Chapter 5

To assess the habitat use by sun bears in Namdapha Tiger Reserve.

5.1 Introduction

In India, the increase in human and livestock population has created pressures on all natural resources. Most of the protected areas are fragmented, degraded, and disturbed from anthropogenic activities. Forests, pastures and wastelands were brought under cultivation to sustain increased demand of cereals and other food products (Chauhan and Sawarkar, 1989). The unsustainable land-use patterns in rural areas have further altered landscapes. This habitat modification has caused wildlife species to become ecologically dislocated. For the management of wildlife and its habitat, information on food, water and shelter and conditions suited to a particular animal species have to be known accurately. The quality of habitat is generally reflected in the status of vegetation cover and its seasonal variation. The site characteristics like fruiting trees and shrub availability, location of dens, water availability and presence of termite mounds and ant nests are directly related to the habitat use. The necessity of assessing preference or avoidance of a given habitat or plant species in terms of its availability has long been recognized (Neu et al., 1974).

The habitat utilization by bear species showed varied patterns in different places. Sun bears rely mainly on tropical forest habitat. Two ecologically distinct categories of tropical forest occur within its range, distinguished by differences in climate, phenology, and floristic composition (IUCN Red list, 2006). Tropical evergreen rainforest is the main habitat of sun bear in Borneo, Sumatra, and peninsular Malaysia. This seasonal habitat receives high annual rainfall that is relatively evenly distributed throughout the year. Tropical evergreen rainforest includes a wide diversity of forest types used by sun bears, including lowland dipterocarp, peat swamp, freshwater swamp, limestone/karst hills, hill dipterocarp, and lower montane forest.
In contrast, sun bears in mainland Southeast Asia inhabit seasonal ecosystems with a long dry season (3-7 months), during which rainfall is <100 mm per month (IUCN Red list, 2006). Seasonal forest types are usually interspersed in a mosaic that includes semi-evergreen, mixed deciduous, dry dipterocarp (<1,000 m elevation), and montane evergreen forest (>1,000 m). The range of sun bears overlaps with that of Asiatic black bears (*Ursus thibetanus*) in this seasonal forest mosaic.

Some observations have been reported of sun bear occurrence in secondary forests or disturbed areas (Wong, 2002; Wong *et al.*, 2004 and Fredriksson, 2005), but the ages of these forests, as well as the scale and frequency of use by these bears relative to their overall populations, are important factors when analysing population-level patterns. Results concur with those of several other studies (Wilson and Wilson, 1975; Wilson and Johns, 1982; Johns, 1983 and Normua *et al.*, 2003, 2004) that indicated sun bears predominantly occur in primary forest. Wong *et al.* (2004) extrapolated across the sun bear’s global range, concluding that the importance of primary forests for sun bear survival is uncertain and that bears clearly occur in logged forests.

Sun bears also have been reported in mangrove forest, although their occurrence in this forest type probably depends on proximity to other more favoured habitats. Sun bears use selectively logged areas (Wong *et al.*, 2004 and Meijaard *et al.*, 2005), and oil palm plantations near forest edges (Nomura *et al.*, 2004). However, there is no evidence that sun bears can survive in deforested or agricultural areas in the absence of nearby forest (Augeri, 2005). This can alter a bear’s movement dynamics through the landscape and prohibit critical habitat use (McLellan and Shackilton, 1988; Augeri, 1994, 2000; Mattson *et al.*, 1996; Merrill *et al.*, 1999; Boyce, 2000 and Augeri, 2002b)

Sun bears occur from near sea level to over 2,100 m elevation, but appear to be the most common in lower elevation forests. In Indonesia and western Thailand, for example, sun bears occur primarily below 1,200 m (Augeri, 2005 and Vinitpornsawan *et al.*, 2006). Sun bears have been observed up to 2,100 m in Myanmar (Saw Htun, 2006), 1,600 m in Lao PDR (Steinmetz *et al.*, 1999), and 2,143 m in Sumatra (Augeri, 2005).
Sun bears are omnivores, and use habitats where they feed primarily on termites, ants, beetle larvae, bee larvae and honey, and a large variety of fruit species, especially figs (Ficus spp.), when available (McConkey and Galetti, 1999; Wong et al., 2002; Augeri, 2005 and Fredriksson et al., 2006a). Occasionally, growth shoots of certain palms and some species of flowers are consumed in these habitats (Fredriksson et al., 2006a), but otherwise vegetative matter rarely occurs in the diet. In Bornean forests, fruits of the families Moraceae, Burseraceae and Myrtaceae make up more than 50% of the fruit diet (Fredriksson et al., 2006a), whereas in western Thailand fruits of Lauraceae and Fagaceae are the most commonly consumed (Vinitpornsawan et al., 2006). In Thailand sun bears and Asiatic black bears use many of the same habitats and have extensive overlap in diet. However, in montane forests >1,200 m elevation (where ground cover is sparse) Asiatic black bears are more abundant than sun bears (Vinitpornsawan et al., 2006).

Nair and Jayson (1988) studied the habitat utilization by large mammals in teak plantation and natural forest, and focused their study on abundance of animals, fodder consumption by animals and damage to plantation by animals. Nams et al. (2001) studied the scale dependent habitat selection by grizzly bear in the central Selkirk Mountains and found that grizzly bears were patchy in abundance at all spatial scales. The bears selected about six kilometres areas at higher elevations and fewer trees within the radius of 15 km areas. In the Mission mountains of Montana, food habits, movement pattern and habitat selection were studied by Servheen (1983), and the habitat use was ascertained from 381 radiolocations of six bears during 1977-1979. Habitat component elevations and aspects were recorded for each radio locations, and only one location was used per bear per 24 hours period.

Habitat loss and fragmentation are two of the main challenges in the conservation and management of large carnivores in the world (Peyton et al., 1999 and Tirira et al., 2001). Habitat fragmentation can result in small, isolated populations that become increasingly vulnerable to extinction (Diamond, 1986 and Wilcove, 1987). The sun bear presents a clear example of how habitat fragmentation and illegal hunting have caused severe population reductions; consequently, this species is now considered threatened at a global scale (Hilton-Taylor, 2000) and in danger of extinction in Southeast Asia IUCN 2009. The sun bear is a key species in the conservation and
management of habitats due to its large spatial requirements, its ecological role (e.g., potential seed disperser), and its profound charisma (Yerena and Torres, 1994; Young, 1999 and Cuesta, 2000). The sun bear's wide ecological requirements and its seasonal use of different habitats, such as extensive paramour and tropical forest areas, make this species an appropriate subject on which to base conservation planning to preserve the high biodiversity of these ecosystems (Peyton, 1999). The seasonal variability in food availability in habitats used by sun bears triggers wide-ranging movements of the animals within their home ranges, as has been documented for other bear species (Schoen, 1990). Those movements, however, often are impeded by the loss of cloud forest and paramour because of advancing agricultural frontiers and expanding infrastructure (e.g. roads).

Most habitat use studies of large mammals rely on direct observations or radio-telemetry. Wild bears in Southeast Asia are rarely observed and difficult to capture, however, so used incidence of bear signs to examine habitat use. Bear signs have been used to describe habitat use by brown bears (Clevenger et al., 1997 and Poscillico et al., 2004), Asiatic black bears (Carr et al., 2002), and Andean bears (Cuesta et al., 2003 and Rios-Uzeda et al., 2006). Bears in Southeast Asia leave abundant signs in the forest which are conspicuous, long-lasting, and related mostly to feeding. Signs most commonly encountered are diggings and logs torn apart for invertebrates, and claw marks on trees climbed for fruits, resting, or refuge. Such signs result from behavioral decisions related to feeding or security, and thus are a good currency for quantifying habitat use and selection because they are linked directly to individual fitness. Bear signs are discrete ‘event sites’ places where animals have invested time and energy to accomplish important life functions (Buskirk and Millsapugh, 2006).

No systematic information is available on the habitat use, its seasonal variation and nesting activities of sun bear in Namdapha Tiger Reserve. How the increasing biotic pressure is affecting sun bear habitat and its population in this area is also not known? The study therefore envisages assessing the habitat use pattern of sun bear in Namdapha Tiger Reserve.
5.2 Methods

To study the habitat use pattern of sun bear, the following methods have been used in Namdapha Tiger Reserve.

5.2.1 Transect sampling

Monitoring of wildlife populations through sign records has been used in many studies to determine population abundance and to quantify habitat use and availability (Nams, 1989 and Clevenger et al., 1997). Bear sign information was gathered along 43 transects with a length of 2-3 km each. Placement of transects within the study areas was stratified according to the area represented by each vegetation type in the study area (Kendall et al., 1992). Given the poor accessibility within the study area, starting locations for most transects were placed near the Gandhigram villages to Namdapha and Dehing River or near the unpaved road that connects different village with portions of the study area. Once we located the start of each transect, we followed an upslope direction for those transects starting near the Namdapha and Dehing River and a random direction for high-elevation transects.

In the study area, vegetation showed high degree of heterogeneity and variable degree of biotic pressure. After the reconnaissance survey, 43 linear transects were laid at random encompassing in six different habitat categories viz. Mix forest, Tropical semi-ever green forest, Tropical wet-ever green forest, Semi-ever green forest, Temperate forest and Bamboo forest in Namdapha Tiger Reserve. Along each transect of 2 km length, ten sampling plots of 10 m radius with 200 m interval were laid. Appendix 1 shows the sampling layout for vegetation quantification and collection of bear evidences. Indirect evidences such as digging signs, presence of scats and claw marks, were recorded from within 430 plots marked along the transects. In addition, information on habitat variables like terrain, vegetation type, tree and shrub species, number of cut and lopped trees, stand height, canopy cover, nearest water source, cattle dung and distance from the habitation was recorded from within these sample plots as per the formats. The data of each sampling plot was
pooled as per habitat type for analysis. Bear sighting on both sides of transects and habitat types of bear locations were recorded.

The 43 transects were surveyed once every 1 months. For each site with bear sign, field personnel collected (1) global positioning system (GPS) coordinates of the location, (2) the type of sign, and (3) additional field measurements to characterize the site. The GPS co-ordinates were used in combination with GIS to measure topographic, ecological, and anthropogenic variables selected to assess bear habitat use within the study area.

To generate a habitat map of the study area, 430 permanent vegetation plots were marked along 43 transects at an interval of 200 m. Within each sampling plot, a 10 m circular plot was laid to quantify tree density, 5 m circular plots for shrub density, and four 1 x 1 m quadrates for ground cover (herb, grass, bare ground, rock and litter) estimation. Habitat parameters such as altitude, slope and aspect were also recorded by using GPS and ocular estimation for each sampling plot. Aspect was measured on four point scale of North, South, East and West using a compass. For the habitat characterization and community classification, TWINSPAN analysis (Hill, 1979) was used.

5.2.2. Availability of food plants

From the vegetation data of different sample plots, assessment of food plants and their abundance in each habitat type was calculated. The food plants were counted within circular plot of 10 m radius and shrub species were counted within plot of 5 m radius for their density estimation. Certain species with ≥ 30 cm GBH were considered as tree and other species with ≤ 30 cm GBH were considered as shrub. Identification of food plants of bear diet was ascertained on the basis of analysis of scats, collected from the study area.

To assess the habitat use by sun bear in Namdapha Tiger Reserve, availability and utilization approach of Neu et al. (1974) was adopted here and analysis was done in
the ‘PREFER’ software package developed at the Wildlife Institute of India. During this exercise, following hypothesis was tested using Chi square test: bear utilized each habitat category in exact proportion to its occurrence within the study area. To know the difference between the habitat variables in the plots where bear signs were present or absent, Kruskal-Wallis non-parametric test was used (Zar, 1984). Multi-dimensional scaling, regression analysis, and non-parametric analysis were performed in SPSS software (Norussis, 1994).
5.3 Results

The habitat use by sun bear was assessed based on direct sightings and indirect evidences such as claw marks, scats, nests, dens, digging sign and foot prints etc. in Namdapha Tiger Reserve, Arunachal Pradesh. The Namdapha Tiger Reserve encompasses an area of 2200.25 km², and has six distinct habitat types viz. Tropical semi-evergreen forest, Tropical wet-evergreen forest, Semi-evergreen forest, Mix forest, Temperate forest and Bamboo forest. In Exposed rock with slope grasses and Tropical semi-evergreen forest and Tropical wet-evergreen forest, trees were dominated by *Ficus, Alginium chinense, Spondias axillaris* and *Horsefieldia amygdalina* species. **Plate 1 to 6** show the Eastern Himalayan, Mix forest, Tropical wet-evergreen forest, Tropical semi-evergreen forest, Semi-evergreen forest, Temperate forest and Bamboo forest habitats in the Tiger Reserve.

5.3.1 Availability of food plants

In Namdapha Tiger Reserve, the habitat use by sun bear was found to be largely dependent on the availability of food resources, variety of food plants and shelter in different habitat types. There were 11 species of food plants found in Tropical semi-evergreen forest and Semi-evergreen forest, followed by 8 species in Mix forest, 7 species in Tropical-wet evergreen forest, 6 species in Temperate forest and 4 species in Bamboo forest. Since the habitat use by bears was largely dependent on the availability of food resources and shelter, number of fruiting tree and shrub species were recorded in various habitat types. Fruiting tree species recorded in these forest types were *Spondias axillaris, Horsefieldia amygdalina, Micromelum pubescens, Natsiatum herpeticum, Turpinia pomifera, Ardisia spp., Lithocarpus pachyphyllus, Balanophora involucrate, Symplocos sp., Actinodaphne obovate, Gnetum montanum, Eulophia spp., Alangium chinense, Streptopus simplex, Phoebe spp., Dimocarpus longan, Polyalthia simiarum, Calamus spp., Elaeocarpus serrata, Medinilla rubicunda, Ostodes paniculate, Knema angustifolia, Symplocos cochinchirensis, Acer sikkimense, Terminalia chebula, Terminalia bellerica, Emblica officinalis, Bischofia javanica, Phoebe cooperina, Flosrajae spp., Amara wallichii and Ficus spp* (Table...
1). These fruiting trees and other food items including insects and ants were available in different habitat types in the Tiger Reserve and in the vicinity of villages.

5.3.2 Habitat variables

Habitat variables based on GIS technology are suitable tools to predict the presence and relative use of bear habitat across large landscapes (Clark and van Manen, 1992), particularly because such models are appropriate for generalist species (Donovan et al., 1987). Six variables, namely elevation, slope, vegetation cover, distance to water, human disturbance and terrain type were used to measure habitat conditions for the bear sign locations sampled during the field surveys (Table 2).

5.3.3 Habitat use by sun bears

In Namdapha Tiger Reserve, the data on habitat use by sun bears collected from the 430 sample plots along the 43 transects showed maximum number of plots with bear signs in Tropical semi-ever green forest (n=99), followed by Tropical wet-ever green forest (n=98), Semi ever green forest (n=72), Mix forest (n=55), Dry Mix forest (n=44) and Bamboo forest (n=11) (Table 3). Although sun bears showed some preference for Tropical semi-ever green forest and Tropical wet-ever green forest habitat categories, but as such there was no preference or avoidance by bears for rest of the habitat types. Out of 430 plots along the transects, bear evidences were found in 339 plots. Maximum number of plots (n=92) with bear signs fell in Tropical semi-ever green forest, followed by Tropical wet-ever green forest (n=87), Semi ever green forest (n=66), Mix forest (n=47), Temperate forest (n=38) and Bamboo forest (n=9). Density of bear signs per hectare was found highest in Mix forest and Temperate forest (140.1/ha each), followed by Semi ever-green forest with (131.0/ha), Tropical wet-ever green forest (113.5/ha), Tropical semi-ever green forest (105.1/ha) and Bamboo forest (35.0/ha) (Table 3).

The frequency occurrence of food plants in plots used by bears varied considerably in Namdapha Tiger Reserve (Table 4). Plots with presence of 1, 2, 3 and 4 food plant
species were 11.9%, 13.0 %, 18.4% and 20.5% respectively. Further as the number of 
food plant species increased, the percentage of these plots decreased. Plots with 
presence of 6, 7, 8 and 9 food plant species were 9.3%, 8.8%, 7.9% and 4.7% 
respectively. Irrespective of this variation, the proportional utilization of these plots 
with variable number of food plant species was very high, except the plots without 
any food plants. The proportional utilization of these plots ranged from 60% to 
91.1%. The Chi square test comparison showed that expected high proportional 
utilization in each habitat category differed significantly from the occurrence of 
habitat categories within the study area ($\chi^2=2.951$, df=9 $p=0.967$). Indirect bear 
evidences were mainly recorded from the forests, located far from villages, hillocks 
and water bodies. Perhaps bears did not spent much time in villages, and in search of 
food and shelter.

5.3.4 Habitat availability vs. utilization

In Namdapha Tiger Reserve, the data on habitat use by sun bears collected from the 
430 sample plots along the transects showed maximum number of plots in Tropical 
semi-ever green forest (n=120), followed by Tropical wet-ever green forest (n=110), 
Semi-ever green forest (n=70) Mix forest (n=50) and there were 40 plots in each of 
Temperate and Bamboo forest (Table 5). The Tropical semi-ever green forest near 
water bodies, river and streams and Tropical wet-ever green forest were characterized 
by the presence of Actinodaphre obovata species. The habitat category: Mix forest 
characterized by Spondias axillaris and Ardisia spp. and Exposed rocks with slope 
grasses and Tropical wet-ever green characterized by Horsefieldia amygdalina and 
Calamus species were found to have 5 plots in each. So among various habitat 
categories, the proportional availability of Tropical semi-ever green forest was found 
 to be highest (0.279), followed by Tropical wet-ever green forest (0.256), Semi-ever 
green forest (0.163), Mix forest (0.116) and the proportional availability was 0.093 in 
each of Temperate forest and Bamboo forest. In comparison to the availability of 
various habitat types, the expected use of these habitat categories was found in 
proportion.
The habitat use based on density of bear signs per hectare was highest in Tropical semi-ever green forest (0.271), followed by Tropical wet-ever green forest (0.257), Semi-ever green forest (0.195) Mix forest (0.139), Temperate forest (0.112) and Bamboo forest (0.027) (Table 5). The use of Tropical semi-ever green forest Tropical wet-ever green forest habitats was high, and the expected use was highest. So the habitat use by sun bears was also found to be in proportion to the availability and the expected use of these habitat categories.

The Kruskal-Wallis test comparison showed that there was no significant difference between the expected utilization of each habitat category and the use of these habitat categories within the study area ($\chi^2=15.709$, df=5, p=0.0077). The null hypothesis was therefore accepted, implying that observed bear evidences were distributed proportionally to the occurrence of habitat categories. The availability and the utilization patterns of different habitat types by sun bear used the Tropical-wet ever green habitat more than its availability.

5.3.5 Seasonal variation in habitat use

The habitat use pattern of sun bears showed marked seasonal variation in Namdapha Tiger Reserve (Table 6). Except Mix forest, Temperate with conifers and Bamboo forest, although the overall extent of habitat use was considerably high for most of the habitat categories as indicated in Table 5, but there was considerable seasonal variation in the use of each of these habitat categories.

Based on number of signs and presence of scats, use of different habitats was highest during winter in Namdapha Tiger Reserve (Table 6). During summer season, use of Bamboo forest characterized by *Flosrajanca* spp. and *Ficus* spp. (36.4%) by bears was highest, followed by Semi-ever green forest characterized by *Medinilla erythrophylla* (26.4%), Tropical semi-ever green forest characterized by *Actinodaphre obovata* species (25.2%), Temperate forest characterized by *Calamus* spp. and *Ostodes paniculata* (25.0%), Tropical wet-ever green characterized by *Horsefieldia amygdalina* species habitat (23.5%), Mix forest characterized by *Spondias axillaris*
and *Ficus* spp. (12.7%) with the mean value 14.83±3.56. During monsoon season, habitat use by sun bear in Tropical semi-ever green forest was highest (36.4%), followed by Tropical wet-ever green forest (33.7%), Semi-ever green forest (33.3%), Temperate forest (29.5%), Mix forest (29.1%) and Bamboo forest (18.2%) with the mean value 20.66±5.25. Whereas during winter season, the use of Mix forest by bears was highest (58.2%), followed by Temperate forest (45.5%), Bamboo forest (45.4%), Tropical wet-ever green forest (42.8%), Semi-ever green forest (40.3%) and Tropical semi-ever green forest (38.4%) with the mean value 27.66±5.49.

### 5.3.6 Habitat use overview

By surveying a total of 43 transects covering six different habitats, 379 bear signs were collected from 1500 trees. All these bear signs were recorded in Tropical semi-ever green forest, Tropical wet-ever green forest, Semi-ever green forest, Temperate forest, Mix forest and Bamboo forest. The highest percentage (46.4% with 29.33±7.19) of bear signs were recorded during 2009, followed by (30.9% with 14.33±3.75) during 2010 and (22.7% with 19.5±4.16) during 2008 *(Figure 1)*. During 2008, sun bear signs were highest in Tropical semi-ever green forest (6.9%) followed by Tropical wet-ever green forest (6.1%), Semi-ever green forest (4.5%), Mix forest (2.9%), Temperate forest (1.3%) and Bamboo forest (1.1%). In 2009, bear signs were highest recorded in Tropical wet-ever green forest (12.9%) followed by Tropical semi-ever green forest (12.7%), Semi-ever green forest (8.7%), Mix forest (7.1%), Temperate forest (3.2%), and Bamboo forest (0.8%). Whereas in 2010, sun bear signs were highest in Temperate forest (7.1%), followed by Tropical wet-ever green forest (6.9%), Tropical semi-ever green forest (6.6%), Semi-ever green forest (5.8%), Mix forest (4.5%). There were no signs were found in Bamboo forest in 2010 during the study periods.

### 5.3.7 Use of terrain types

Based on sign surveys and presence of scats and nests, various terrain types viz. flat, undulating, gentle slope and steep slope were found to be differentially used by sun
bears in the study area (Table 7). The use of flat terrain by sun bear was maximum (52.8%), followed by steep slope (32.4%), gentle slope (8.4%) and flat terrain (6.1%) in different forest types. Sun bears were found to use flat terrain maximum in Bamboo forest (18.1%), followed by Temperate forest (15.9%), Tropical semi-ever green forest (5.1%), Semi-ever green forest (4.2%), Tropical wet-ever green (4.1%) and Mix forest (3.6%) with mean value of 3.83±0.79. Sun bears were found to use undulating terrain maximum in Mix forest (63.6%), followed by Tropical semi-ever green forest (59.6%), Tropical wet-ever green forest (55.1%), Semi-ever green forest (45.8%), Temperate forest (36.4%) and Bamboo forest (27.3%) with mean value of 33.33±8.77. Whereas they were found to use gentle slope maximum in Bamboo forest (18.1%), followed by Mix forest (12.7%), Semi-ever green forest (9.7%), Tropical wet-ever green forest (9.2%), Temperate forest (6.8%) and Tropical semi-ever green forest was (5.1%) with mean value of 5.50±1.08. The steep slope terrain was used maximum in Temperate forest (40.9%) by sun bear, followed by Semi-ever green forest (40.3%), Bamboo forest (36.5%), Tropical wet-ever green forest (31.6%), Tropical semi-ever green forest (30.2%) and Mix forest was (20.1%) with mean value of 20.5±4.62.

The data on proportional availability and utilization of various terrain types: flat, undulating, gentle slope and steep slope has been compared with the expected use of these terrains by sun bears (Table 8). The proportional availability of undulating terrain was found to be the highest (0.437), followed by gentle slope (0.288), steep slope (0.167) and flat terrain (0.107). The expected use of these terrain types was found to be directly proportional to the availability of these terrains. The expected use of undulating terrain was found to be highest (0.450), followed by gentle slope terrain (0.323), steep slope terrain (0.138) and flat terrain (0.089).

Following hypothesis was tested using the Chi square test: sun bear used each type of terrain category in exact proportion to its occurrence within the study area (null hypothesis). The observed utilization of each terrain category was compared with expected utilization of terrain. Goodness fit of comparison showed that the expected utilization of each terrain category was not significantly different ($\chi^2=2.202$, df=3, p=0.531) from the observed utilization. The null hypothesis was therefore accepted,
implying that the observed utilization of each terrain category was in proportion to its occurrence. There was neither any preference nor avoidance by bears for any type of terrain. Bear used certain category of terrains for specific purpose.

During the study period, indirect evidences: nests, scats and digging signs were recorded in different terrain as sun bears were feeding and resting in various terrain types (Figure 2). The digging signs were highest in undulating terrain (37.5%), followed by flat and gentle terrain (25.0% each) and steep slope (12.5%). Scat signs were highest in undulating terrain (29.4%), followed by steep slope (25.9%), flat terrain (24.7%) and gentle slope (20.0%). Similarly nests were highest in undulating terrain (42.2%), followed by (26.7%) gentle slope, (17.8%) steep slope and (13.3%) flat terrain.

5.3.8 Use of disturbed and undisturbed habitats

Sun bear were found to use disturbed and undisturbed habitats to varying extent along different elevations. There were three categorise of elevations i.e. Lowland ranged from 0 to 500 msl, Mid-elevation was 501 msl to 1500 msl and Temperate was 1500 msl and above. The majority of bear signs (74.1%) were observed in undisturbed forest regardless of sites (r2=0.8291, F=4.851, df=3, P<0.2713). In areas with higher intensities and extents of disturbance, fewer bear signs (25.9%) were observed (Figure 3).

5.3.9. Analysis for variance among the variables (Kruskal-Wallis test)

Two hypotheses were assessed; first was that all the habitat variables viz. number of trees, lopped trees, fell trees, number of shrubs, number of herbs, cattle dung, distance from habitation, distance from water and distance from road were evenly distributed in the used and unused areas of sun bears i.e. null hypothesis (H₀), and second was that all the habitat variables were not evenly distributed in the areas where bear signs were present and absent i.e. Alternative hypothesis (Hₐ).
The Chi-square values clearly showed that when habitat variables within the sampled plots were correlated with the bear presence as a fixed variable, then the number of shrubs (109.146), distance from human habitation (413.590), distance from road (413.408) distance from water sources (416.081), and cattle dung (90.938) had highly significant correlation with bear presence. This has proved that these variables were not the same in areas where bear signs were present or absent. This rejects the null hypothesis (H₀) and accepts the Alternative hypothesis (Hₐ). Whereas, for the number of trees (84.103), lopped trees (162.367), fell trees (21.140), number of herbs (140.754) and distance from road (413.408), Chi-square values were not significant. This showed that these habitat variables were almost the same in the areas where bear signs were present or absent (Table 9). Therefore null hypothesis was not rejected.

5.3.10. Analysis of Fixed Kernel

The Fixed Kernel showed that, which was more than suitable for habitat use in the three different Fixed Kernel analyses. The estimated habitat use (99%, 95% and 50% Fixed Kernel) of all was given in (Figure 4). The core activity (50% Fixed Kernel) area of sun bear habitat as determined, followed by 95% Fixed Kernel and less activity in (99% Fixed Kernel).
5.4 Discussion

In Namdapha Tiger Reserve, six distinct habitat types, namely, Tropical semi-ever green forest, Tropical wet-ever green forest, Semi-ever green forest, Mix forest, Temperate forest and Bamboo forest. Sun bears have been found to use all these habitat categories. Due to increasing human population, expansion of agricultural land, continuous encroachment on forest land, livestock grazing and biotic pressure, sun bear population seems to be adversely impacted in this Reserve, and so it is threatened. These factors together might have also adversely impacted the habitats and their use in the study area.

The Malayan sun bear occurs in low densities in these habitats. Survival of sun bear is found to be largely dependent on availability of suitable habitats, and food resources, variety of food plants, water and shelter within these habitats. There were 11 species of food plants available in the Tropical semi-ever green forest and Semi-ever green forest, followed by 8 species in Mix forest, 7 species in Tropical-wet ever green forest, 6 species in Temperate forest and 4 species in Bamboo forest. Since the habitat use by bears was largely dependent on the availability of food resources and shelter, number of fruiting trees and shrub species were recorded in various habitat types. These fruiting trees and other food items including insects and ants were available in different habitat types in the Tiger Reserve and in the vicinity of villages.

The frequency occurrence of food plants in plots used by bears varied considerably in Namdapha Tiger Reserve. Plots with presence of 1, 2, 3 and 4 food plant species were 11.9%, 13.0 %, 18.4% and 20.5% respectively. As the number of food plant species increased, the percentage of these plots decreased. Irrespective of this variation, the proportional utilization of these plots with variable number of food plant species was very high, except the plots without any food plants.

It is important to consider the frequencies of individual bears among different habitat types relative to forest age and the overall population. Some observations have been reported of sun bear occurrence in secondary forests or disturbed areas (Wong, 2002; Wong et al., 2004 and Fredriksson, 2005), but the ages of these forests, as well as the scale and frequency of use by these bears relative to their overall populations, are
important factors when analysing population-level patterns. Habitat models based on GIS technology are suitable tools to predict the presence and relative use of bear habitat across large landscapes (Clark and van Manen, 1992), particularly because such models are appropriate for generalist species (Donovan et al., 1987). Six variables, namely elevation, slope, vegetation cover, distance to water, human disturbance and terrain type were used to measure habitat conditions for the bear sign locations sampled during the field surveys.

The habitat use by sun bear was assessed based on direct sightings and indirect evidences such as claw marks, scats, nests, dens, digging sign and foot prints etc. in Namdapha Tiger Reserve. Results from the present study showed that the significant majority of sun bear activity in undisturbed areas was predominantly in older heterogeneous forests that retained some primary forest traits and had substantial time to regenerate and evolve through older succession stages that provide mature forest structure. The overwhelming majority of bear signs, photographs, and hair snags were observed in undisturbed primary forest regardless of habitat, ecosystem, site, or region.

In Namdapha Tiger Reserve, the data on habitat use by sun bears collected from the 430 sample plots along the 43 transects showed maximum number of plots with bear signs in Tropical semi-ever green forest, followed by Tropical wet-ever green forest, Semi ever green forest, Mix forest, Dry Mix forest and Bamboo forest. Although sun bears showed some preference for Tropical semi-ever green forest and Tropical wet-ever green forest habitat categories, but as such there was no preference or avoidance by bears for rest of the habitat types. Out of 430 plots, bear evidences were found in 339 plots. Maximum number of plots with bear signs fell in Tropical semi-ever green forest. Density of bear signs per hectare was found highest in Mix forest and Temperate forest. However there was a specific pattern of habitat use in the study area. In Namdapha Tiger Reserve, habitat use pattern of sun bears showed marked seasonal variation. Although the overall extent of habitat use was considerably high for most of the habitat categories, but there was considerable seasonal variation in the use of each of these habitat categories. Based on number of signs and presence of scats, use of different habitats was highest during winter.
Although sun bears showed some preference for Tropical semi-ever green forest and Tropical wet-ever green forest habitat categories, but as such there was no preference or avoidance by bears for rest of the habitats in Namdapha Tiger Reserve. Since maximum bear signs were from Tropical wet-ever green forest located far away from the Gandhigram village, perhaps bears did spend much time in this habitat for feeding on fruits and other food items. More bear signs in these habitats might be due to intensive use of these habitats by bears and more availability of preferred food items and shelter to bears. Several studies documented habitat use and movement patterns of sun bears (Wong, 2002; Augeri, 2005 and Steinmtz, 2009). Sun bears in South East Asia ranged widely during the season.

Presence of bear signs in different habitats varied with availability of food items in different seasons. Black bear feeding signs in decaying stumps and ground cavities on sand ridges to feed on insects were seen frequently during spring and summer. Black bears need large areas with a variety of habitat types in coastal plains of North Carolina to meet their food and cover requirement (Landers et al., 1979). In Denali National Park, Alaska, habitat use and activities of bears were found to be influenced by the phenological development of cowberry (Empetrum nigrum), peavine (Hedysarum alpinum), horsetail (Equisetum arvense), polar grass (Arctagrostis latifolia), soapberry (Shepherdia canadensis) and availability of animal food items (Stelmock and Dean, 1986).

In Namdapha Tiger Reserve, the proportional availability of Tropical semi-ever green forest was found to be highest, followed by Tropical wet-ever green forest, Semi-ever green forest, Mix forest, Temperate forest and Bamboo forest. In comparison to the availability of various habitat types, the expected use of these habitat categories was found in proportion. Likewise the habitat use based on density of bear signs per hectare was highest in Tropical semi-ever green forest, followed by Tropical wet-ever green forest, Semi-ever green forest, Mix forest, Temperate forest and Bamboo forest. The use of Tropical semi-ever green forest Tropical wet-ever green forest habitats was high, and the expected use was highest. So the habitat use by sun bears was also found to be in proportion to the availability and the expected use of these habitat categories. In comparison to the availability of various habitats, the expected use of these habitat categories was found in proportion. So the habitat use by sun bears was also found to
be in proportion to the availability and the expected use of these habitat categories. Thus, habitat use in proportion to its availability could be correlated with availability of food items and also shelter. The relation between utilization and availability of sun bear habitat features using ten variables was compared by testing the hypothesis i.e. bears used habitats in proportion to their availability. The null hypothesis was not rejected.

Ultimately, compression can create insular effects, possibly increase stress levels in individual bears, and exert notable pressure on the population. Reduced food density, availability or access can influence bear health, movements, mating, recruitment, and population dynamics (Jonkel and Cowan, 1970; Rogers 1976, 1987; Craighead et al., 1995; Powell et al., 1997 and Wasser et al., 2004) and can increase physiological stresses on the bears (Cattet et al., 2003; van der Ohe et al., 2004; Owen et al., 2004 and Wasser et al., 2004). The habitat used by grizzly bear more than expected were riparian zones and wet seeps in spring, wet seeps and alpine slab rock in summer and riparian zones and, wet seeps, in spring, wet seeps and alpine slab rock in summer and riparian zones, wet seeps, wet meadows, and alpine slab rock (Servheen, 1983). In Arctic National Wildlife Refuge, northeast Alaska, tussock tundra and tall shrub land were used slightly more frequently by grizzly bears during spring than expected based on availability, whereas low shrub land was used much more frequently than expected and bears were observed in tall and low shrub land usually digging hedysarum roots (Phillips, 1987). In North Bilaspur forest division, sloth bear population used different habitat types, and the expected utilization in each habitat category differed significantly from the occurrence of habitat categories within the study area (Akhtar et al., 2002). Reynold and Beecham (1980) also recorded the movements of black bears in response to the phenological stages of food plants in different areas. Amstrup and Beecham (1976) indicated that bears associated mostly with particular plant species during its peak fruit availability. Manjrekar (1989) in Dachigam National Park found that black bears were mainly dependent on fruits of *Prunus avium*, *Morus alba*, *Quercus robur* and *Juglans regia* by extensively utilizing forest habitats.

The habitat use pattern by sun bears in Namdapha Tiger Reserve revealed that they differentially used available habitat types. The habitat use pattern by sun bears
showed marked seasonal variation. Except Mix forest, temperate with conifers and Bamboo forest, although the overall extent of habitat use was considerably high for most of the habitat categories but there was considerable seasonal variation in the use of each the habitat category.

Augeri (2005) compared natural patterns of Malayan sun bear (*Helarctos malayanus*) habitat selection, ecology and landscape use with the effects of disturbance. Augeri (2005) conducted two phases of field work at 16 study sites grouped among three focal areas in the Leuser Ecosystem in northern Sumatra and three focal areas in the Kayan Mentarang Bulungan ecosystems in East Kalimantan, Borneo. Sloth bear population also showed no avoidance or preference for any habitat type in North Bilaspur forest division, Madhya Pradesh (Akhtar et al., 2002). Sloth bears were found to use different habitat types covering smaller areas and showed distinct seasonal shifts between different habitat types. Presence of bear signs in different habitats was found mainly dependent on availability of food items in different seasons. In Mudumalai wildlife sanctuary, maximum scats were found in Dry deciduous tall grass forest, followed by Dry deciduous short grass, Thorn forest and Moist deciduous forest (Desai et al., 1997). In North Carolina, black bears need large areas with a variety of habitat types in coastal areas to meet food and cover requirement (Landers et al., 1979).

In Namdapha Tiger Reserve, flat, undulating, gentle slope and steep slope terrains were found to be differentially used by sun bears based on sign surveys and presence of scats and nests, in the study area. The use of flat terrain by sun bear was maximum, followed by steep slope, gentle slope and flat terrain in different forest types. Sun bears were found to use flat terrain maximum in Bamboo forest, and they were found to use undulating terrain maximum in Mix forest. The proportional availability of undulating terrain was found to be the highest, followed by gentle slope, steep slope and flat terrain. The expected use of these terrain types was found to be directly proportional to the availability of these terrains. The expected use of undulating terrain was found to be highest, followed by gentle slope terrain, steep slope terrain and flat terrain. In Namdapha Tiger Reserve, the differential use of terrains in various habitat types could be related to factors like availability food, resting, seeking shelter, escape cover and biotic disturbance.
The indirect evidences in different available habitats revealed that sun bears were generalist as far the habitat use was concerned. In northern Sumatra and in East Kalimantan, Borneo, another study on the habitat use by sun bear indicated that differences in family age, seasons, and years contribute to differences in overall habitat use patterns (Augeri, 2005). In spring, bears were generally on low slopes and in valley bottoms, whereas in summer they were found on upper and middle hillsides. They moved back down to lower hillsides and valleys in fall but were less concentrated in valley bottoms than in spring.

Sun bear were found to use disturbed and undisturbed habitats to varying extent along different elevations in Namdapha Tiger Reserve. Sun bears preferred forested habitats and the phenomenon may explain the tight home range patterns of sun bears in small forest reserves such as Sungai Wain Protection Forest, East Kalimantan (Meijaard et al., 2005), where the bears have also been observed in edge areas and local gardens (Fredriksson, 2005). In the current study, sun bears avoided the use of or movement through such disturbed areas, but in smaller patches, forage and habitat losses could force bears into marginal edge habitats and human-cultivated areas for food. Changing contiguous primary forests into a discontinuous patch-work of disturbed and undisturbed areas bordered by abrupt, sharply contrasting edges can induce geographic and density dependent compression. This can alter a bear’s movement dynamics through the landscape and prohibit critical habitat use (McLellan and Shacklton 1988; Augeri, 1994, 2000; Mattson et al., 1996; Merrill et al., 1999; Boyce 2000 and Augeri, 2002).