKenzie et al. (2002) presented a closed population model to estimate occupancy rates based on presence-absence data when detection probabilities are less than one. This model assumes that the target species is never falsely detected at a site when absent (i.e., misidentification of the species or sign). The sampling method consists of multiple replicates to the sites and this provides probability of detection estimates, which can be used to account for individuals never detected. MacKenzie et al. (2002) used simple probabilistic arguments to determine probability of detection and proposed a likelihood-based method for estimating site occupancy rates. Through the logit function, the model allows for the inclusion of covariate information, such as site characteristics and other environmental factors that could influence probability of detection and occupancy rates. Similarly, missing observations can be easily accommodated using model likelihood.

1.3 Consequences of Using Indirect Sign Survey

Many ecological investigations depend on direct observation to monitor spatial and temporal patterns of the species (Rhodes et al. 2011). However, a large sampling effort and sophisticated methods are required to collect the desired data. In contrast, indirect signs of species presence (e.g. scats, tracks, pugmarks etc.) have been frequently used to detect rare or elusive species in wildlife studies (e.g. Kendall et al. 1992, Beier and Cunningham 1996, Karanth et al. 2011). Sloth bears are nocturnal and secretive species and leave conspicuous signs during their activities. This makes sense of using indirect evidences for sloth bear study. While field signs such as scats, diggings and scrapes often provide the only practical means to detect elusive species (Wilson and Delahay 2001), misidentification and decaying property of indirect signs like scats may result some potential errors for their use in occupancy estimation (Evans 2006, Rhodes et al. 2011). Surveys of indirect signs record the presence of species prior to the survey, rather than only at a time of the survey. If signs decay rapidly, the false-negative rate will be higher where as false-positive error can occur if signs decay slowly (Rhodes et al. 2011). Similarly, misidentification of signs may result either false-negative or false-positive errors.

1.4 Objectives

The main objective of this study was to estimate the proportion of area occupied by Sloth Bear in Chitwan National Park (CNP) based on the sign survey. The specific objectives were:

- To estimate the occupancy and detection of probability,
- To identify the factors affecting detection probability of Sloth Bear,
- To assess the general distribution pattern and habitat preference of Sloth Bear.

1.5 Rational of the Study

The first ever documented investigation on ecology of Sloth Bear in CNP was that of Laurie and Seidensticker (1977) followed by Shakya (1993) and Shrestha (1993). Some appreciable works have been done on Sloth Bear by Joshi et al. and Garshelis et al. during 1994-1999 which brought the remarkable results on many ecological aspects of the species in CNP. But since then, monitoring Sloth Bear status in Nepal has been neglected as most of the conservation efforts have been concentrated on umbrella species like tiger and rhinos. However, Sloth Bears are considered as an indicator of healthy carnivore communities and conservation challenges may be effectively addressed using the Sloth Bear as a surrogate for conservation (Simberloff 1999, Ratnayeke and Manen 2012). The updated information on Sloth Bear is much needed to reveal the current status of the species and also to assess the impact of habitat covariates on its occurrence. This study provided the baseline data on occupancy of Sloth Bear in CNP. It also explored the factors influencing detection probabilities and occupancy. Thus the finding of this study seems to be useful to devise conservation action for this species.

1.6 Limitations of the Study

The present study was conducted during dry season with limited time and resources. Random sampling method was used to collect the data and not all randomly selected grids were sampled. Thus, the result could not be generalized to entire National Park. The frequencies of replicate were not equal to all studied grids, giving a number of missing observations. Similarly, density of fruiting trees was not accounted in this study. In addition, difficult topographic features, security threats and lack of skilled man powers were other problems during the study.

2. LITERATURE REVIEW

Habitat use by animals, especially mobile and opportunistic species like Sloth Bear, is largely shaped by a number of factors such as availability of food, habitat types and disturbances. Laurie and Seidensticker (1977) in their study on behavioural ecology of Sloth Bear in CNP, Nepal suggested that the use of different habitats by Sloth Bear was associated with fruit availability. Similar result was obtained in India by Gondaliya et al. (2012) and Rani et al. (2012) in which more bears were observed where high densities of fruit plants were recorded. In contrast to the view of Laurie and Seidensticker (1977), Joshi et al. (1995, 1999) in their pioneer works in CNP, Nepal indicated that the differences in habitat use of Sloth Bear were the characteristic of insect availability.

The occupancy estimation, while accounting for detection probability, has recently gained popularity for monitoring the status and distribution of wide variety of vertebrate taxa (Wan et al. 2009, Thorn et al. 2011). Many investigations in conservation biology such as extinction processes, dispersal and range expansion, inventory and mapping, species distribution modeling, species-area relationships and conservation planning are fundamentally reliant on occupancy data (Wintle et al. 2012). When concerning with single species, the most commonly used state variable is abundance or population size. Estimation of abundance requires considerable effort, usually involves costly capture-recapture methods (Pollock et al. 2002, Bailey et al. 2004, MacKenzie et al. 2006). Even observation based methods such as distance sampling (Buckland et al. 2001) and multiple observers (Nichols et al. 2000) are too consumptive of time and effort (Tyre et al. 2001, Royle and Nichols 2003). As an alternative state variable, the methods to estimate proportion of sites occupied by a species can be implemented more easily and less expensively than the methods used for estimation of abundance (MacKenzie et al. 2002, MacKenzie et al. 2006). However, many ecological research using occupancy data has not produced reliable inferences because of a failure to deal adequately with detection probability (MacKenzie et al. 2006) as a species may never be detected even if it is present (Yoccoz et al. 2001). The most common problem arises from the issue of detectibility is imperfect detection (MacKenzie et al. 2003, Kery et al. 2009) such as false presences or false absences (Gu and Swihart 2004, Rhodes et al. 2011), false zeros (Moilanen 2002, Martin et al. 2005, Dorazio et al.

2011) and false negative (Tyre et al. 2003). Furthermore, occupancy and detection probability may be influenced by some site characteristics which should be taken into consideration to obtain reliable inferences (ManKenzie et al. 2002).

There are many different survey methods for assessing data to estimate presence and site occupancy of species (MacKenzie et al. 2002, Royle and Nichols 2003, O'connell et al. 2006). These methods often depend on data derived from direct observation of the species. However, reliance on direct observations may be impractical for nocturnal, rare and elusive mammals like Sloth Bear (MacKenzie and Royle 2005, Kindberg et al. 2009, Rhodes et al. 2011). An alternative is to estimate species' occupancy based on indirect signs they leave during their activities (Kendall et al. 1992, Gese 2001, Wilson and Delahay 2001). In many presence/absence surveys, indirect evidences have been used as a means of detecting target species (Stanley and Royle 2005, MacKenzie et al. 2006, Thorn et al. 2011). However, misidentification and decaying properties of indirect signs such as scats, pugmarks, scrapes, etc. can result false-negative or false-positive errors (Evans 2006, Rhodes et al. 2011).

Detection/non-detection surveys in site occupancy modeling have been successfully used in numerous species monitoring programmes worldwide. Some examples of such study are evaluation of potential Northern spotted owl territories in Northern California (MacKenzie et al. 2003), assessing site occupancy for monitoring the population of an endangered insect, the Mahoenui giant weta, in New Zealand (MacKenzie 2003). Such models have also been applied in monitoring of anurans and salamanders species abundance in the United States (MacKenzie et al. 2002, Bailey et al. 2004). Many researches in monitoring mammalian species are broadly based on detection/nondetection survey such as habitat occupancy of Asian small-clawed otter (Perinchery et al. 2011), estimating Brown Hyaenas occupancy and abundance (Thorn et al. 2011), site occupancy and relative abundance of four-horned antelope (Krishna et al. 2008), estimating occupancy of Ghoral and Serow (Bhattacharya et al. 2012) etc. A remarkable work of Nichols and Karanth (2002) applied occupancy surveys based on animal sign (tracks, scat) to perform large-scale monitoring of Tigers and their major prey species in India. Similarly, occupancy and abundance of Tigers and their prey in the Terai Arc Landscape, Nepal (Karki 2011), occupancy estimation of Tiger and Leopard in Banke National Park, Nepal (Thapa 2012) and assessing the influence of prey depletion and human disturbance on tiger occupancy in Nepal

(Barber-Meyer et al. 2013) are some works that have been included detection/ nondetection survey technique for occupancy modeling in the country.

Among ursids, many ecological researches including occupancy estimation have been done throughout their range. Trent (2010) assessed occupancy of Asiatic Black Bear in China. Sign based occupancy survey by Tsai et al. (2012) revealed that occupancy of Asiatic Black Bears varied greatly by the degree of human access in Taiwan. Linkie et al. (2007) applied a detection/nondetection sampling technique using camera trap data for the estimation of Sun Bears' occupancy in Sumatra in which habitat types was found to influence the occupancy of species. Very few studies have been conducted on Sloth Bear so far in Nepal and none of them describes the proportion of area occupied by the species in the range. In India, Mandal et al. (2012) have shown the degree of human interference including livestock grazing influenced occupancy. Similarly, Ramesh et al. (2012) found positive relationship of occupancy with fruiting tree densities.

3. MATERIALS AND METHODS

3.1 Materials

The main scientific instruments used during the field study were:

1. GPS (Garmin Etrex7)
2. Camera (Casio, 10.1 Megapixel, Zoom lens- 3X1S)
3. Topographic map of study area
4. Binocular (Bushnell 10X42)

3.2 Methods

3.2.1 Study Area

The study was carried out in Chitwan National Park (CNP). The park is situated in the south central Nepal and spans across portions of four districts namely Chitwan, Nawalparasi, Parsa and Makawanpur. It was established in 1973 as the first National park of Nepal to protect the habitats of several endangered wildlife species and the rich ecosystem of the area. In recognition of its unique biological resources, UNESCO designated CNP as a World Heritage Site in November 1984. Initially the area was 544 sq km which was extended to 932 sq km in 1977. However, the GPS survey of the park boundary and topographic maps show a total park area of 1182 sq km (DNPWC 2001).

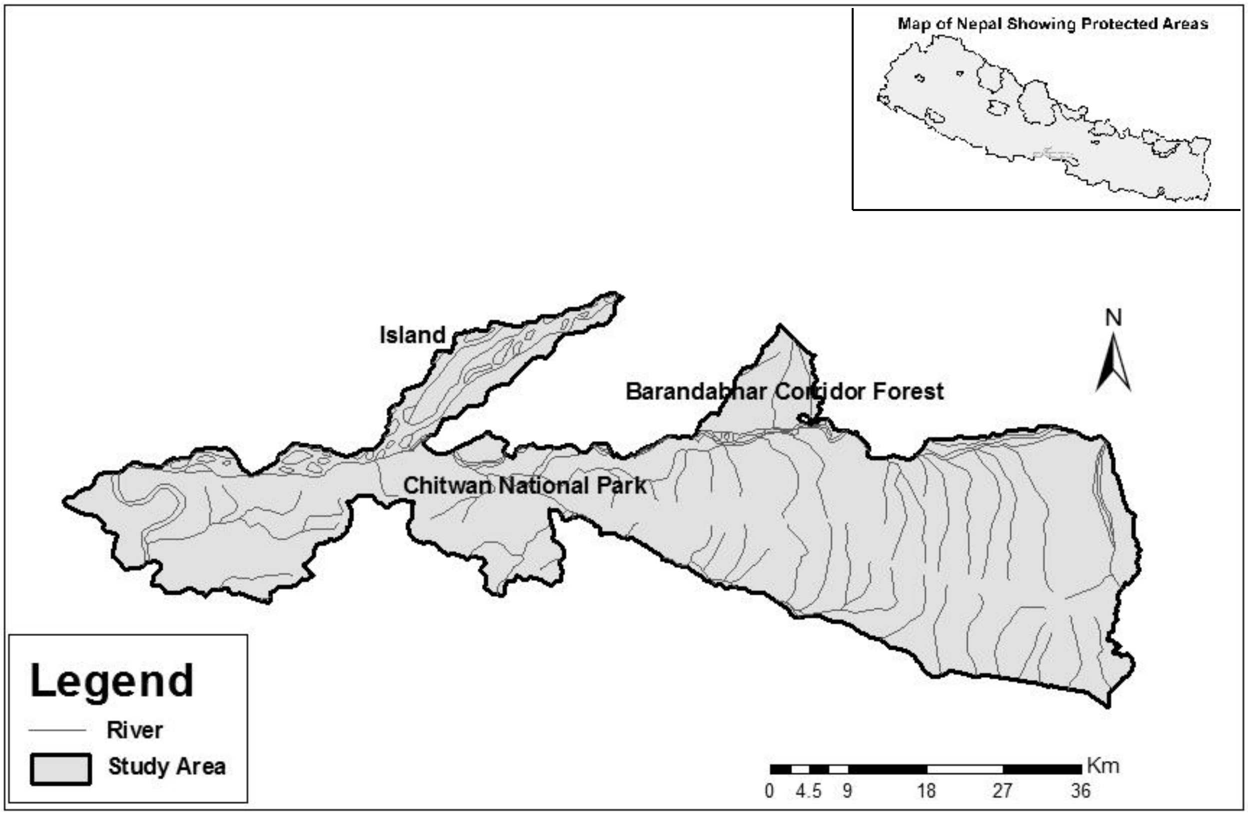

Figure 1: Map of the study area showing CNP.

CNP lies in between 83º50'23"E and 84º46'25"E, and 27º16'56"N and 27º42'14" N (DNPWC/UNDP /PPP 2000). The elevation ranges from 110 m of lowland of inner Terai to 850 m of Churia Hills. From the watershed of the Churia ridge, numerous permanent and seasonal streams flow into the Rapti and Reu River. The Rapti and Reu Rivers flow through the Park and ultimately join the Narayani River in the northern part.

The Barandabhar Corridor Forest (BCF) is the only existing corridor forest adjacent to the CNP (Figure 1) which is bisected by the Mahendra Highway. The portion of area south of the Highway (61 Km^2) is designated as a Buffer Zone. The BCF links CNP to the Siwalik forests and the Mahabharat Range in the north (Thapa and Basnet 2008).

3.2.1.1 Climate

This region of Nepal is known for a hot summer and devastating monsoon followed by short winter season. The climate is subtropical with relatively high humidity. The mean annual rainfall between 2001 and 2010 was 1520 mm. More than 90% of the total rainfall occurs within five months i.e., May to September (Figure 2).

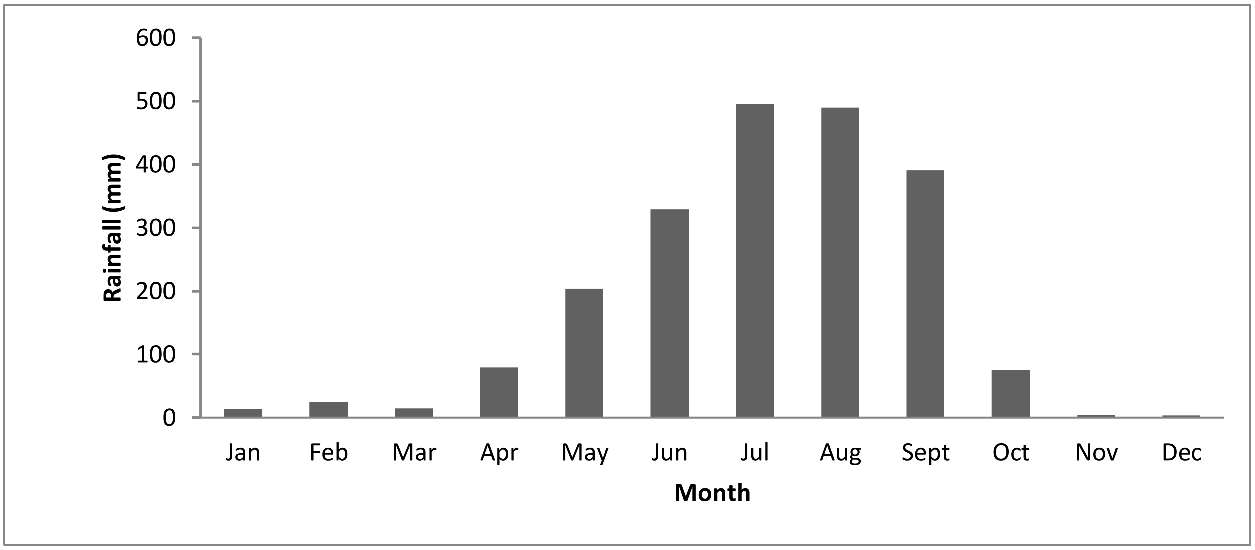

Figure 2: Mean monthly Rainfall (mm) for ten year period from 2001 to 2010, recorded at Bharatpur, Chitwan (Source: NG/DHM).

The annual average minimum temperature in ten years (2001-2010) was recorded to be 17.6º C. January is the coldest month of the year with average of 8.5^{o} C. Likewise the average maximum temperature was 31.1^{o} C (Figure 3). April and May are the hottest months of the year with mean temperature of 35.4^{o} C. Winter temperature falls almost to freezing point where as from March to June temperature can reach as high as 43º C (DNPWC 2010).

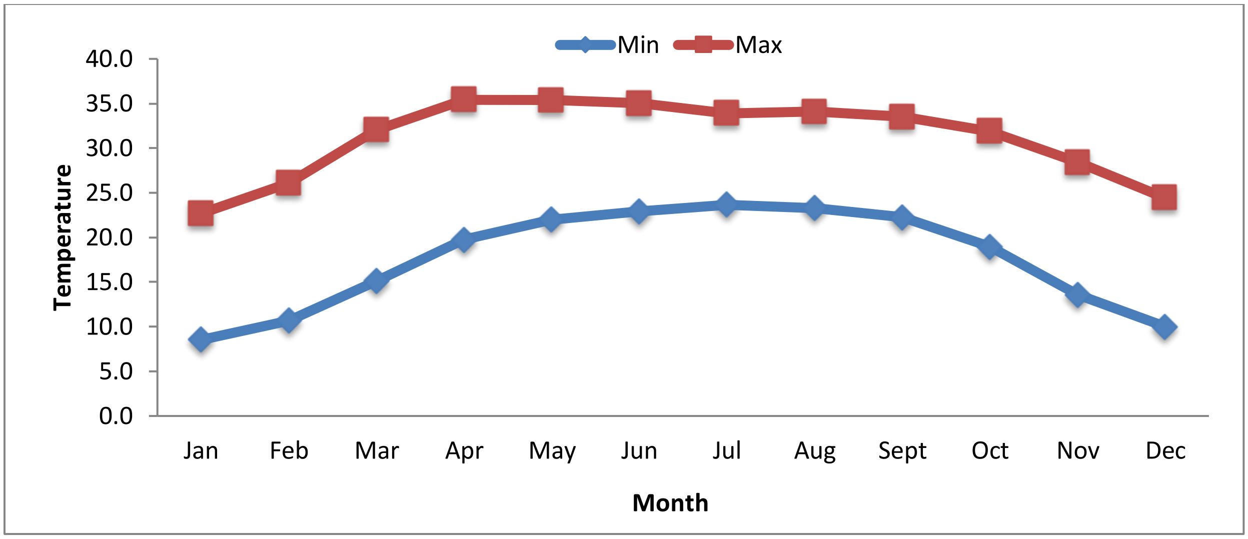

Figure 3: Mean monthly Temperature (º C) for ten year period from 2001 to 2010, recorded at Bharatpur, Chitwan (Source: NG/DHM).

The relative humidity was recorded maximum 96.9% in the month of January and minimum 67.2% in the month of March (Figure 4).

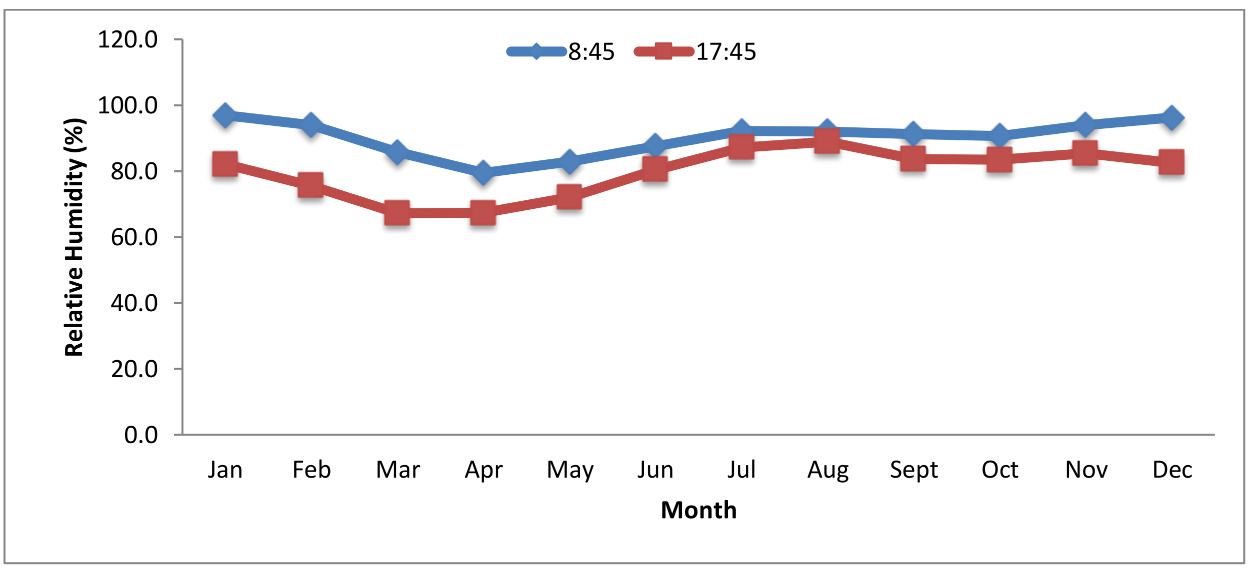

Figure 4: Mean monthly Relative Humidity (%) for ten year period from 2001 to 2010, recorded at Bharatpur, Chitwan (Source: NG/DHM)

3.2.1.2 Vegetation

The floral diversity of the park consists of more than 600 plant species (DNPWC 2010). Vegetation in CNP mainly comprises Sal (*Shorea robusta*) forest, Grassland, Mixed and Riverine forest. Sal is the dominant species attaining a maximum height of 30 m. A recently developed land cover map by Thapa (2011) identified 15 different land cover associations in core area of CNP. The map showed that 72.9% of the area is covered by Sal forest including 15.49% of mixed forest in which other tree species such as *Terminalia alata*, *Terminalia belerica Adina cordifolia*, *Anogeissus latifolia*, *Dilenia pentagyna*, *Anogeissus latifolia*, *Lagerstroemia parviflora*, *Buchnania latifolia*, *Diospyros melanoxylon*, *Hymenodyction* spp., *Ficus* sps, *Cedrela toona, Lannea coromandelica*, *Phylanthus emblica* etc. dominate.

Riverine forest is confined to the area close to rivers, lakes and springs which covers about 7.5% of the Park (Thapa 2011). The dominated tree species are *Acacia catechu*, *Delbergia sisoo*, *Trewia nudiflora*, *Bombax ceiba*, *Ficus benzamina, Ficus cunia*, *Syzigium cumuni* etc. Grassland covers about 11.5% of the total park area. Most abundant grass species are *Saccharum* spp., *Imperata* spp., *Themada* spp. etc.

3.2.1.3 Fauna

The CNP harbors exceptionally diverse wildlife population. The Park is the home to more than 68 species of mammals, over 545 species of birds and 55 species of amphibians and reptiles (DNPWC 2010). There are 503 One Horned Rhinoceros (2011*), 125 Tigers (2011*), 312 Gaurs (2011*), 40-50 Wild Elephant (2002*), 200-250 Sloth Bear (1994*) (CNP 2011-2012). (* indicates the census year). The Park also supports a good number of Wild pigs (*Sus scrofa*) and four species of deers (*Axis axis, A. porcinus, Cervus unicolor* and *Muntiacus muntjak*).

3.3 Data Collection

3.3.1 Identification of Covariates

Ground covariates were identified through the review of literature and information gathered during reconnaissance survey. Measurable habitat covariates were selected using the following criteria: (1) Covariates that reflected habitat type; (2) covariates that reflected altitudinal gradients (3) covariates that indicated the anthropogenic disturbances and (4) proximate variables such as distance to water sources, distance to road and distance to settlements. A total of six ground based covariates were generated. The habitat type was generalized to Sal forest, mixed forest, grassland and riverine forest. Signs of past and current fire, presence of cut and broken stem, presence of humans engaged in forest activities and presence of cattle/cattle dung were used to infer the anthropogenic disturbances.

3.3.2 Sampling Design

A preliminary field reconnaissance survey was carried out by selecting a site near Sauraha during the month of March (2012) to be familiar with the sites and signs of the Sloth Bear. Prior to field visit, intensive field information were gathered through discussions and interactions with Park staffs and experts. The secondary information about study site and concern species were collected from published and unpublished literatures.

The occupancy estimation of Sloth Bear was based on single season single species model (MacKenzie et al. 2006). For occupancy survey, entire study area was divided into the grids of size measuring 16 Km^2 (4 Km×4 Km) using ARC GIS 9.2, approximately the home range size of the concerned species (Hines et al. 2010). Those grids in which most part lies outside the study area boundary were excluded from sampling. Of the 74 grids generated, 35 grids (47%) were selected for occupancy survey (Figure 5).

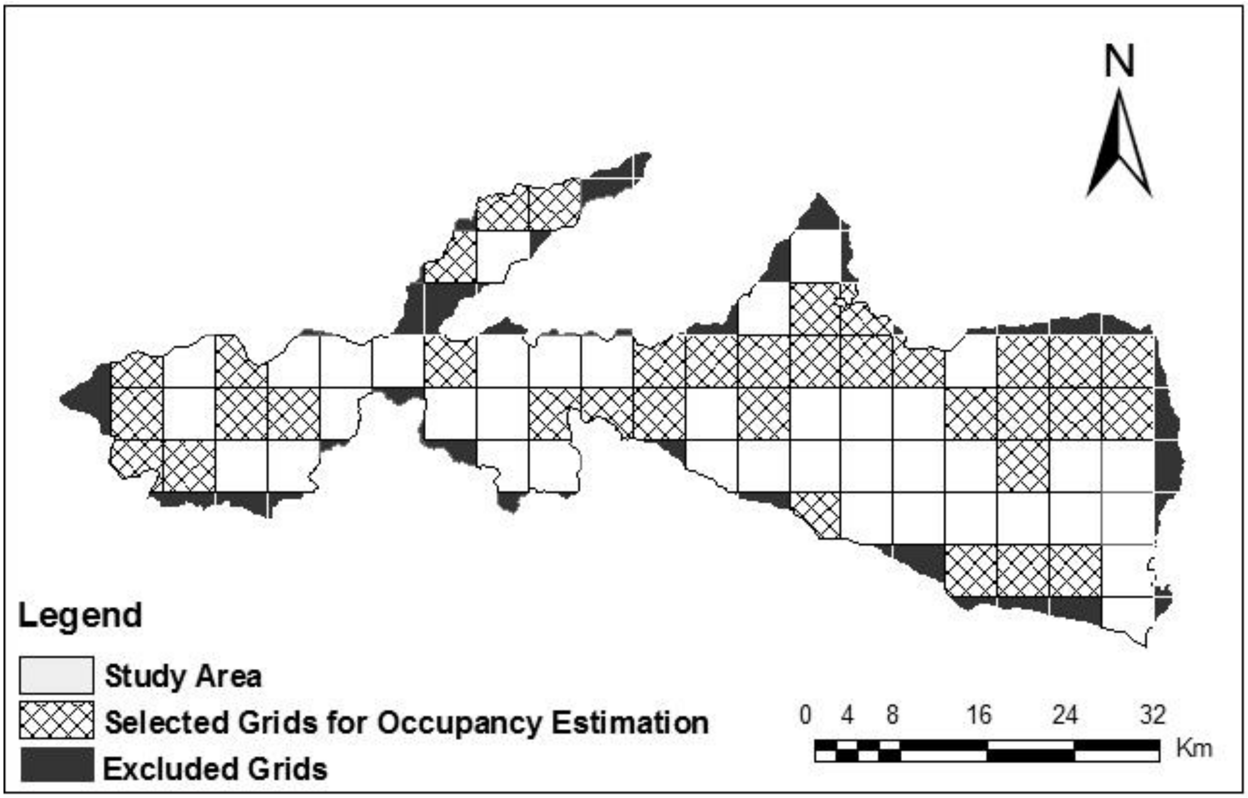

Figure 5: Map showing selected grids and excluded grids in the study area.

3.3.3 Occupancy Survey

The field work was conducted in dry season from March to May, 2012. Both direct sightings as well as indirect bear signs such as diggings, scats and scrapes were recorded while walking along the transect. It was not much difficult to identify the signs of Sloth Bear like scats and scrapes, however when confused, these were confirmed by comparing with colour photographs. In the case of ground holes, diggings more than 30 cm deep were considered as Sloth Bear sign (Garshelis et al. 1999b). Route measuring 1.5 km to 8.5 km of transect walk was carried out for each surveyed grid. Survey was completed between 4–11 hrs in each of the surveyed grid and reasonably met the closure assumption (MacKenzie et al. 2006). Detection data were collected in every 500 m spatial replicates. Survey was focused on high probability location for bear sign detections on those grids where inaccessible terrains and safety reasons restricted further transect walk.

Six habitat covariates were recorded for every 500 m segment along the transect. Habitat type was assessed visually and classified into four categories (Sal forest, Mixed forest, Riverine forest and Grassland). GPS readings were recorded on each segment for measuring altitudinal range and were classified into four categories: ALT1, ALT2, ALT3 and ALT4 representing 100 m – 200 m, 200 m – 300 m, 300 m - 400 m and > 400 m respectively. Three types of disturbances were noted as: human presence (DH), indication of fire (DF) and the presence of cattle/cattle dung (DC). Distances to nearest water source were recorded as DWA (less than 0.5 km), DWB (0.5-1 km), DWC (1-1.5 km), DWD (1.5-2 km) and DWE (more than 2 km). Similarly, distances to nearest settlement were classified as DSA, DSB, DSC, DSD, DSE, DSF, DSG, DSH, DSI and DSJ having one kilometer interval and distances to road as DRA, DRB, DRC, DRD, DRE, DRF and DRG with 0.5 kilometer interval. Each covariate, when detected in a segment, was recorded as ‘1’ and ‘0’ otherwise.

3.4 Data Analysis

3.4.1 Detection Probability and Occupancy Estimation

Detection histories were constructed for each grid, where ‘1’ indicates detection of the animal/animal sign, ‘0’ indicates non-detection and ‘_’ indicates a missing observation. For example, a detection history of ‘101-’ indicates that the animal/animal sign was detected in the first and third segments, not detected in the second segment and the fourth segment was not sampled. Presence/absence data obtained from each habitat type were used to determine the general distribution pattern and habitat preference of the animal.

Most of the segments of surveyed grids were characterized by different categories of covariates. Thus, rather than designating a specific covariate that represented a grid, the contribution of all the categorically recorded covariate data for each grid were transformed into their respective score using following equation (Krishna et al. 2008).

$$\text{Score} = \frac{\text{Number of segments that contained covariate presence in a grid}}{\text{Total number of segments in the grid}}$$

The detection histories were used to construct two key parameters; the probability that a grid is occupied by the species (ψ) and the detection probability (p) estimation using likelihood functions (MacKenzie et al. 2002). The data were analyzed using 'custom model' of single season analysis available in the program 'PRESENCE' ver. 4.4 (Hines 2006). Models were ranked on the basis of AIC (Akaike's Information Criteria) value and all the models whose ΔAIC < 2 were considered as equivalent models (Burnham and Anderson 2002). Model precisions (Standard error /occupancy × 100) were calculated for those models having ΔAIC < 2. Models are considered to have a good precision if the values are less than 30 (Bailey et al. 2004, Linkie et al. 2007). The summed model weight of particular covariate in the top models was used to infer the relative influence of each covariate because a single 'best' model could not necessarily represent all of the variables that influenced the probability of occupancy or species detection probabilities (Bailey et al. 2004).

A step wise approach i.e. detection probability (p) was modeled first and then modeled occupancy (ψ). A total of 12 models were produced to assess the influence of different covariates on detection probability as given below.

1. psi (.), p (.), the simplest model keeping the variability in occupancy and detection probability constant.
2. psi (.), p (DRB), occupancy constant with detection probability influenced by disturbance (3 types).
3. psi (.), p (ALT), occupancy constant with detection probability influenced by Altitude (4 categories).
4. psi (.), p (HB), occupancy constant with detection probability influenced by Habitat type (4 types).
5. psi (.), p (DW), occupancy constant with detection probability influenced by distance to water sources (5 categories).
6. psi (.), p (DR), occupancy constant with detection probability influenced by distance to road (7 categories).

7. psi (.), p (DS), occupancy constant with detection probability influenced by distance to settlement (10 categories).
8. psi (.), p (DRB+HB), occupancy constant with detection probability influenced by disturbance (3 types) and habitat type (4 types).
9. psi (.), p (DRB+ DW), occupancy constant with detection probability influenced by disturbance (3 types) and distance to water (5 categories).
10. psi (.), p (DRB+ALT), occupancy constant with detection probability influenced by disturbance (3 types) and altitude (4 categories).
11. psi (.), p (DRB+DS), occupancy constant with detection probability influenced by disturbance (3 types) and distance to settlement (10 categories).
12. psi (.), p (DRB+DR), occupancy constant with detection probability influenced by disturbance (3 types) and distance to road (7 categories).

For occupancy modeling, it was hypothesized that all the above mentioned covariates would influence ψ, and variables like disturbance, habitat type and distance to water sources would influence *p*. A total of 18 candidate set of *a priori* models were created to evaluate the influence of different covariates on probability of occupancy which are listed below.

1. Psi (.), p (.), the simplest model keeping the variability in occupancy and detection probability constant.
2. psi (DRB), p (DRB+HB), probability of occupancy influenced by disturbances (3 types) with detection probability influenced by disturbances and habitat types (4 types).
3. psi (ALT), p(DRB+HB), probability of occupancy influenced by altitude (4 categories) with detection probability influenced by disturbances (3 types) and habitat types (4 types).
4. psi (HB),p (DRB+HB), probability of occupancy influenced by habitats (4 types) with detection probability influenced by disturbances (3 types) and habitat types (4 types).
5. psi (HB),p (DRB+DW), probability of occupancy influenced by habitats (4 types) with detection probability influenced by disturbances (3 types) and distance to water sources (5 categories).
6. psi (DW), p (DRB+DW), probability of occupancy influenced by distance to water sources (5 categories) with detection probability influenced by disturbances (3 types) and habitat types (4 types).

7. psi (DR), p (DRB+HB), probability of occupancy influenced by distance to roads (7 categories) with detection probability influenced by disturbances (3 types) and habitat types (4 types).
8. psi (DR), p (DRB+DW), probability of occupancy influenced by distance to roads (7 categories) with detection probability influenced by disturbances (3 types) and distance to water sources (5 categories).
9. psi (DS), p(DRB+HB), probability of occupancy influenced by distance to settlements (10 categories) with detection probability influenced by disturbances (3 types) and habitat types (4 types).
10. psi (DW), p (DRB+HB), probability of occupancy influenced by distance to water sources (5 categories) with detection probability influenced by disturbances (3 types) and habitat types (4 types).
11. psi (DRB), p (DRB+DW), probability of occupancy influenced by disturbances (3 types) with detection probability influenced by disturbances (3 types) and distance to water sources (5 categories).
12. psi (ALT), p (DRB+DW), probability of occupancy influenced by altitude (4 categories) with detection probability influenced by disturbances (3 types) and distance to water sources (5 categories).
13. psi (HB+ALT), p (DRB+DW), probability of occupancy influenced by habitat types (4 types) and altitude (4 categories) with detection probability influenced by disturbances (3 types) and distance to water sources (5 categories).
14. psi (HB+DW), p (DRB+DW), probability of occupancy influenced by habitat types (4 types) and distance to water sources (5 categories) with detection probability influenced by disturbances (3 types) and distance to water sources (5 categories).
15. psi (HB+DW), p (DRB+HB), probability of occupancy influenced by habitat types (4 types) and distance to water sources (5 categories) with detection probability influenced by disturbances (3 types) and habitat types (4 types).
16. psi (HB+DR), p (DRB+HB), probability of occupancy influenced by habitat types (4 types) and distance to roads (7 categories) with detection probability influenced by disturbances (3 types) and habitat types (4 types).

17. psi (DR+DW), p (DRB+HB), probability of occupancy influenced by distance to roads (7 categories) and distance to water sources (5 categories) with detection probability influenced by disturbances (3 types) and habitat types (4 types).

18. psi (HB+ALT), p (DRB+HB), probability of occupancy influenced by habitat types (4 types) and altitude (4 categories) with detection probability influenced by disturbances (3 types) and habitat types (4 types).

3.4.2 General Distribution Pattern

The Direct sighting or indirect signs of Sloth Bear such as diggings, scats and Scrapes were considered the presence of the animal on that particular area. Data obtained from such animal locations were recorded in each habitat type and were used to determine the distribution pattern. The distribution pattern was calculated by variance to mean ratio (Odum 1996) which is based on the fact that in Poisson distribution, the variance (S^2) is equal to the mean.

If $S^2 / \overline{X} < 1$, Distribution is uniform

If $S^2 / \overline{X} = 1$, Distribution is random

If $S^2 / \overline{X} > 1$, Distribution is clumped

Where S^2 = Variance = $\frac{1}{n} \sum (X-\overline{X})^2$

$\overline{X}$ = mean value

Chi-square test for goodness-of-fit (χ^2−test): A chi-square goodness-of-fit test was used to determine whether the direct or indirect signs of Sloth Bear were distributed significantly in four different habitat types. The test was performed by setting hypothesis that the Sloth Bear was uniformly distributed in all habitat types in CNP.

Chi-square (χ^2) = $\sum \frac{(O-E)2}{E}$ …………………….. (1)

Where, O = Observed value

E = Expected value

3.4.3 Habitat Preference

Relative preference indices were calculated by following the method of Stinnet and Klebenow (1986) to examine habitat preference of the Sloth Bear in CNP.

$$\textbf{Relative preference index (RPI)} = \frac{\textbf{Percentage utilization}}{\textbf{\% availability of the habitat}} - \mathbf{1}$$

Positive values of RPI indicate preference, negative values between 0 and -1 indicate no preference, and -1 indicates no use.

Chi-square test for goodness-of-fit ($\chi^2 - \mathbf{test}$): A chi-square goodness-of-fit test was used to determine any significant difference in the preference of different habitats. The test was performed by setting hypothesis that there was no significant difference in the preference among different habitats.

4. RESULTS

A maximum of 17 spatial replicates were recorded and average number of replicates to each grid was 8.2. To reduce imprecision in model estimates of detection probability, detection histories were truncated to a maximum of six replicates per grid (Kroll et al. 2010). The total effort invested in the survey was 183 km of transect walk detecting 87 signs of Sloth Bear.

4.1 Detection Probability and Occupancy Estimation

A sampling effort of 288 locations across 35 grids yielded 87 evidences of Sloth Bear presence. The most frequently detected sign was dug out insect moulds (n=50) followed by scat (n=25). Live animals were observed in eight different locations and four scrapes were found. Out of total surveyed units, bear sign was not detected in 11 grids which were located near Triveni in the west, Thori and Amuwa post in the south east region of the Park (Figure 6).

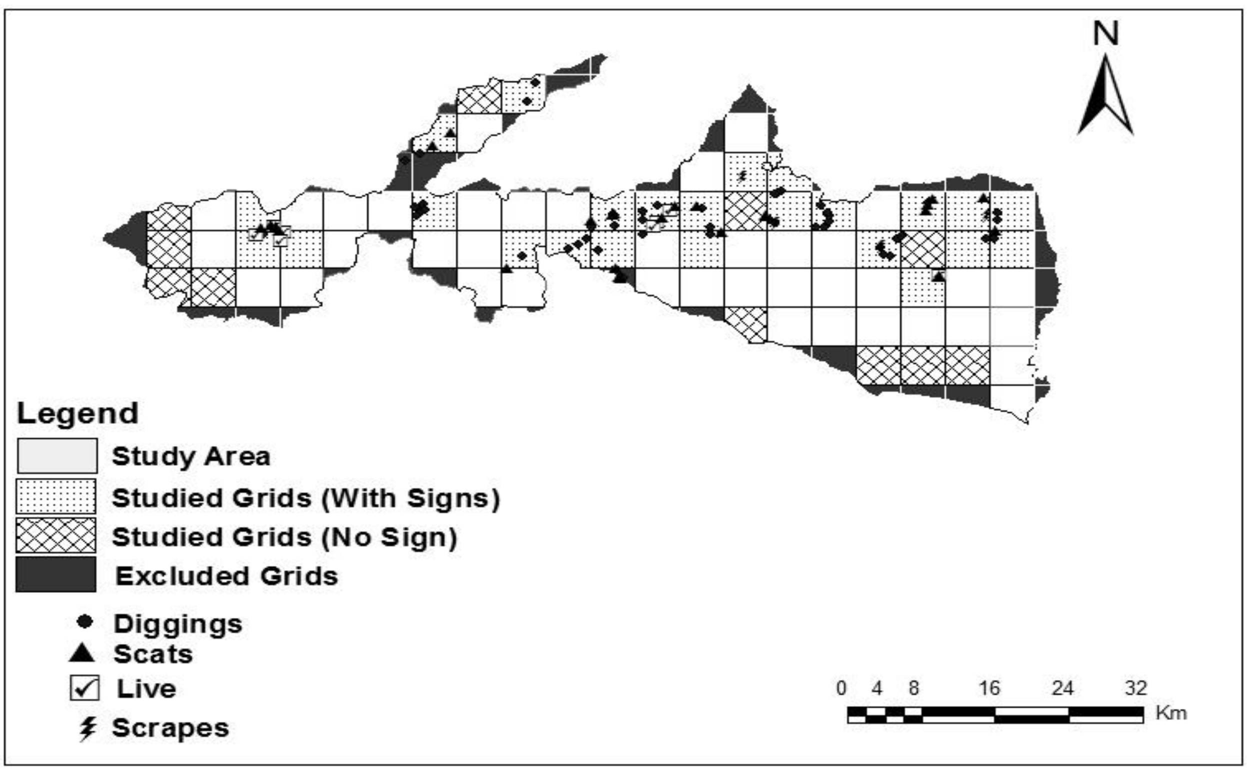

Figure 6: Different evidences found in studied grids.

The psi(.), p(.) model performed poorly as can be seen from the summary statistics ranked according to AIC value. Among all the models, model 8 and 9 received 75% of total weight and were considered top models (Δ AIC < 2) (Table 1). So the detection probability and associated standard errors were averaged from these two models. The final estimate of detection probability was 0.44 ±0.09 $_{SE}$. The 12 candidate models had good precision as all had model precision less than 30 (Table 1).

Table 1: Summary of model selection procedure for factors affecting detection probability of Sloth Bear in CNP.

Model	**P**	**SE**	**AIC**	**Δ AIC**	**W**	**k**	**Model precision**
psi(.),p(DRB+HB)……………8	0.444	0.088	158.1	0	0.434	8	19.93
psi(.),p(DRB+DW)………......9	0.438	0.094	158.7	0.60	0.322	9	21.46
psi(.),p(DRB)…………………2	0.370	0.040	160.73	2.63	0.116	4	10.81
psi(.),p(DRB+ALT)…………10	0.436	0.086	161.85	3.75	0.066	8	19.72
psi(.),p(DRB+DS)…………...11	0.435	0.119	162.21	4.11	0.055	14	27.36
psi(.),p(DRB+DR)…………..12	0.429	0.116	167.48	9.38	0.004	11	27.04
psi(.),p(.)……………………...1	0.549	0.054	178.46	20.36	0	2	9.84
psi(.),p(ALT)………………....3	0.532	0.106	183.76	25.66	0	5	19.92
psi(.),p(HB)…………………...4	0.550	0.105	184.27	26.17	0	5	19.09
psi(.),p(DW)…………………..5	0.543	0.109	185.71	27.61	0	6	20.07
psi(.),p(DR)…………………...6	0.545	0.126	187.05	28.95	0	8	23.12
psi(.),p(DS)…………………....7	0.515	0.145	187.4	29.30	0	11	28.16

*Given are the Model numbers as referenced in Analysis, Occupancy rate (psi), detection probability (p), Standard error (SE), relative difference in AIC values compared to top ranked model (Δ AIC), AIC model weights (W), number of parameters in the model (k). Constant (.), Disturbances (DRB), Habitat types (HB), Distance to water (DW), Altitude (ALT), Distance to settlements (DS), and Distance to road (DR).

Summed model weight indicate good support for covariates DRB (1.0), HB (0.43), DW (0.32) and considerably less support for the other covariates (Table 2). Detection probability of Sloth Bear was negatively correlated to DRB (β = - $6.52 \pm 2.79_{SE}$).

Table 2: Covariates influencing detection of Sloth Bear ranked on the basis of summed model weights, with averaged β coefficients and associated standard errors.

COVARIATES	**Σ Model WT.**	**β co-efficient**	**SE**
DRB	1	-6.52	2.79
HB	0.4348	0.83	0.88
DW	0.3221	0.47	1.15
ALT	0.0667	0.38	0.8
DS	0.0557	-0.86	2.83
DR	0.004	0.33	2.03

*Disturbances (DRB), Habitat types (HB), Distance to water (DW), Altitude (ALT), Distance to settlements (DS), and Distance to road (DR).

Model fit was greatly improved for the candidate models of occupancy estimation when p was modeled as a function of either combination of DRB and DW or DRB and HB (Table 3). These two combinations of covariates greatly influenced the detection probability of Sloth Bear (Table 1 and 2).

Table 3: Summary of model selection procedure for factors affecting occupancy of Sloth Bear in CNP.

Models	AIC	ΔAIC	W	Model Likelihood	K	-2l
psi(HB),p(DRB+DW)…………...5	162.20	0.00	0.2103	1	12	138.20
psi(HB),p(DRB+HB)……………4	162.28	0.08	0.2020	0.9608	11	140.28
psi(DW),p(DRB+HB)…………10	162.96	0.76	0.1438	0.6839	12	138.96
psi(DR),p(DRB+HB)……………7	163.66	1.46	0.1013	0.4819	14	135.66
psi(ALT),p(DRB+HB)…………..3	164.02	1.82	0.0846	0.4025	11	142.02
psi(DW),p(DRB+DW)…………..6	164.57	2.37	0.0643	0.3057	13	138.57
psi(ALT),p(DRB+DW)………...12	164.70	2.50	0.0602	0.2865	12	140.70
psi(DR),p(DRB+DW)…………...8	165.20	3.00	0.0469	0.2231	15	135.20
psi(DRB),p(DRB+HB)…………2	165.93	3.73	0.0326	0.1549	10	145.93
psi(HB+ALT),p(DRB+HB)……18	167.30	5.10	0.0164	0.0781	15	137.30
psi(DRB),p(DRB+DW)………...11	167.56	5.36	0.0144	0.0686	11	145.56
psi(HB+DW),p(DRB+HB)…….15	167.66	5.46	0.0137	0.0652	16	135.66
psi(HB+ALT),p(DRB+DW)…...13	170.20	8.00	0.0039	0.0183	16	138.20
psi(HB+DR),p(DRB+HB)……..16	171.66	9.46	0.0019	0.0088	18	135.66
psi(DS),p(DRB+HB)…………….9	172.03	9.83	0.0015	0.0073	17	138.03
psi(HB+DW),p(DRB+DW)……14	172.20	10.00	0.0014	0.0067	17	138.20
psi(DR+DW),p(DRB+HB)…….17	173.66	11.46	0.0007	0.0032	19	135.66
psi(.),p(.)…………………………1	178.46	16.26	0.0001	0.0003	2	174.46

*Given are the Model numbers as referenced in Analysis, relative difference in AIC values compared to top ranked model (Δ AIC), AIC model weights (W), number of parameters in the model (k), twice the negative log likelihood (-2l), Constant (.), Disturbances (DRB), Habitat types (HB), Distance to water (DW), Altitude (ALT), Distance to settlements (DS), and Distance to road (DR).

Summary statistics showed that none of the models could be judged as the 'best'. Models having ΔAIC < 2 are 5, 4, 10, 7 and 3 and have received the most support, with 74% of total AIC weight (Table 3). Hence model averaging from these top five models was undertaken to estimate ψ, 95%

CI and model precision. The model averaging produced the estimated occupancy rate of 0.90 (with SE of 0.08, 95% CI 0.34-0.97). The naïve occupancy estimate (number of grids where species detected / total number of grids sampled) was 0.68. The top five models had good precision as all had model precision less than 30 (Table 4).

Summed model weight of covariates represented in top 5 models indicate good support for HB (0.45), DW (0.22), ALT (0.16) and DR (0.15) and considerably less support for the other two covariates that were not included in top models (Table 3).

Table 4: Probability of occupancy (psi) with model precision of top 5 models.

Models	**psi**	**SE**	**95% CI**		**Model precision**
psi(HB),p(DRB+DW)	0.9042	0.0713	0.3497	0.9808	7.89
psi(HB),p(DRB+HB)	0.9062	0.0705	0.3521	0.9528	7.78
psi(DW),p(DRB+HB)	0.9282	0.0574	0.7349	0.9866	6.18
psi(DR),p(DRB+HB)	0.8779	0.162	0.2596	0.9887	18.45
psi(ALT),p(DRB+HB)	0.9242	0.0887	0.0046	0.9887	9.60
Average	0.90814	0.08998	0.34018	0.97952	

*Occupancy rates (psi), Standard error (SE), Confidence interval (CI), Disturbances (DRB), Habitat types (HB), Distance to water (DW), Altitude (ALT) and Distance to road (DR).

Among the total of 35 grids sampled, 37% grids had occupancy rates lower than 0.90. Five grids located in southeast of the Park had Occupancy rates ranged from 0.70 to 0.79. Similarly, most of the grids in western part had occupancy rates between 0.8 - 0.89 (Figure 7).

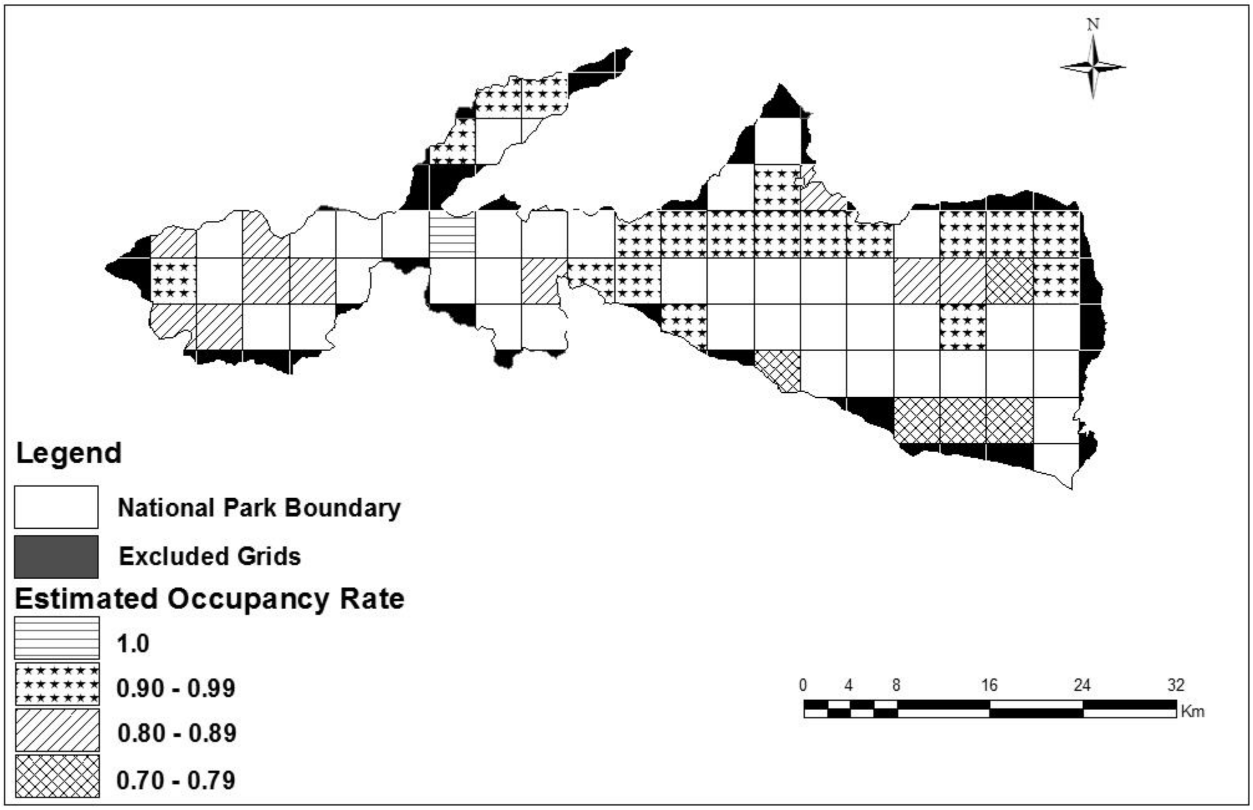

Figure 7: Estimated occupancy rates in different grids.

4.2 General Distribution Pattern

A total of 87 direct or indirect signs were detected from the studied areas. The highest among them, 54.02% of signs were recorded in Sal forest alone. It was so because 61.1% of total replicates were specified to Sal forest. Similarly, percentage of signs found in Mixed forest, Riverine forest and Grassland were 25.28%, 8.04% and 12.64% respectively (Figure 8).

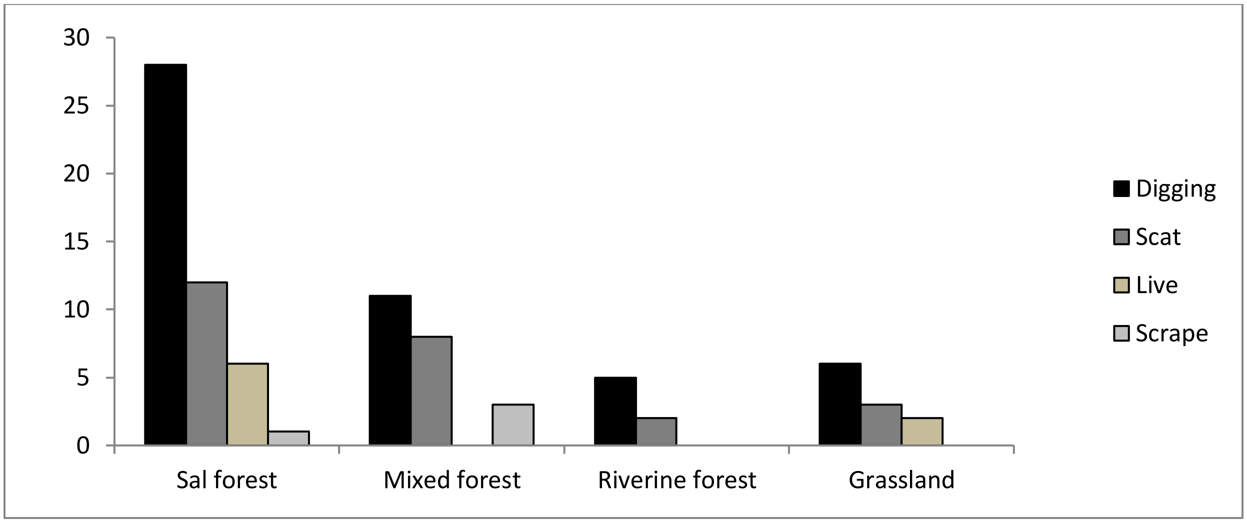

Figure 8: Number of signs found (habitat wise)

The Sloth Bear signs were encountered in almost all types of habitat. However, the calculation of variance to mean ratio showed clumped distribution pattern of Sloth Bear ($S^2 / \overline{X} = 11.15 > 1$). The chi-square test also showed uneven distribution ($\chi^2 = 11.1$, p = 0.01 and 0.05, df =3).

4.3 Habitat Preference

CNP is the complex of different types of forest systems. In this study, mainly four types of habitats namely Sal forest, Mixed forest, Riverine forest and Grassland were considered as habitat sites. Out of total 288 locations surveyed, 176 points lied on Sal forest, 51 points on mixed forest, 31 on riverine forest and 30 points were recorded in grassland.

The RPI values revealed that the mixed forest was found to be most preferred (RPI = 0.42) by Sloth Bear followed by grassland (RPI = 0.21). Riverine forest and Sal forest were less preferred by the species (RPI = -0.25 and -0.11 respectively) but not totally avoided (Figure 9).

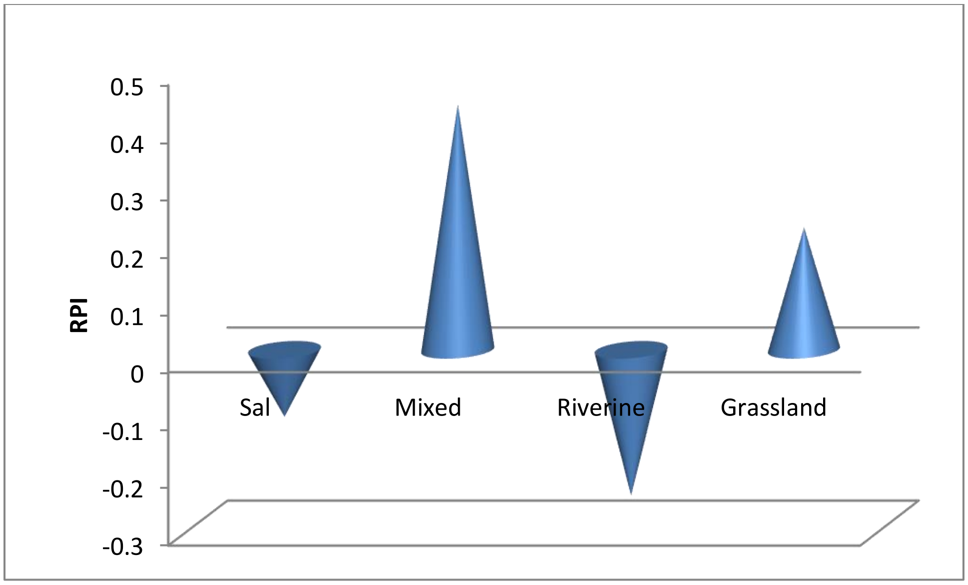

Figure 9: Relative preference indices (RPI) of different habitat types for dry season (2012).

Regardless of the RPI values, Chi-square contingency test showed no significance difference in using different habitat types by Sloth Bear (χ^2= 4.21, p = 0.05, df = 3).

5. DISCUSSION

5.1 Detection Probability and Occupancy Estimation

The study was consistence with the research assumptions. Grids were constructed according to the home range size of the species and were visited as quickly as possible not to violate 'closed population' assumption. Sloth Bears and their signs were correctly identified and the spatial replicates were considered independent to each other in terms of animal/animal sign detection.

The results indicated that Sloth Bear were not detected when present at a site because detection probabilities (p) in each site were less than 1.0. Traditional approaches in naïve estimation which assume perfect detection of species i.e. $p = 1.0$ (Rota et al. 2009) was found to underestimate the occupancy value of ψ (.), p (.) by 12% and it clearly supported the need to incorporate a function of detection probability to produce more reliable occupancy estimates. The results revealed that factors such as disturbances, habitat type and distance to water sources have a significant effect on the detection probability of Sloth Bear in CNP (Table 2). The negative correlation of detection probability with disturbance indicated that the detection probability decreases with increasing level of disturbances. The sites, where disturbances were severe, had very low value of detection especially in the westernmost part and South East in Thori region. The model averaged detection probability was 0.44, ranged from 0.05 to 0.78 in different grids (Annex IV) and was higher than the results found in India. For instance, the studies conducted in Achanakmar Tiger Reserve, Central India (Mandal et al. 2012), Mudumalai Tiger Reserve, South India (Ramesh et al. 2012) and Ranthambhore Tiger Reserve, India (Singh et al. 2012) showed low rate of detection probabilities of 0.23, 0.35 and 0.015 respectively. The lower values of detection probability estimated by these studies were probably associated with topographical differences and forest types. Sloth Bears are primarily lowland species and generally occur at higher densities in the moist deciduous forest compared to other forest types (Yoganand et al. 2006). The camera trapping method was used to collect the data in above mentioned studies which could be another reason for this difference because indirect sign based approach generally produces high detection probability (Linkie et al. 2007).

Model averaged parameter estimates and summed Akaike weights suggest that habitat type was the most important determinant of occupancy of sloth bear in Chitwan followed by distance to water, distance to road and altitude (Table 4). The presence generated average occupancy estimate suggested that 90% of surveyed grids were occupied by Sloth Bear and was approximately 25% higher than naïve estimate. The traditional approach to derive naïve estimate (presence-versus-absence), without incorporating detection uncertainty, generally underestimate true level of occupancy (MacKenzie et al. 2006). The estimated occupancy rate in CNP was higher than anywhere else across their range. Similar studies conducted in India by Mandal et al. (2012), Ramesh et al. (2012) and Singh et al. (2012) estimated occupancy rate as 0.69, 0.83 and 0.52 respectively. The higher rate of occupancy in CNP must be related to high density of Sloth Bear and suitable habitat to provide different types of food all over the year (Garshelis et al. 1999a). The study found no relationship between Sloth Bear habitat use and distance to nearest village. The result revealed that the status of Sloth Bear in CNP was good enough to maintain their survival in future though some areas had high disturbances which might be the obstacle for species conservation.

5.2 General Distribution Pattern

The distribution of Sloth Bear in Chitwan National Park showed clumped pattern in dry season. Similarly, the Chi-Square test showed uneven distribution in the area (χ^2=11.1, p = 0.01 and 0.05, df =3). The clumped pattern of distribution is most common in nature because of the aggregation of individuals in response to various factors such as habitat differences, daily or seasonal weather changes, reproductive processes or the social attractions (Odum 1996). In nature the resources such as food availability, water sources and cover are not distributed uniformly leading to the uneven distribution of the species.

Being mobile and opportunistic, Sloth Bears shift their area of use in accordance with the distribution of food. Seasonal movements corresponding with changes in food availability is very common in Sloth Bear. By the beginning of dry season, Sloth Bears generally aggregate in grassland due to hard soil condition in upland forest which impedes bears ability to excavate termite mounds (Joshi et al. 1995). In the case of Chitwan National Park, there is sharp segregation of different habitats which provide the food for Sloth Bear year-round (Garshelis et al. 1999a). Clumped pattern of distribution resulted due to the tendency of Sloth Bear to visit areas where food availability is relatively higher.

5.3 Habitat Preference

Sloth Bear showed high preference of Mixed forest (RPI = 0.42) during dry season, followed by Grassland (RPI = 0.21) whereas Sal forest and Riverine forest were less preferred (RPI = -0.11 and -0.25 respectively). Though ursids have large home ranges and distinct seasonal shifts, Sloth Bears cover variable distances of different land patches in search of water and food (Chauhan et al. 2010). Laurie and Seidenstiker (1977) reported that seasonal variations in habitat use by Sloth Bear are associated with fruit availability. During non-fruiting season, Sloth Bear concentrate on grassland where ants and termites are readily available. In contrast, Joshi et al. (1997) suggested that movements of bear from grassland to upland are not stimulated by fruiting alone, but saturated ground due to monsoon rain hamper foraging in the grasslands compel bears to move to elevated areas. Similarly, for bears that move to upland Sal forest migrate back to grassland because of the dry, hard soil condition in Sal forest hinder it to dig termite colonies (joshi et al. 1995). Thus, habitat preference of Sloth Bear is determined by the availability of ants and termite colonies which differ in different type of forest with seasonal variations.

Furthermore, various studies (Baskaran 1990, Santiapillai and Santialillai 1990, Garshelis et al. 1999a, Yoganand et al. 2006, Ratnayeke et al. 2007b) revealed that Sloth Bears prefer areas having less human disturbances. A survey across lowlands of Nepal indicated that Sloth Bears were either absent or occurred in low densities in areas with high human use, despite high termite densities (Garshelis et al. 1999 b). Sloth Bear signs were not detected in the present study where high human disturbances prevalent.

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6. CONCLUSION AND RECOMMENDATIONS

Very few studies have been conducted for Monitoring Sloth Bear status in Nepal. Charismatic megafauna like tigers and rhinos usually garner the most attention. However, Sloth Bears are considered as an indicator of healthy carnivore communities and conservation challenges may be effectively addressed using the Sloth Bear as a surrogate for conservation (Simberloff 1999, Ratnayeke and Manen 2012). Furthermore, monitoring Sloth Bear is relatively easy and effective because they leave conspicuous and easily identifiable signs.

The results revealed the proportion of area occupied by Sloth Bear in Chitwan National Park during dry season. The study was based on single-season single-species model (MacKenzie et al. 2002) using sign survey. Out of total 288 spatial replicates in 35 different grids, 87 evidences of sloth Bear presence were detected. None of the bear sign was recorded in 31% of the grids gave a naïve estimate of 0.68. The detection probability of the species was negatively correlated with disturbances like fire and cattle grazing. Among 18 sets of models for occupancy estimation, five models with $\Delta AIC<2$ (Table 4) were used to calculate the relative influence of different covariates. About 90% of the sampled areas of Park were actually occupied by Sloth Bear. However, 37% of the grids had lower occupancy rates than the model averaged rate (0.90). The summed model weight indicated that the habitat type was the most prominent factor influencing Sloth Bear habitat use.

The general distribution pattern of Sloth Bear was clumped because it has tendency to migrate from one habitat to another according to the change in season and food availability. Mixed forest was much preferred in dry season followed by Grassland. Sal forest and riverine forest were less preferred but not avoided as well.

Based on present study following recommendation were drawn which will help concerned authorities to make conservation plans.

- The present study was carried out in single season with limited sites. A rigorous multi-season analysis should be done to evaluate the relative effect of covariates throughout the year.

- Degradation of grassland by natural catastrophe and succession has reduced the cover for insect colonies which ultimately impact on food availability of Sloth Bear. About 2 sq km of grassland was regenerated in 2011 (CNP 2012). This kind of activities should be carried out on a regular basis to improve the quality and area of grassland.
- Despite of the security, intrusion into forest by local settlements, cutting non timber forest, collection of fodder and extraction of Sloth Bear's food like honey and fruits are still going on. So the Park authorities should be more attentive in minimizing such activities.
- Very few researches have been conducted to monitor the status of Sloth Bear in CNP. Authorities should encourage researchers to study on ecology of Sloth Bear. Park authorities should also monitor the status of this animal in a regular basis.
- An active education and awareness programme in local communities surrounding the Park area is needed to support the conservation of Sloth Bear.

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APPENDICES

I. Average monthly Rain fall (2001-2010)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
2001	*	6.8	0	113.3	283.4	380.9	*	*	293.7	*	23.0	0
2002	0	*	*	*	*	*	*	*	*	*	*	*
2003	0	*	*	*	*	*	*	*	*	*	*	*
2004	58.8	0	9.0	184.4	145.8	603.7	336.3	293.4	443.9	92.9	9.1	0
2005	41.7	6.0	24.1	24.0	218.9	215.6	479.0	532.2	115.5	192.7	0	*
2006	*	*	*	*	*	*	436.5	429.0	643.7	*	5.5	19.0
2007	0	141.5	27.5	155.5	228.4	408.4	635	576.4	1002.3	60.4	0	0
2008	4.6	2.5	43.6	23.3	122.9	267.4	422.9	374.2	179.0	44.5	0	0
2009	0	0	0	0	172.7	144.1	454.5	736.6	107.0	0	0	*
2010	5	18.0	0	55.9	254.7	282.6	704.3	484.0	342.5	63.1	0	0

II. Average Monthly Humidity % at 8:45 and 17:45 (2001- 2010)

Month	Humidity	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Jan	8:45	97.2	100.0	*	98.9	97.7	*	93.9	94.8	97.1	95.9
	17:45	77.7	96.4	*	69.3	87.4	*	89.9	88.4	74.2	73.4
Feb	8:45	99.8	98.8	*	97.8	97.7	*	92.5	89.0	88.1	88.2
	17:45	95.7	86.9	*	74.5	88.8	*	87.2	64.4	51.0	55.8
Mar	8:45	100	99.8	*	96.0	97.9	*	87.2	71.6	63.0	70.4
	17:45	97.3	77.6	*	70.0	93.9	*	59.7	61.1	35.4	42.9
Apr	8:45	100	87.4	90.6	94.3	91.5	*	73.4	65.2	53.5	59.2
	17:45	97.8	67.9	69.5	74.7	87.6	*	63.3	68.0	34.8	42.5
May	8:45	100	81.0	85.8	95.1	93.0	*	77.8	70.2	70.4	72.5
	17:45	92.9	62.9	64.4	92.4	81.7	*	73.0	66.6	57.0	57.3
Jun	8:45	100	87.4	90.9	97.8	88.3	95.8	83.4	82.5	76.2	73.9
	17:45	97.8	78.8	77.3	84.7	80.3	97.4	75.9	81.1	63.9	66.8
Jul	8:45	99.7	95.6	93.1	97.1	89.2	96.3	89.6	86.9	86.8	87.1
	17:45	95.7	86.3	82.8	90.0	83.1	95.2	89.4	90.8	80.1	78.2
Aug	8:45	100	92.3	93.9	95.5	89.0	96.4	90.4	87.7	85.1	90.2
	17:45	98.2	89.2	86.4	93.9	84.2	95.1	87.9	90.7	82.2	81.3
Sep	8:45	100	91.5	95.6	91.3	89.6	94.1	90.8	84.9	84.6	90.2
	17:45	87.2	87.1	83.3	82.6	82.2	91.9	85.1	85.7	71.5	80.9
Oct	8:45	100	92.8	96.7	88.0	93.7	95.6	88.4	81.9	85.3	84.5
	17:45	80.1	81.1	90.6	80.2	88.1	96.2	83.6	86.2	75.9	72.2
Nov	8:45	100	97.6	96.0	96.4	97.7	96.8	86.3	86.7	90.5	92.1
	17:45	91.9	80.1	90.6	90.5	94.2	95.1	84.7	81.2	73.4	71.6
Dec	8:45	99.9	98.6	99.4	94.3	*	*	93.3	95.8	*	92.5
	17:45	97.7	80.4	75.5	79.0	*	*	90.8	86.2	*	67.9

III. Average Monthly Minimum and Maximum Temperature (2001- 2010).

Month	Temp.	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Jan	Min	7.5	8.8	*	9.7	5.5	*	7.8	9.0	10.5	9.4
	Max	24.5	22.8	*	22.6	22.8	*	21.4	22.0	24.4	21.0
Feb	Min	10.9	12.2	*	11.2	6.7	*	12.2	9.2	11.9	11.0
	Max	26.3	26.5	*	26.3	25.0	*	23.9	25.2	29.6	25.8
Mar	Min	14.4	16.3	*	14.2	12.1	*	14.7	15.9	15.5	17.9
	Max	32.4	31.5	*	33.7	31.5	*	29.7	31.9	32.8	32.8
Apr	Min	20.0	21.1	22.0	14.2	15.4	*	21.3	19.7	21.7	22.2
	Max	35.6	34.1	35.3	34.0	33.4	*	34.9	36.3	37.5	37.6
May	Min	23.0	23.3	22.2	17.7	19.4	*	23.6	23.0	22.5	23.5
	Max	33.8	33.6	35.8	37.1	35.5	*	35.8	35.5	35.5	35.8
Jun	Min	24.8	24.8	24.3	17.0	20.9	18.0	24.7	25.0	25.0	24.6
	Max	33.8	34.8	33.8	34.4	38.1	35.0	34.2	34.1	36.1	35.8
Jul	Min	25.5	25.4	25.2	18.0	20.1	20.4	25.0	25.5	25.9	25.5
	Max	34.4	32.2	33.6	35.0	36.6	34.1	31.7	34.1	34.0	33.5
Aug	Min	25.1	25.2	25.3	19.2	19.7	19.0	24.8	25.3	25.2	24.2
	Max	34.0	33.5	34.1	35.6	36.9	33.8	33.4	33.8	33.0	32.7
Sep	Min	24.0	23.7	24.3	18.2	18.5	17.3	23.5	24.2	24.6	24.2
	Max	33.1	33.2	33.1	34.4	35.6	32.7	31.9	34.1	34.3	32.7
Oct	Min	21.4	19.9	20.7	16.1	14.4	14.5	21.4	20.0	20.5	20.8
	Max	32.4	32.0	32.3	32.2	31.4	31.6	31.0	32.8	31.7	31.5
Nov	Min	15.4	14.7	15.0	9.2	9.1	10.9	15.6	14.7	14.6	16.5
	Max	28.1	28.7	28.2	29.0	27.9	29.3	28.3	29.1	27.5	28.1
Dec	Min	9.7	10.8	11.2	7.1	*	*	9.8	12.3	*	9.2
	Max	22.9	24.1	25.4	25.9	*	*	23.2	25.3	*	24.3

IV. Occupancy and Detection Probability of Sampled Grids.

Grid Number	Estimated occupancy rate	Standard Error	Detection Probability	Standard Error
108	0.88732	0.1174	0.68044	0.07958
88	0.89072	0.0723	0.39026	0.13354
80	0.90858	0.0698	0.47866	0.11106
34	1	0	0.5961	0.10346
87	0.9818	0.0175	0.5961	0.10346
95	0.95668	0.0376	0.60932	0.09244
76	0.79624	0.1722	0.47866	0.11106
98	0.7536	0.2571	0.68044	0.07958
54	0.90858	0.0698	0.68044	0.07958
47	0.89616	0.1779	0.17096	0.11844
60	0.93064	0.0798	0.46424	0.1185
66	0.9155	0.0671	0.51346	0.14488
61	0.90858	0.0698	0.47866	0.11106
73	0.97488	0.0201	0.60932	0.09244
79	0.99694	0.0301	0.57254	0.12798
68	0.90858	0.0698	0.68044	0.07958
115	0.76692	0.1521	0.68044	0.07958
107	0.95668	0.0376	0.78926	0.10546
109	0.95362	0.0677	0.05376	0.05744
116	0.91244	0.0973	0.6684	0.08874
123	0.95362	0.0677	0.62148	0.14918
122	0.97874	0.0476	0.77722	0.11462
36	0.9818	0.0175	0.61224	0.1479
16	0.88732	0.1174	0.68044	0.07958
7	0.89038	0.0873	0.07086	0.07068
6	0.9155	0.0671	0.0672	0.06862
5	0.8741	0.1679	0.07086	0.07068
9	0.88732	0.1174	0.07086	0.07068
51	0.9404	0.1183	0.41828	0.1445
101	0.86452	0.1722	0.17928	0.12408
105	0.75064	0.2327	0.17928	0.12408
112	0.79204	0.132	0.1716	0.12158
74	0.96848	0.1225	0.59728	0.1016
20	0.82745	0.1611	0.61224	0.1479
44	0.96552	0.0981	0.61224	0.1479

V. List of Photographs

Scat of Sloth Bear

Insect Mould dugout by Sloth Bear

Collection of fodder from the Park

Sloth Bear

Forest Fire

Researcher in the field