HABITAT USE, RANGING PATTERN AND MANAGEMENT OF SLOTH BEAR (*MELURSUS URSINUS*) IN NORTH BILASPUR FOREST DIVISION, MADHYA PRADESH

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Certificate

I have great pleasure in forwarding the thesis of Naim Akhtar, titled" Habitat use, ranging pattern and management of sloth bear (*Melursus ursinus*) in North Bilaspur forest division, Madhya Pradesh" for the acceptance for the degree of Philosophy in Wildlife science. The thesis embodies original findings and interpretation of facts. The research was carried out by Mr. Naim Akhtar under my supervision and has not been submitted in part or full to any other University/Institution for award of any degree.

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Summary

In the North Bilaspur forest division (NBFD) Chhattisgarh, sloth bears have created very formidable image among the local people. The habitat available to sloth bears is highly disturbed, fragmented, unprotected, and interspersed with villages, small townships, and cultivation areas. Sloth bears invade human habitation and agricultural crop fields and increasingly attack on people and cause extensive crop damage. This is the first study on sloth bears in India, which has been conducted outside the protected areas. The study is very important not only for the benefit of local people, suffering from the bear menace but also for the bear itself whose status is vulnerable in these areas. The study was carried out in Pendra and Marwahi ranges using transect sampling of vegetation and bear evidences, remote sensing, bear count at den sites, tracking of collared bears, and village survey.

The chapter IV deals landuse/landcover study and quantification of vegetation composition. The land cover and landuse pattern were studied by using the Arc/Info, Arcview software, Survey of India toposheets. The forest cover was to 343.79 km^2 out of total 1395.72 km^2 area. We identified 28 broad landuse categories, which were finally reduced to 16 landuse categories. The vegetation, habitation and agriculture, water distribution, road network, elevation, aspect, and biotic pressure maps were generated. The Scrub land covered the maximum area, followed by Habitation and agriculture, Mix forest, Sal forest, Dry river course, Water bodies, Plantation and Riparian area. Tree and shrub communities were found to be heterogeneous based on eigenvalues. These habitats were highly degraded due to heavy biotic pressure. The floral diversity was found to rich as indicated by Shannon, Simpson and Hill diversity indices. Sal and Sal mix vegetation showed maximum similarity based on cluster analysis. Sal forests were found to be highly dense, followed by Sal mix, Mix forest and Plantation. Thick density of Sal forest and Sal mix was mainly due to low girth classes of Sal trees.

Chapter V deals with assessment of biotic pressure on bear habitat. About 46% area of NBFD was found highly affected from biotic pressures. Whereas, only 2.5% area found most suitable for sloth bear. More than 27% area was severely affected and was not found occupied by bears. Altogether, 42 items of non-timber forest produce were regularly collected by villagers from bear areas. Thirty two items were of plant

origin, 3 of insects and 7 were mushrooms. Over exploitation of these exerts tremendous pressure on sloth bears and their habitats. The bear areas were highly disturbed at the time of tendu patta and mahua collection. Maximum number of cut/fell of trees was in Sal mix habitat, followed by Sal forest, Mix forest, Plantation and Scrub land. An increase of 8.31% was estimated in the number of cut/fell trees during one year period. Number of lopped trees was highest in Sal mix forest, followed by Mix forest, Sal, Plantation, Land near to water bodies, Scrub land and Crop field. An average of 10.43% increase in the lopping activity was recorded during one year interval. Dung abundance was found to be maximum in Open land, followed by Plantation, Scrub land, Land near to water bodies, Mix forest, Crop field, Sal mix, and Sal forest. Human population and livestock density is less, compared to the protected areas, but it is considered very high and detrimental for sloth areas. Every year nomadic graziers bring thousands of sheep and goats and camp at Silpahri, Pakariya, Salekota, Lityasarai, Chullapani and Andhiyarkho forests, the important bear areas. In Bedkudra and Karangra forest areas, Dahiyan and their cattle greatly impact the bear habitats. Due to illegal stone mining activities, dens in Jhandi dongri of Surungtola, Marakot and Jhandi and Bhuthi dongris of Barbasan were almost destroyed. As a result bears got displaced and their survival was highly threatened. Forest fires had adversely impacted the fruiting shrubs species, namely, makoiya and jungali ber important food species of bears.

Distribution and population abundance of sloth bears was assessed in Chapter VI. In Pendra and Marwahi ranges, 44 and 65 den sites respectively were identified. Out of total 109 den sites, 56 dens were found to be actively used by bears. Spaces in between the rocky boulders also provide shelter to bears. For denning, bear used gentle to steep slope, whereas the undulating or flat terrain was used as feeding ground. About 77% of the dens had the water accessibility within the limit of 500 m. More than 96.33% dens were located within the limit of 1250 m from the human habitation. In total 312 walks along the transects, only 4 bears were directly sighted in the study area. In disturbed and fragmented habitat conditions, bears were rarely active during the day time. Out of 78 transects, indirect evidences were recorded along the 76 transects. Based on the indirect evidences, sloth bear found to use diverse range of habitats and landuse categories. Average density of diggings and scats in different habitats was 16.69/ha and 2.29/ha respectively and was proportional to the abundance of sloth bears in these areas. In the vicinity of Pundi dongri, Jhandi dongri, Amli dongri, Lamra dongri, Ladara dongri and Niranjan kharil den sites, 10 males, 9 females, 6 cubs and 10 unidentified bears were counted and an average of 5.83 bears per den site was estimated. The bear population of 6 den sites was extrapolated at 95% confidence limit with number of active den sites, and it was estimated to be 326 ± 90 bears in the study area. The bear population in NBFD could be projected as one bear in 4.28 km^2.

Chapter VII mainly deals habitat use and ranging pattern of sloth bear using radio-telemetry. As many as 4 species of fruiting plants were recorded in 390 sample plots. Generally one or two fruiting species were found in the sample plots with bear evidences. Among all habitat types, average fruiting trees density was estimated 37.55 per hectare. The average shrub density was estimated 727.31 per hectare among various habitats types. The Sal mix forest, Sal and Mix forest with high fruiting trees and shrubs showed increased use of these habitats based on indirect evidences of bears. Availability of water and herb cover did not discriminate the presence or absence of bears in the study area. Two-dimensional scaling of habitat variables showed that bears could sustain the biotic pressure on their utilized habitats. Most of the dens were located very close to the human habitation within the limit of 1000 m. Denning was mainly related to the availability of food material. As preferred feeding items were available in the vicinity of human habitation, occurrence of live dens was more in the close proximity of villages.

A totals of 30 food items were found in 1086 scats. Gular, pakri, bargad, peepal, ber, bel, jamun, mahua, termites ants, maize and ground nut were the main food items of the bear diet. Availability of fruiting trees and food items in the forests and villages influence the use of these areas by bears. In forests and villages, there were 17 fruiting trees and food items, whereas 7 and 6 feeding items were exclusively found in forests and villages respectively. Termites act as one of the favourite food item of sloth bear. Although highest density of termite mounds was found in Land near to water bodies and Plantation, but proportionally the habitats covered small areas. Average density of termite mounds in different habitats was 16.35 per hectare.

In Pendra and Marwahi ranges, habitat utilization by sloth bears was studied based on compositional analysis. The radio-collared bears and other bears inhabiting den sites in different areas were found to use habitats without showing any territorially. The radio-collared bear 1, bear 2 and bear 5 showed home range at 95% confidence level was 22.33 km^2, 7.8 km^2 and 20.01 km^2 respectively. The movement pattern of sloth bears was correlated with the availability of food and shelter. In NBFD, availability of food resource varied with seasons. During winter and summer months, bears were mainly feeding on fruits, whereas in monsoon season, bears mainly feed on termites and black ants. Irrespective of seasons, the bears largely used Habitation and agriculture, Rocky outcrops, Dry river course, Scrub land, Sal, Sal mix and Mix forest habitat categories. Sloth bears were generalistic, there was no preference or avoidance of any habitat types. Bears were found to move frequently in villages in search of fruiting trees. During winter and monsoon bears were increasingly attracted to the villages and crop field due to availability of ber, maize and ground nut. Perhaps due to this reason, there were more and more encounters in the vicinity of villages.

Recommendations were made in Chapter VII. The following recommendations are hereunder. In Pendra and Marwahi ranges the potential bear habitats and denning areas have been increasingly encroached upon by villagers, the encroachment needs to be immediately checked and protected for habitat improvement. Illicit cutting and lopping of trees by villagers must be completely banned in bear denning areas and regulated in other forest areas. Removal or cutting fruit trees of utmost food value of sloth bears should be banned in bear areas. Regulation or imposing restriction on cattle grazing and NTFP collection in highly preferred habitat use area's need to be reviewed. Emphasis should also be given on proper resource management in critical areas. Among the local tribal people, the need of education and awareness programmes with respect to conservation of bear populations, forest protection and coexistence with bears is greatly felt. The local people need to restrict their activity for collection of forest produce only during 1000 to 1400 h. Stone mining activities in important bear habitats and denning should not be allowed and reinforced effectively. Suitable compensation scheme for the crop losses need to be developed. Victims of bear attack must receive proper medical aid.

Translocation of isolated bear population who does not have any future, to other suitable areas need to be considered.

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Chapter I. General introduction and objectives

1. 1. Introduction

In the North Bilaspur forest division, sloth bears have created very formidable image among the people of Pendra and Marwahi ranges. Sloth bears frequently raid agricultural crop fields and fruiting species, which, leads to serious encounters with human beings. Now a day's man-bear conflicts are on the rise and immediate attention need to be paid, not only to resolve the conflicts but also for conservation of this threatened species (Shankar and Murthy, 1995 and Chauhan *et al.*, 1999). In general, the people have some religious sentiments to this animal as locally it is called as 'Jamvant'. Kalander (Jugglers) used the religious text of Ramayana to add to the mythical dimension when they performed the bears play before the audience. The bear tribe, commonly called *Jamvant,* assisted Lord Rama in his search for Sita when Ravana kidnapped her. These references have given the bear a special status and it is regarded as the animal of power and strength, one that can frighten away evil spirits from possessed individuals and grant blessing of good health and peace particularly to the children (Seshamani and Satyanarayan, 1997).

Wildlife habitat is the environment that provides the essentials of food, cover and space to a population. These essentials are needed for reproduction, body maintenance and growth of both the individual animal and the population. In the North Bilaspur forest division, the habitat available to sloth bears is highly disturbed, fragmented, unprotected, and interspersed with villages, small townships, and agriculture fields. Moreover, people increasingly collect non-timber forest produce from the forests, which lead to confrontation with bears. This is the first study on sloth bears in India, which has been conducted outside the protected areas. It has great importance not only for the people of that area, suffering from the bear danger but also for the bear itself whose status is vulnerable and precarious in these areas.

1.2. Bear species and distribution

There are eight living species of bears found in the world. Family Ursidae can be divided into two sub families viz. Ailurinae (Giant and Red Panda) and Ursinae (Eight species of true bears). The members of family ursidae do not occur in Africa, Madagascar, Australia, various oceanic islands and the Antarctica, with the exception of polar bear, inhabiting the Arctic region. Spectacled bear (*Tremarctos oratus*) is found south of the equator. Malayan sun bear and Alaskan brown bears are the smallest and largest respectively in the bear family. Four species of bears viz. sloth bear, Asiatic black bear, Himalayan brown bear and Malayan sun bear, have been reported in India (Prater, 1980). Himalayan black bear and brown bear are only restricted to the Himalayan belt mainly in Jammu and Kashmir, Himachal Pradesh and Uttaranchal. The sun bear is distributed in the lowland of tropical rain forests of Southeast Asia and Northeast of India (Kurt, 1995). Sloth bear (*Melursus ursinus*) is found in the forested areas and grasslands of India and Sri Lanka. This bear is also found in Nepal, Bangladesh and Bhutan. The sloth bear once ranged through all the forests of Indian sub-continent and south of the

Himalayas in India (Prater, 1980). The central tropical deciduous forests appear to be its optimal habitat, as in Karnataka, Madhya Pradesh, parts of Orissa, and also the once heavily forested border between Nepal and India.

1.3. Status of the bear species

All bear species are listed as endangered, threatened, or potentially facing a precarious future (Schoen, 1990). The North American black bear (*Ursus americanus*) and giant panda (*Ailuropoda melanoleuca*) are significantly impacted by change in the habitat composition (Schaller *et al.*, 1985). Servheen (1990) mentioned that Asiatic black bear (*Ursus thibetanus*), sun bear (*Helarctos malayanus*) and sloth bear (*Melursus ursinus*) are in jeopardy because of degradation and loss of habitat. Mortality of threatened black bear of northern America, brown bear in Europe and spectacled bear in South America is very common because of forest fragmentation and insularisation. Knight (1984) mentioned that low density, secretive behaviour and high mobility make census of grizzly bear (*Ursus arctos horribilis*) difficult. Poaching and deforestation have been slowly eroding the available population of sun bear and its habitat. Long ago sloth bear inhabited the deciduous monsoon forests and thorn bush forests of India up to the Thar desert in the west and southern foot of the Himalayas (Kurt, 1995). They were also found in the rain forests and grass jungles in the North-east. Over exploitation of sloth bears by poachers and kalanders (jugglers) and due to severe habitat loss and fragmentation, population of this species has declined steadily (Johnsingh, 1986). Sloth bear is species of Schedule I of the Indian Wildlife Protection Act (1972) and

Appendix II of the CITES (Servheen, 1990), and being severely affected by poaching for its bile that is generally used for preparation of various medicines (WWF-India handbook published in 1998). The National laws in India forbid trade of any part of the sloth bears. However the TRAFFIC Japan, a branch of WWF, reported 681 kg of dried sloth bear gall bladders entered Japan from India between 1978 to 1988. According to the report of Servheen (1990), the import was from India via Singapore.

1.4. Habits

Sloth bear is the only bear, which has adopted itself to both temperate and tropical conditions. Sloth bear is very tolerant to heat. Ivory coloured claws are strong and curved and are eminently suitable for digging up beetles and termites nest. Smell is the dominant sense in these animals, but hearing and sight are poor. The brown bear can pick up the wind born scent of a man from long distance (Kurt, 1995) while sloth bear is comparatively short scented. The Himalayan black bear is said to see and hear better than brown bear, and better still than sloth bear. Its loose lips and long snout, together with a concave palate, give the animal extra sucking power. Its front two upper incisors are missing that allow it to draw in insects through gap. To prevent ingesting dust along with ants, bear pushes against the hole it digs, closing the flaps of its nose pad before sucking its meal. This is also responsible for the hoarse sucking snuffle it makes (Pillarisett, 1992).

1.5. Problem

The North Bilaspur forest division harbours large number of sloth bears. Available sloth bear habitat is fragmented and surrounded by villages and agricultural fields. Due to the habitat loss, fragmentation and encroachment on forests, the bear population is causing lot of nuisance. Incidence of human killing and mauling are quite frequent. Sloth bears invade agricultural crop fields, human habitation and cause extensive crop depredation and increasingly attack on people. As a result, human-sloth bear conflicts are on the increase in this forest division. Many incidence of bear encounter with human beings and consequently, several cases of human killing and mauling have taken place in this division. In the past few years, the conflicts have become beyond the tolerable limits. In January 1995 alone, seven people were killed by sloth bear in the North Bilaspur forest division besides mauling cases (Sankar and Murthy, 1995). There is little known about the habitat use, activity and movement patterns and spatial distribution of sloth bear (Bhaskaran *et al.*, 1997 and Joshi *et al.*, 1995). Generally, sloth bears not only feed on fruits and berries, but also on roots, carcasses and many small animals including ants, termites and bees as well as honey. They crack open ant hills, bee nest and termitaries as hard as brick. Sloth bears are known to feed on mahua (*Madhuca indica*) flowers as delicacy (Prater, 1980). They also raid agricultural crops frequently and scavenge meat occasionally (Laurie and Seidensticker, 1977).

Generally, food, water and cover are the basic requirements of an animal. The extent of the use of a habitat by animal is determined largely by the extent to which the habitat can supply these requirements. In addition, there are other factors that influence the use of a habitat, e.g. terrain, weather, human influence and other biotic factors (Bhat, 1993). These factors also determine the purpose, time of day, duration, season and strategy of the use of a habitat. Remote sensing gives a perspective horizontal view of landscape and helps in delineating different elements and their spatial characteristics. The study of vegetation communities, their stratification on landscape and relationship with various environmental variables is important in formulating management strategies for problematic sloth bears. Similarly structural analysis of landscape helps in problem identification and severity, which is useful in planning ecosystem management. Visual interpretation of satellite data has been successfully used for vegetation stratification based on type and structure (Shirish and Roy, 1995).

As the habitat available for sloth bears within the Pendra and Marwahi ranges is highly degraded and fragmented, the movement pattern and home range of sloth bears may be greatly affected in disturbed man-altered situation. In Chitwan National Park, annual home range of male and female sloth bear is 14.4 km^2 and 9.4 km^2 respectively (Joshi *et al.*, 1995). The home range is found to be influenced by food availability, dry and wet seasons and reproductive activity. The total human population of the affected area projected in 1995 was around 25,300 and the estimated livestock population was around 10,000

(Sankar and Murthy, 1995). But now the human population of North Bilaspur forest division is more than 2,00,000 and livestock population is over 1,50,000. There is tremendous pressure on the habitat of sloth bear due to increasing human and livestock population. Consequent to this, the status of the bear not only is endangered in this area, but it may also lead to more conflicting situation. This requires immediate conservation and management related studies in the problem areas. To mitigate the problem, it is necessary to have the knowledge of the ecology of the problematic sloth bears in man-altered fragmented areas of Pendra and Marwahi ranges of the North Bilaspur forest division.

1.6. Significance of study

As stated, the Pendra and Marwahi ranges harbour large number of sloth bears and available sloth bear habitat is fragmented and interspersed with villages and agricultural fields. As a result, the bear population has become isolated and its exposure to human beings has led to more encounters. The bear population is causing lot of nuisance; incidence of human killing and mauling are quite frequent and increasing beyond tolerable limits. This requires immediate conservation and management related studies in the problem areas. There is an urgent need for protecting the bear habitat and suggest ways to reduce the human-sloth bear conflicts and conservation of this threatened species.

Habitat analysis is considered to be important for the wildlife management. In poor habitat condition of North Bilaspur forest division, the resources availability for bear population need to be studied. Presence of den sites near human settlements is quite unusual but clearly is an indication of forced use of degraded habitat by the bear. The resources available in the vicinity of the villages are non-timber forest produce including mahua flowers and agricultural crops such as maize, sweet potato, sugarcane and peanut. These perhaps attract bears to live in these areas and which results in serious human-bear conflicts. The study on assessment of the bear habitat using remotely sensed satellite data and home range and movement pattern using radio-telemetry will also help developing conservation and management plan for sloth bear in the North Bilaspur forest division.

1.7. Objectives

(i) To prepare habitat maps for the study area, Pendra and Marwahi ranges of the North Bilaspur forest division, and quantify vegetation composition and structure within each habitat type.

(ii) To assess the distribution and population abundance of sloth bears in Pendra and Marwahi ranges.

(iii) Quantify habitat use and ranging pattern of sloth bear using radio-telemetry.

(iv) To assess impact of biotic pressures on bear habitat.

Chapter II. Study area

2.1. Introduction

The study was carried out in Pendra and Marwahi ranges of the North Bilaspur forest division, Chhatisgarh, covering an area of 1395.73 km^2 (Map 1). Geo-coordinates of the study area lie between the latitude 22^0 40' N and 23^0 06' N and longitude 81^0 44' E and 82^0 13' E. Available forest cover is highly degraded, fragmented and interspersed with agriculture fields and human settlements and small townships. Sloth bear habitat within the two ranges was also highly degraded and fragmented. The forests are patchy and scattered, covering an area of 337 km^2 and is managed under North Bilaspur forest division. The area of the fragmented forest blocks ranges from 11 to 97 ha (Map 2). In this forest division, human population is more than 2,00,000 and livestock population is over 1,50,000, inflicting severe extent of biotic pressure. Recently the North Bilaspur forest division has been reorganized into Kenda, Gaurela, Pendra and Marwahi ranges, but for this study, we used the Pendra and Marwahi ranges, the previous organization of this division. The study area lies between one of the oldest mountain chains of India i.e. Vindhya range. The western part is having mines of bauxite, whereas northern part has coal mines. The North Bilaspur forest division is classified under Eastern Deccan biogeographical zone (Rodgers and Panwar, 1988).

2.2. Topography

Topography of the area is undulating, interspersed with chain of hillocks and rocks. Some of the hillocks are scattered and surrounded by villages; these hillocks provide caves (dens) to sloth bears. The elevation of hillocks varies between 450-1050 m and commonly known as Vindhya or Maikal range. The forest areas lie along the Vindhya range of mountains and undulating parts of north Marwahi. The Son river is only major river in this area and there are seasonal streams and nullas. The Son river has its origin in the hills of Amarkantak, which is on the border district Shahdol, and flows through the study area. It becomes dry in winter and summer, but flows well during monsoon. In this area, people follow the conventional method of water harvesting from ponds and check dams scattered all over the study area.

2.3. Boundaries

The forest areas of Pendra range along the Amarkantak chain of hillocks are connected with forests of Lamni range of Achanakmar sanctuary from western side and extended further up to Kenda range in south. The Achanakmar sanctuary has good forest cover and faunal diversity as well. It indicates that both areas would have been contiguous in the past through good forest cover, but over the period of time it has been degraded and fragmented due to increasing biotic pressure. Shahdol makes the boundary in the north and western sides, whereas west Sarguja covers this division from the eastern side. The Bilaspur district surrounds it from the southern side. The eastern boundary starts from the border of Pasan range and touches the Usad village, which is on the border area of Sarguja and Marwahi. Further it extends up to the Amarkantak chain through Venkatnagar town of Shahdol district.

2.4. Geology and soil

Ground shape, terrain and texture govern the type and distribution of forests. Distribution of Sal largely depends on geology and soil type of the area. Generally, Sal does not found in pure trap but grows in mature soil, which has acidity and low pH. Basic soil encourages the growth of mix forest. The rocks of this area belong to Archaean and proterozoic era, and metamorphatics and granites gneisses are the important types. Rivers are filled with gravel and porous soil. The northern part comes under the category of lower Gondwana. Topography is the major factor behind the soil formation. Increase in leaching from the peaks and high elevated areas, leads to the decreased depth of soil. Such places loose the ability to retain water; consequently it affects the vegetation type and regeneration in the area. Areas, which collect the soil from the high land, receive lot of soil nutrients as well, which make their soil good for vegetation growth. Topography also changes the physical and chemical properties of the soil. Following soil types are found in these areas:

i. Talchari (Yellow soil): This is soil of Sal forest areas. Quantity of iron changes the colour of soil. If soil has less amount of iron oxide or affected from leaching, it makes the yellow colour.

ii. Kali mitti (Black soil): This soil has developed from the weathering of Deccan trap. This type of soil is found in the north-western part of the North Bilaspur forest division. This is rich soil with aluminium, silica and magnesium. Due to alumina, soil gets the ability to hold water for more time. Soil weathers after getting dry, which is harmful for plants as well. Places with such soil favours to have good forests in that area.

iii. Brown or grey soil: This is developed from the weathering of gneisses, sand and lime rocks. Locally people term it as Kanhar mitti.

Clay, grey soil and loam are important soil types found in crop fields. Crop fields along the hillocks generally have underground rocks, which make the soil unsuitable for digging for water.

2.5. Climate

The area experiences three distinct seasons i.e. winter (November-February), summer (March-June) and monsoon (July-October). Temperature fluctuation in this area is significant during night time. Generally days are hot, but evenings become cool. Even winter is not severe during day time, but temperature goes down considerably during night hours. Rainfall and temperature vary with change in altitude and topography. More than 5^0C difference has been observed between Pendra and Marwahi ranges. Major part of the rainfall is received during monsoon. Ground fire is common in summer, but not dangerous as such for trees. It is harmful for shrubs and ground vegetation.

From December to February, daily average temperature remains almost constant, which is between 24.45^0C and 27.10^0C. After February, there is sharp increase in temperature, which culminates in May with 39.36^0C. In June, temperature falls quickly after receiving the first rain; average temperature of this season has been reported as 35.96^{0}C. There is sharp reduction in the night temperature during monsoon season. Average temperature of the winter season is 10.71^{0}C, but some times, it goes down up to 2^{0}C because of cold wave. Maximum temperature recorded at Pendra road meteorological observatory was 46.2 ^{0}C. Monsoon begins in June last and continues up to September. Average rainfall of this region is 1375.68 mm. Proportional rainfall received during the monsoon is 84.73 percent of the year.

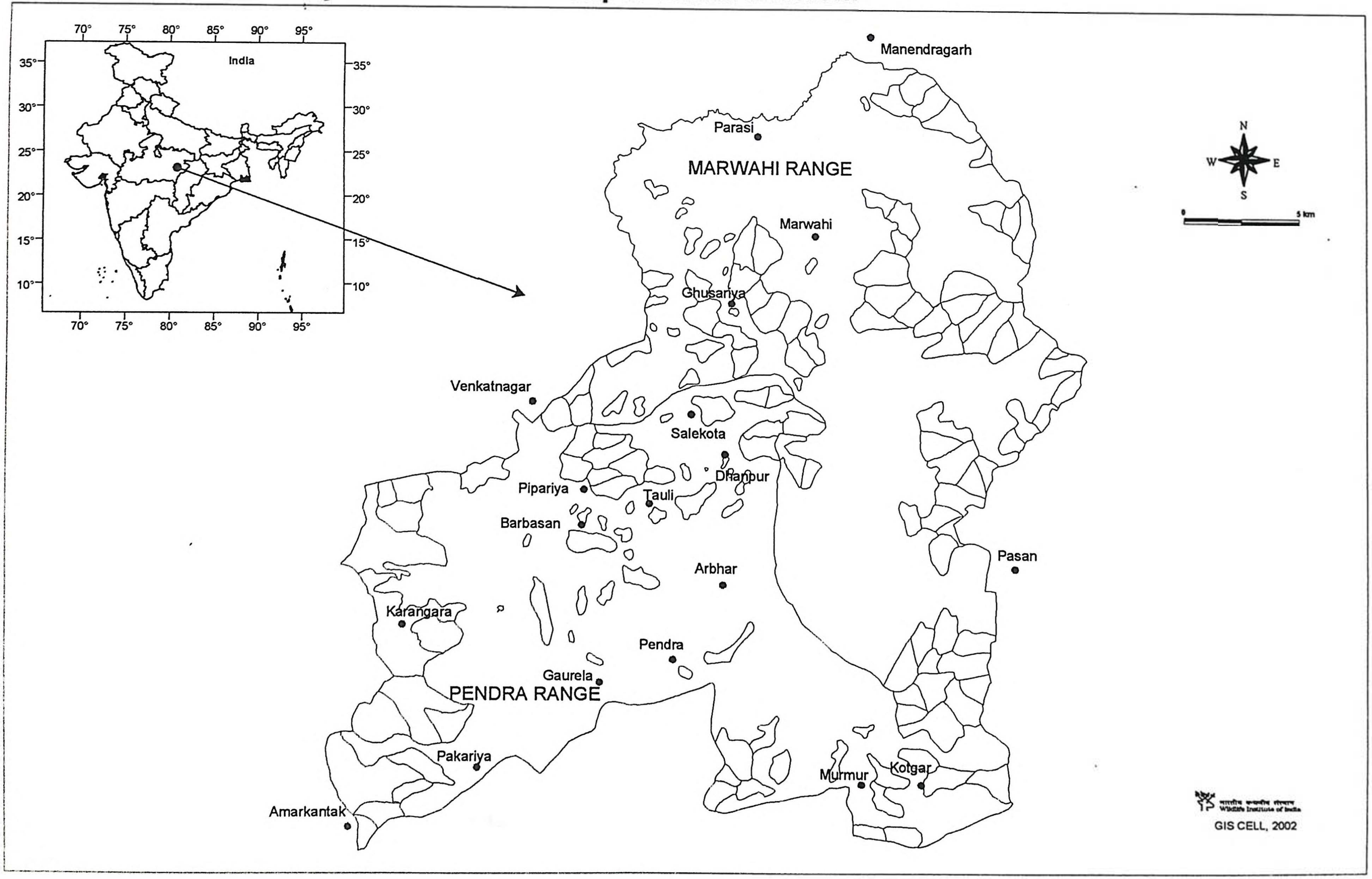
2.6. Vegetation

Champion and Seth (1968) classified the forest types of the area as Dry deciduous peninsular Sal forest (5B/C1,C), Northern tropical dry Mixed deciduous forest (5B/C2) and Northern tropical secondary Moist mixed deciduous forest (3C/C3). Amarkantak belt has the Sal and Sal mix forest with some patches of Moist mix forest. Undulating surface of Marwahi range has Sal mix forest and Moist mix forest, whereas the hillocks carry Mix forests.

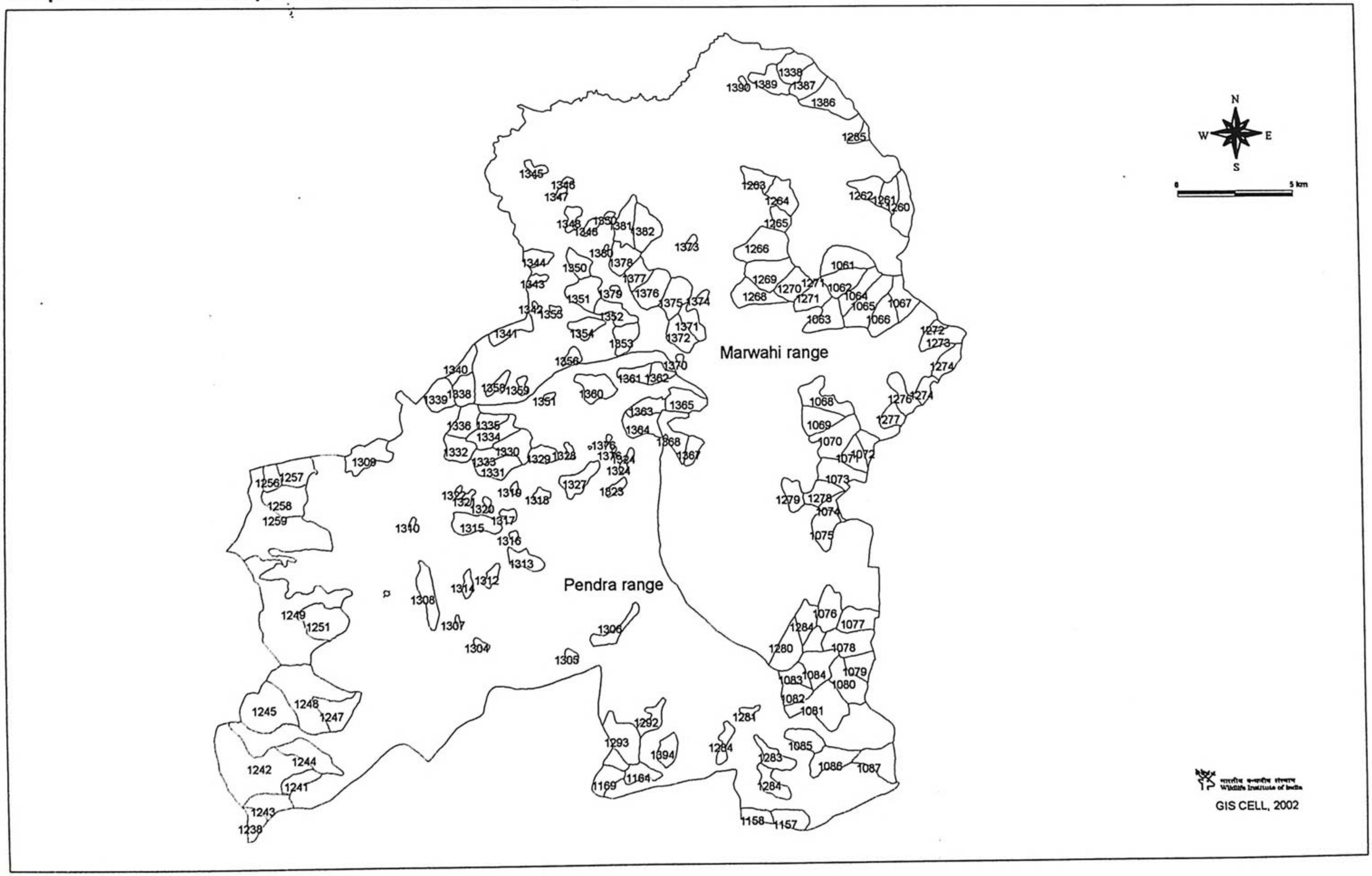
2.7. Fauna

The wild animals of the study area are sloth bear (*Melursus ursinus*), leopard (*Panthera pardus*), nilgai (*Boselaphus tragocamelus*), spotted deer (*Cervus axis*), hyena (*Hyena hyena*), jackal (*Canis aureus*), Indian fox (*Vulpes bengalensis*), four-horned antelope (*Tetracerus quadricornis*), wild pig (*Sus scrofa*), common langur (*Presbytis entellus*), rhesus macaque (*Macaca mulatta*), toddy cat (*Paradoxurus hermaphroditus*) and Indian porcupine (*Hystrix indica*).

Map 1: Sloth bear study area in North Bilaspur forest division.



Map 2: Forest compartments in North Bilaspur forest division.



Chapter III. Review of Literature

3.1. Land cover and landuse pattern in Pendra and Marwahi ranges

To study the changes in landcover, diversity and landuse pattern, remotely sensed satellite imageries along with ground verification and geographical information system (GIS) are increasingly used. The satellite remote sensing, a new technological development for surveying and monitoring land cover is very collectively used in habitat management and biodiversity conservation. Remote sensing provides spatial distribution of vegetation types and is considered as prime requisite for vegetation analysis. Detailed forest cover type and land use mapping have been successfully done in various parts of the country and abroad using aerial photo interpretation technique. The use of remote sensing technique at national level was attempted for the first time by the Forest Survey of India in 1982. Black and white imagery of band 5 of Landsat -2 and -3 were interpreted to prepare a national vegetational map and to assess the vegetation cover of the country (Choudhury *et al.*, 1983). During 1983, the National Remote Sensing Agency (NRSA) prepared a vegetation map of the country using false colour composite imagery for the period 1980-1982 (NRSA, 1983). The Forest Survey of India (FSI) did the second exercise on the vegetation mapping of the country by using false colour imagery for the period 1981-1984 (Mishra and Dabral, 1986). In 1985, the NRSA prepared wasteland map of the country on 1:1 million scale using Landsat imagery for the period 1980-1982 (NRSA, 1985). Satellite mapping of alpine pastures in the Himalayas was done by Lal *et al.* (1991). Mapping of the forest cover has also been done using satellite images viz. Landsat Multispectral Scanner (MSS) and False Colour Composite (FCC). Madhvan Unni *et al.* (1983), Roy *et al.* (1985) and others have used Landsat MSS FCC successfully for forest cover mapping and monitoring the change in vegetation. Vertical stratification and structural association of different plant communities based on ground methods have been studied effectively by the profile analysis in tropical rain forest (Roy *et al.*, 1993). Ecological status of tiger habitat between Kanha National Park and Achanakmar Wildlife Sanctuary was studied using remote sensing data (Mathur *et al.*, 1995). Suitability analysis, interspersion, and juxtaposition of tiger habitat of Kanha National Park and Achanakmar Wildlife Sanctuary have been studied using satellite data. Suitability classes of various habitats for tiger were mapped in the same areas. In a study on goral (*Nemorhaedus goral*) in Rajaji National Park, suitability index was developed on the basis of interspersion, juxtaposition and relative disturbance factor (Roy *et al.*, 1995). More than 35% area was found suitable, whereas more than 20% was not suitable for goral. Hood and Parker (2001) studied the impact of human activities on grizzly bear habitat in Jasper National Park. To know the habitat effectiveness coefficient for grizzly bear realized habitat, potential habitat and cumulative disturbance coefficient were estimated, using Arc/Info. Pant and Roy (1990) used Landsat TM data to assess the vegetation and landuse cover of Aghlar watershed area of Garhwal. Vegetation distribution and landuse practices were identified on southern and northern aspects of the Aghar watershed. Southern aspects were more inhabited and subjected to terrace cultivation and acute shortage of vegetation resources for fuelwood and fodder. The northern aspect was covered with thick vegetation and inhabited with low human density.

Visual interpretation of Landsat TM FCC has been carried out to identify bio-climatic vegetation types in Palghat division of western ghats (Porwal and Roy, 1992). Jorgenson and Nohr (1996) used the satellite images for the mapping of landscape and biological diversity in the Sahel (Senegal). In this study., they compared ornithological field survey data with satellite images and landscape diversity with biomass of the area. Forest cover type and landuse of Chakrata (western Himalayas) was mapped using Landsat thematic map by Porwal and Pant (1989).

In the last two decades, attempts have been made by various scientists and field managers to study floristic composition of different forest types and most of vegetation data were collected through sampling from representative sites. The sampling units were standardized to suit the purpose, name of the vegetation, climate, availability of man power, material, time etc. Sharma *et al.* (1983) worked on the standardization of methodology, quadrat size and laying out quadrat for speedy and convenient collection of vegetation data for vegetation classification and mapping. In the tropical zone forest of the Makalu-Barun conservation area of eastern Nepal, five community types were identified within three major forest formations using TWINSPAN analysis (Zomer *et al.*, 2001). Importance Value Index (IVI) was calculated for all species within each community. Importance value (RIV) data of perennial vegetation sampled in quadrats at 251 sites covering all habitats in Thar Desert Jaisalmer were analysed for classification and ordinations by Kumar (1992). Classification of vegetation by two-way indicator species analysis (Twinspan) revealed three site classes and four species classes, both arranged along a gradient of soil texture. Shrish and Roy (1997) studied impact of disturbance on landscape structure using satellite remote sensing and geographic information system (GIS) in Madhav National Park, India. The Landsat TM data has been used to identify vegetation types. The patch characteristics of the vegetation like size, shape porosity and patch density have been studied with physical and human made features. Species diversity index, concentration of dominance, distribution patterns and community coefficient were calculated for woody species of forests of Chakrata Himalayas (Singhal *et al.,* 1986). In total 90 genera within 49 families were identified in Costa Rican forests (Hooftman, 2001). The vegetation was separated in three forest types using TWINSPAN classification. Elevation and forest age showed overall no correlation between number of genera and elevation. Abd El-Ghani (2001) used two-way indicator species analysis (TWINSPAN), deterended canonical analysis (DCA) and deterended canonical correspondence analysis (DCCA) to produce a classification of plant communities and relationship of these plant communities to certain edaphic factors, namely, soil reaction, total soluble salts, calcium carbonate, organic matter, moisture content and fine fraction at Egyptian inland salt marshes. To study ecological parameters in tropical forest community at Andaman islands, Importance Value Index (IVI), Ab/F, Index of maturity and diversity, Index of dominance and Index of similarity were estimated by Roy *et al.* (1993).

Shannon index and rarefaction estimates were calculated by Meera *et al.* (1998) to identify potential areas for conserving biodiversity in the western Himalayas. In Pendra and Marwahi ranges, satellite images of IRS 1B LISS II B FCC (1996), Survey of India toposheets (E/16, F/13, F/14, I/4, J/1, J/2) and compartment map of North Bilaspur forest division were used to study the landuse pattern. Land cover (vegetation) was stratified on the basis of random sampling, and then diversity indices, cluster analysis and plant density were calculated using TWINSPAN, Biodiversity Pro and EXEL-2000 software.

3.2. Impact of biotic pressures on bear habitat

The dependence of growing human population on forest is considered high. Forest products contribute substantially to various components of the livelihood systems of people by providing inputs for agriculture, animal husbandry and horticulture. The Swedish International Development Cooperation Agency (SIDA) commissioned a study in 1993-94 on climate changes and forests in Himachal Pradesh, India, which was undertaken jointly by the Stockholm Environment Institute and the Tata Energy Research Institute, Delhi (Deshingkar, 2000). They found that Himachal Pradesh has a large animal population with over 5.6 million animals on a land area of 55,700 km^2. Nearly 42% of the total fodder consumption of 10-14 million tones per annum is met by grazing in public forests. About 1.6 million tons of total firewood consumption is also provided by public forests. This evidently shows as to the how much pressure is exerted on forests, which may be directly affecting the wild animal population as well.

A few studies have been conducted to estimate the biotic pressures on wildlife animal habitats and indirectly on the wild animals. Impact of jhum cultivation on three arboreal squirrels and a few primate species densities was examined in successional jhum fallows of known age with the primary evergreen and semi evergreen forests in Mizoram (Raman, 1996). Mackie (1995) studied the impacts of livestock grazing on wild ungulates in North America, where he observed direct negative impacts, indirect negative and operational impacts. Sinha (1993) studied the impacts of landuse on the eco-degradation of the wild ass habitat in the Little Rann of Kutch, Gujarat, and found that fuelwood collection, salt farming and livestock grazing were exerting tremendous pressure on the habitat.

Joshua and Johnsingh (1994) found that among the disturbances which affect the grizzled giant squirrels directly in south India were collection of tamarind fruits and climbers and shouting, throwing stones on squirrels and use of crackers by pilgrims. Even during the crucial birth and nursing season, the study area was impacted by high pilgrim pressure, which caused considerable disturbance to the squirrels. The study of biotic pressures e.g. grazing and tree lopping and cutting was conducted in tiger habitats between Kanha and Achanakmar sanctuary using remote sensing data (Mathur *et al.*, 1995). They characterized the habitats with nil, low, moderate and high pressures.

The habitat suitability index was developed for goral (*Nemorhaedus goral*) on the basis of interspersion, juxtaposition and relative disturbance factor in the Rajaji National Park. More than 50% habitat was found highly affected from biotic pressures, whereas more than 20% was not suitable for goral (Roy *et al.*, 1995). Hood and Parker (2001) studied the impact of human activities on grizzly bear habitat in the Jasper National Park. Presence of people and other biotic pressures were identified along the transects using cameras in the national park. The realized habitat, potential habitat and cumulative disturbance coefficient were estimated to assess the actual extent of biotic pressures. Whole study area was mapped to show the habitat effectiveness on grizzly bear using Arc/Info software. The Pendra and Marwahi ranges were inhabited by more than 2,00,000 human and 1,50,000 livestock population. Moreover, people were also depended on forests for non-timber forest produce. In this study, attempts were made to collect the biotic factor variables, which affect the bear population, and their cumulative impacts were mapped.

3.3. Distribution and population abundance of sloth bears

The protected areas have been especially created to conserve flora and fauna of utmost importance. Some species are endangered locally or nationally, and others are ecologically important or dominant in the area, such as tiger, elephant and bear. All of these may require specific management inputs and so have been considered as key species for planning census. Designing census method for such a species would require greater manpower and financial resources (Rodgers *et al.*, 1991). Wild species living outside the protected areas are equally important especially when species is threatened and problematic, which would need attention to conserve the species and mitigate the conflicts as well. The knowledge of population status of such wild species inside and outside protected areas is very important, which would enable formulation of strategies for the management of the concerned species. Inspite of the fact that the Pendra and Marwahi ranges are highly disturbed and fragmented, the two ranges harbour large number of sloth bear. Man-bear conflicts are on the rise in these areas. So attempts were made to know the status and distribution of sloth bear in the two ranges. This would in turn help developing strategies for mitigation of man-bear conflicts.

Techniques to estimate animal density are many (Davis and Winstead, 1980, White *et al.*, 1982). Many of these procedures determine the number of individuals within a study area based on ratio of marked vs unmarked animal. Using capture and recapture technique, number of animals can be accurately estimated. Schwartz *et al.* (1983) studied the black bear predation on moose in the North-central Kenai Peninsula of Alaska, and used home range parameter for the estimation of bear population. Polar bear population in Alaska was estimated and monitored for a long time following the mark and recapture technique (Steven, 1999). Recently, Woods *et al.* (1999) developed a method to estimate grizzly bear population size using hair removal technique and DNA profiling. These sampling methods have been used to estimate the bear population size in several areas of British Columbia and Alberta (Wood *et al.*, 1999 and Nams, 2001).

Grizzly bear population in the Yellowstone National Park was estimated and monitored by Eberhardt and Knight (1996) on the basis of adult female count, their age and distinct families. Assuming the 3 years reproductive interval, their estimate could show 67 adult females for minimum total population of the 254 bears. Knight (1985) had projected the future population of the Yellowstone grizzly bears on the basis of adult female count using Leslie matrix model. Servheen (1983) estimated the grizzly bear population of 16 bears or 1 bear in 49 km^2 using home range in the Mission mountains, Montana; the estimate included 2 adult males, 2 sub adult females, 3 adult females with 7 cubs and 1 adult female with 1 yearling. Home range, capture and recapture, and marking data for 49 grizzly bears and one bear per 22.8 km^2 was estimated in South Western Yunkoon (Pearson, 1975). Munday and Flook (1973) reported that the area covered by one grizzly bear was between 18.1 and 28.5 km^2 in the Glacier National Park. Martinka (1974) computed a density of one grizzly bear per 21.2 km^2 in the Glacier National Park, Montana. Jonkel and Cowan (1971) reported density of black bear from one per 2.1 km^2 to one per 4.4 km^2 in the spruce-fir forest of Montana. In Alaska, Amstrup (1981) conducted polar bear research for estimation of bear density across the country.

Laurie and Seidensticker (1977) estimated sloth bear crude density of 0.1 bears /km^2 (55 bears) in Royal Chitwan National Park for a smaller area, based on the number of different bears encountered within continuously monitored area. Same method was adopted by Desai *et al.* (1997) and estimated 0.17 bears/km^2 (20 bears) within 120 km^2 area in Mudumalai National Park. Besides, density of scats along the transect was calculated for the development of density index. Several reports indicated such low density of sloth bear in protected areas in India and Sri Lanka (Rajpurohit and Krausman, 2000; Desai *et al.,* 1997 and Santiapillai and Santiapillai, 1990). Eisenberg and Lockhart (1972) estimated one sloth bear per 21 km^2 for Ruhena and Wilpatu National Park in Sri Lanka. In Chitwan National Park, population of sloth bear was 250 bears in total or 25-72 bears/100 km^2 using capture, marking, recapture technique by Garshelis *et al.* (1999). Density index for sloth bear population was also developed on the basis of indirect evidences such as digging of termite mounds and presence of scats. Santiapillai and Santiapillai (1990) mentioned 0.05/km^2 crude density of sloth bear in the Ruhena and Wilpatu Natonal Park. In Pendra and Marwahi ranges, all the bear den sites were identified based on repeated surveys to find the distribution and abundance of sloth bear. On the basis of indirect evidences, density index of bear population was developed.

3.4. Habitat use and ranging pattern of sloth bear using radio-telemetry

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 6 km 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 6 bears during 1977-1979. Habitat component elevation and aspect were recorded for each radio locations, and only one location was used per bear per 24 hours period. A Chi-square test was used to determine whether there was any difference ($P<0.05$) between the use and availability of habitat component. Grizzly bears visited traditional livestock carrion dumps regularly. Grizzly bears obtained spring insects by excavating rotting wood from tree stumps and logs. Spacing in grizzly bears was related to distribution of food resources. Female with cubs covered comparatively smaller area (205 km^2) than the solitary male (436 km^2). Habitat component used more ($P<0.05$) than expected in Autumn included riparian area, wet meadows, and seeps in low elevation and alpine slab rock at high elevation. Telemetry data indicated no evidences of territoriality for black bears (*Ursus americanus*) (Rogers, 1977).

Clark *et al.* (1993) developed a GIS model for the habitat use by female black bear. They collared 16 females; adult female bears moved at a mean rate of 0.4 km/hour within the home range of 3.57 km^2 on its mean diameter of 6.7 km. Bears used most pine types less than expected and generally used middle or high elevation during summer and lower elevation during autumn. Bears used flatter terrain more than expected and generally used habitat with low diversity less than expected. Schwartz *et al.* (1983) studied black bear predation on moose in Alaska, and found that the home range of black bear was dependent upon the bear age and sex. Female with cub/yearling and female without offspring covered 4.4 - 45.8 km^2 and 13 - 31.5 km^2 area respectively, whereas adult male and sub adult male covered 40.6 - 340.8 km^2 and 10.9 - 20.9 km^2 area respectively.

Swenson *et al.* (1999) tested the hypothesis regarding selection of ant species, factor influencing seasonal use of ants and foraging behaviour of brown bear in central Sweden. Ants provided abundant, stable and predictable food resource, rich in protein and energy for the bears in the central Sweden. Schwartz and Franzmann (1991) compared two black bear populations in Alaska and found a higher rate of body growth in the population that fed less on ants but more on moose calves.

Garin *et al.* (2000) found that habitat utilization by sheep was not uniform as pellet-group count was different among woodland types. Sheep chose conifer plantation and avoided *Fagus* and *Quercus* woodland, while the use of riparian forest was not significantly different from expectation based on availability. Food and habitat of black bear in south eastern North Carolina was studied by Landers *et al.* (1979). He found altogether 12 food items in the bear diet; only 3 items were from non vegetational (bees, birds, beeswax) matter. Telemetry, trapping and track count data indicated that movement during late winter was primarily by young males, who did not den for extended period of time. They primarily studied the foraging habitat, denning habitat, and escape habitat. Home range size (95% confidence ellipses) averaged 42 km^2 for adult males and 15 km^2 for adult females of black bear in the Great Smoky Mountains National Park (Garshelis *et al.*, 1981). The study conducted by Stralen (2001) in the San Gabriel mountains showed 5.4 - 22.1 km^2 (95% confidence level) home range for black bears. Among 4 collared bears, 1 bear spent most of the time out side the urban area, whereas 3 bears spent much more time in the capture area. Scats collected from the urban area contained a much higher level of non-native and cultivated matter.

Powell *et al.* (1999) studied the ecology and behaviour of black bear in the Pisagh bear sanctuary in the Pisagh national forest of western North Carolina. The males covered large areas much more than the females and moved long distances especially during summer (breeding season) and fall. For the females, spring range did not differ significantly in the area. Mean home range for adult females and males was 16.2 km^2 and 43.3 km^2 respectively.

As far as the habitat use of sloth bear is concerned, very few studies have been done in India e.g. in Panna National Park (Yoganand, 1998 and 2001), Chitwan National Park (Joshi *et al.,* 1995 and Lauri and Seidensticker, 1977) and Mudumalai wildlife sanctuary (Desai *et al.*, 1997). Few observations on the habitat use by sloth bear were also made by Rajesh Gopal (1996) and Gokula (1991) in Bandhavgarh National Park and Mundanthurai wildlife sanctuary respectively. Gokula and Varadharajan (1991) conducted a short term study at Mundanthurai plateau of south India and analyzed 11 scats, which revealed nine food items constituting the diet of sloth bear.

Sixteen sloth bears were collared and tracked by Joshi *et al.* (1995) in the Royal Chitwan National Park and they found that these myrmecophagous bears covered small home ranges. Six of 8 males tracked for ≥1 year exhibited seasonal home range shifts from grassland and riverine forest of alluvial floodplain to upland sal; however the 2 smallest males and most females did not make seasonal range of shifts to sal forest. Alluvial dry season ranges were smaller ($p<0.05$) than wet season ranges. The minimum and maximum home range of male was 5.2 km^2 and 27.4 km^2 respectively, whereas for female it was 4.4 km^2 and 23.8 km^2 respectively.

Desai *et al.* (1997) studied the mother-young relationship, den use, home range, fruit availability, termite mound density and foraging ecology of sloth bear in Mudumalai. The mean group size of sloth bear was 1.8 (n=112), and moving and feeding activities were greater in the mornings and evenings than the middle of the day. More scats were found in dry season and positive correlation was found with fruit abundance as well. The population abundance was estimated using the method of Laurie and Seidensticker (1977) i.e estimated bear density for a smaller area based on the number of different bears encountered within continuously monitored area. Altogether 16 bears were counted in an area of 120 km^2. The home range of mother with two cubs was estimated as 19.1 km^2 and two sub adults showed the range of 5.54 km^2. Sloth bears were generally sighted along nullas, streams and sand banks of rivers. Most of the dens were located in nullas (dry stream beds) and between rocks, and majority of dens had single opening. Correlating the habitat use with scat abundance, maximum scats were found in deciduous tall grass forest, followed by dry deciduous short grass forest, thorn forest and moist deciduous forest. From scats (n=474), 11 plant matter and 4 animal matters were identified. Rajesh Gopal (1996) observed that sloth bear in Bandhavgarh

National Park preferred more than 21 food items, out of which, 13 were seasonal fruits.

Food habits of the Himalayan black bear (*Ursus thibetanus*) was studied in the Dachigam sanctuary, Kashmir by Schaller (1968). He found that the preferred diet of black bear comprised of vegetative material viz. *Celtis australis* (40.2%), walnut (32.9%) and acorn (12.1%). Altogether 12 fruit items were found from 82 scats. Manjrekar (1989) and Saberwal (1989) conducted the study on feeding ecology and distribution and movement of black bear respectively in Dachigam sanctuary.

Tufto *et al.* (1996) in their study in central Norway found that female roe deer adjusted the size of their home range in response to decreasing food supply. The habitat use of an animal is estimated either by the proportion of radiolocations within each habitat or by proportion of home range area constituted by each habitat. If a habitat type is used more than expected from its availability, it is often said to be preferred (Aebischer *et al.,* 1993). Harris *et al.* (1990) reviewed the problems and techniques particularly as applied to the study of mammals in home range analysis using radio-tracking data. Basically they discussed guidelines for planning radio-tracking method, to highlight some of the potential problems in designing the study and collecting the data and to identify constraints that might be encountered during the analytical stages. The advantages and disadvantages of the most frequently used methods of home range analysis were discussed, and methods for determining the minimum number of radio-fixes and techniques for adjusting inadequate sample size were described. The confidence interval technique of Neu *et al.* (1974) has been often used in conjunction with chi-square goodness of fit test. This chi-square test can be used to determine whether there was a significant difference between the expected utilization of vegetation type (based upon their availability) and observed frequency of usage. Byers and Steinhorst (1984) presented a computational example of the technique for analyzing the utilization-availability data.

Chapter IV. Land cover and landuse pattern in Pendra and Marwahi ranges

4.1.0. Introduction

Remote sensing and Geographical Information System (GIS) are the most vigorous tools to interpret the landcover and landuse of any area now a days. These techniques are very helpful and determing to formulate important national policy on environmental conservation, water, soil etc. Remote sensing techniques has helped in investigating and mapping of natural resources (Karale, 1992). Forest Survey of India (FSI) used remote sensing techniques for the first time for operational task at the national level in 1982 (Lal *et al.,* 1991). Black and white imageries of band 5 of Landsat-2 and Landsat-3 were interpreted to assess the vegetation cover of the country and prepare a national vegetation map (Choudhury *et al.,* 1983). During 1983, the National Remote Sensing Agency (NRSA) prepared a vegetation map of the country using false colour composite imageries for the period 1980-1982. The FSI prepared the vegetation map of the country by using false colour imageries for the period 1981-1984 (Mishra and Dabral, 1986). In 1985, the NRSA prepared a wasteland map of the country on 1:1 million scale using Landsat imagery for the period 1980-1882 (NRSA, 1985). The results of the exercises conducted by FSI and NRSA proved that satellite imagery could give an assessment of land cover without any personal or professional bias, which could be used for future landscape planning. Besides the FSI and NRSA, many other national organizations such as the Oil and Natural Gas Commission, Space Application Centre, Geological Survey of India, Central Water Commission, Directorate of Landuse Survey and Planning, French Institute of Pondichery, Indian Institute of Remote Sensing and Wildlife Institute of India, Dehradun are using satellite data to obtain information for differnt purposes.

Traditionally, forest is considered a renewable resource and integration of various aspects of the environment. However, the survival of the man existence is threatened due to exploitation of natural resources, including vegetation wealth. There has been growing concern for the preservation of primary or secondary forests. More and more attention is being drawn to conservation of all kinds of forests for protective regulation and their productive role in maintaining the earth's ecosystems. In North Bilaspur forest division, preservation of forests including dry deciduous Sal forest and Mix forest is very important due the fact that most of the forests cover is under tremendous pressure from the growing human and livestock population. Sloth bear is ecologically dislocated and as a result, human-bear conflicts are on the rise. Therefore, collection of information on spatial distribution of vegetation types, forest structure and composition in Pendra and Marwahi ranges was considered important. The data have been subjected to stratified random sampling to analyze community characters. Ground work carried out in homogenous vegetation strata has been used to derive information on stand density, composition, frequency, abundance, basal area etc of various species present.

4.2.0. Materials and methods

Following methods were used to quantify landuse and vegetatation quantification.

4.1.1. To study the land cover and landuse pattern using the Arc/Info, Arcview software in SUN GIS domain, satellite imageries of IRS 1B LISS II B FCC of January 20, 1996, Survey of India topographical maps on 1:50,000 scale (toposheet numbers E/16, F/13, F/14, I/4, J/1, J/2) and the compartment and block maps of the North Bilaspur forest division were used.

The vegetation classes and landuse pattern were studied by generation of different maps and layers viz. blocks/compartment, contour, drainage, vegetation, road network, habitation, water bodies and bear den sites using the GIS and Arc/Info, Arcview software in the SUN GIS domain.

4.1.2. Delineation of the vegetation types based on tonal and textural variations in the satellite data into broad physiognomic units was done. Each category gave a unique combination of tone, texture and pattern that helped in identification of various vegetation classes. Vegetation and landuse maps showing, drainage, contour, water bodies, road network and habitations and compartment maps, maps were generated.

4.1.3. The first few days were devoted for general reconnaissance of the areas to get an idea of the cover types, terrain and landuse pattern etc. and to develop interpretation key, which was subsequently used for translation of the spectral signature of imageries into actual cover types. Seventy eight linear transects were laid covering the representative landuse cover and vegetation types in Pendra and Marwahi areas. Some of the transects were laid through different bear habitats including den sites. Sampling for trees, shrubs and herbs was done within 390 plots along the transects. Maximum 114 plots fell in Mix forest category, followed by Scrub land (88), Sal mix (55), Sal forest (54), Crop field (25), Open land (25), Land near to water bodies (15) and Plantation (14). Using the toposheets and satellite imageries, ground features were identified and used to position the transects. The location and directional layout of the transects were denoted on toposheets with the help of Geographical positioning system equipment (GPS) and compass. For ground validation, land cover map was divided into 500 x 500 m grid and checked looking at the vegetation and reference points.

4.1.4. For the study of landuse pattern and quantification of vegetation, 78 linear transects laid in different landuse and vegetation types encompassing bear habitats, were used. Sampling for trees was done within 10 m radius circular plots taken at every 250 m point along the transect of 1 km (Figure 2). From the same sampling points, data was also collected for shrubs and herbs within 5 and 1 m circular plots respectively. Number of each shrub and herb species was recorded. Pre-designed formats were used to collect information on terrain, soil, canopy cover, shrub cover, shrub height, stand height, ground cover, number of each tree, shrub and herb species; GBH, water availability, number of trees cut, number of trees lopped, slope characteristics, proximity of water source and bear evidences such as digging signs, pugmarks and claw marks during the field work. Woody species exceeding 30 cm GBH were considered as trees, whereas less than 30 cm in GBH were counted as shrubs. Canopy cover was measured with the help of GRS densiometer. Post-field interpreted details were transferred on to the base map and final mapping was done on 1:50,000 scale.

4.1.5. Optimum size of vegetation sampling plot was chosen as described by Sharma *et al.* (1983). Primary analysis has been carried out to obtain the values of various parameters like density, % frequency, abundance and basal area. Importance Value Index (IVI) has been calculated to assess the ecological value of a species with respect to the community structure (Muller Dombois and Ellenberg, 1974 and Roy *et al.*, 1993). The greater the chance that two randomly picked individuals were of the same species, the less a community's diversity in the intuitive sense (Pielou, 1975). Actually diversity indices could explain both richness and evenness of a species into single value. The purpose of measuring community diversity was to judge its relationship with either to community properties or to the environmental conditions, to which the community was exposed. The vegetation diversity indices, rarefaction (Krebs, 1989) and cluster analysis were done using Biodiversity Pro (2000) window based software package developed by Neil McAleece for the Natural History Museum, London. Measurement of various diversity indices was done by itself using Biodiversity Pro software.

4.1.6. To estimate the tree density in villages, plot less sampling or nearest 10 trees method of Kent and Coker (1992) was used in some randomly selected villages. Cluster analysis where similarity and distance between the clusters gave the idea about association among the various types of vegetation. Less distance between the clusters (Bray-Curtis cluster single link) showed more similarity between the groups. It was analysed using the software Biodiversity Pro.

4.1.7. Twinspan (Hill, 1979) two-way indicator species analysis has been used for numerical hierarchical classification of community data. The technique based on the concept that a group of samples which constituted a community type, would have a corresponding group of species characterizing the group. Since reciprocal averaging (RA) helped arranges the species and samples in a way that could best express the relationship, RA has been used as the basis of Twinspan classification.

4.1.8. The systematic use of satellite data, ancillary data, ground data and stepwise procedures adopted in this study have been shown diagrammatically (Figure 1).

Figure 1. Organization of GIS database.

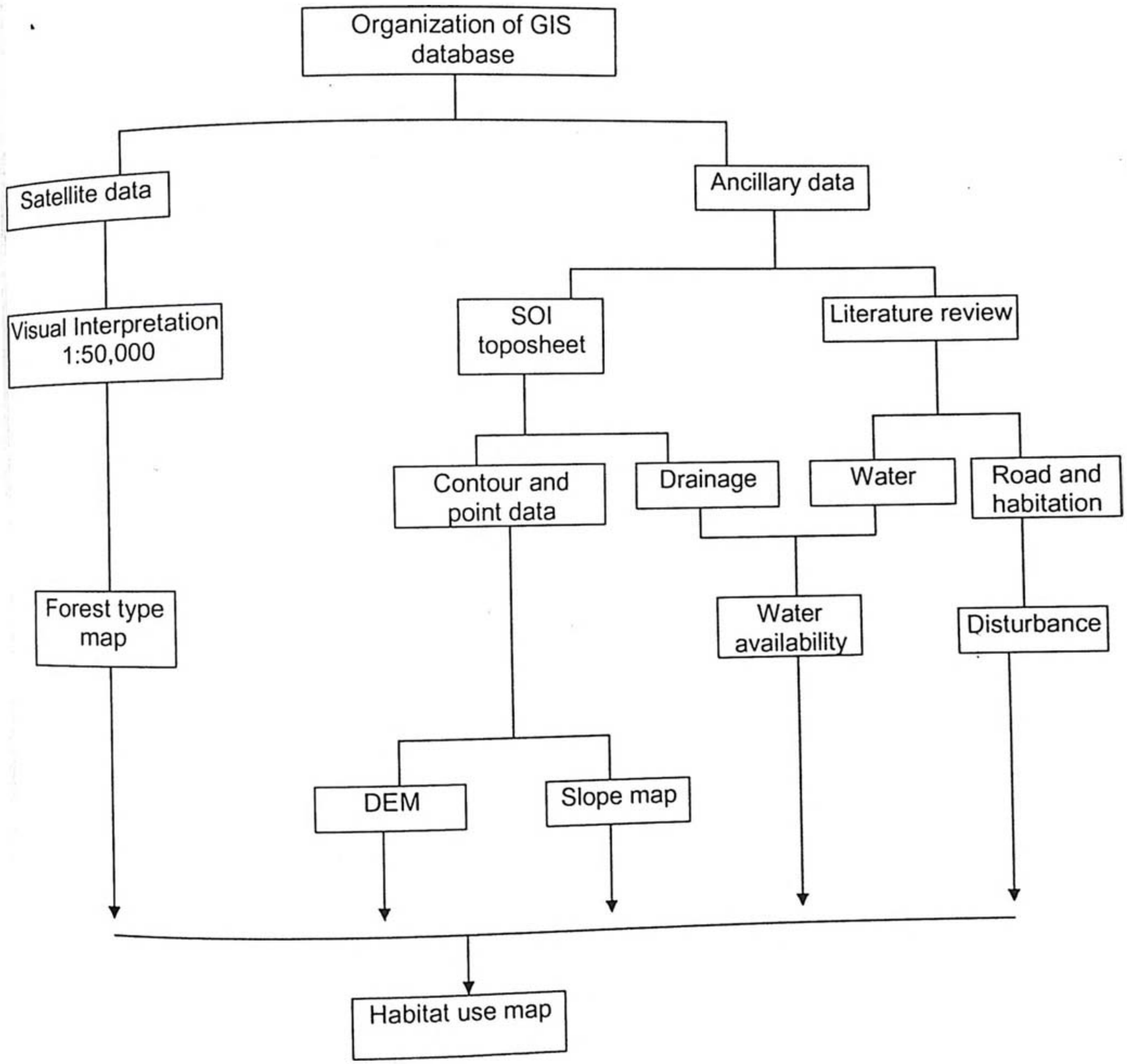
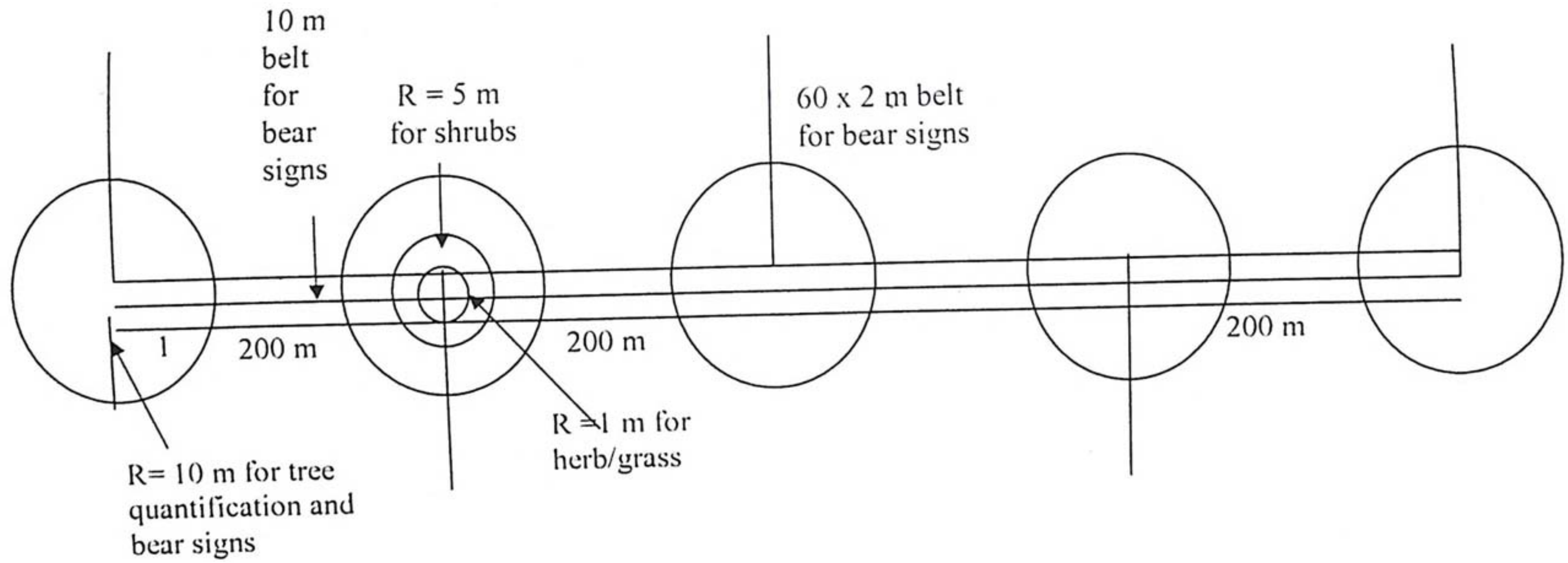


Figure 2. Sampling layout for vegetation quantification and collection of bear evidences.



4.3.0. Results

4.3.1. Landuse cover

The landuse categories of the North Bilaspur forest division identified on the basis of tone, texture and pattern in the satellite imageries showed that each landuse category was distinct with the specific characteristics (Table 1). Altogether 28 landuse categories were initially identified (Map 1). To make it more meaningful and convenient, these were finally reduced to 16 categories. The landcover and landuse pattern in NBFD were studied through generation of maps with vegetation, habitation and agriculture, water distribution, road network, compartment, elevation, aspect and biotic pressure layers. The forest cover was calculated to 343.79 km^2 out of total 1395.72 km^2 area (Table 2, Map 2). Among all the landuse categories, Scrub land covered the maximum area (580.81 km^2), followed by Habitation and agriculture (418.24 km^2), Mix forest (195.39 km^2), Sal forest (148.40 km^2), Dry river course (20.74 km^2), Water bodies (14.86 km^2), Plantation (1.83 km^2) and Riparian area (0.32 km^2). The Habitation agriculture constituted about 30% of the total area and interspersed with various other landuse categories (Map 3, Plate 1). Though water bodies covered 14.86 km^2 area, they were more or less evenly distributed in the whole area (Map 4). All these landcover and landuse categories fell into 411 to 1185 m range and flat to undulation terrain facing different directions (Map 5 and 6).

4.3.2. Sampling adequacy

The species area curve for each of the habitats for trees and shrubs were plotted (Figure 3 and 4). For each site, the number of new species added in each plot was cumulated and plotted against the number of vegetation plots. The species area curve was regarded and stabilized when 10% increase in area yielded only 5% or less than 5% increase of the number of species. Due to fragmentation of forests, small size of forest patches and interspersion of human settlements, Twinspan did not classify the vegetation community distinguishably. Hence, type of vegetation was determined on the basis of tree species, fell in the sampling plots and landuse categories. Visual examination showed that the sampling for trees was close to optimum in Mix forest, Sal, Sal mix and Scrub land, but it was not adequate for Open land (Blank land), Land near to water bodies and Plantation. It also indicated that more sampling efforts might have increased the number of tree species in Open land, Land near to water bodies and Plantation landuse categories. For shrub species, sampling was found to be adequate in Mix forest, Sal, Sal mix and Open land, but it was not adequate for Land near to water bodies, Plantation, Crop field, and Scrub land. Similarly, more sampling efforts might have increased the number of shrubs species in Land near to water bodies, Plantation, Crop field and Scrub land categories.

4.3.3. Rarefaction analysis

The Rarefaction analysis for tree vegetation indicated that the species richness was highest (43) in Mix forest, followed by Scrub land (35), Sal mix (31), Sal (24), Land near to water bodies (13), Plantation (11) and Crop field (5) (Table 3, Figure 5). Similarly, rarefaction estimation for the shrub vegetation was highest for the Mix forest (50), followed by Scrub land (38), Sal mix (37), Sal (29), Land near to water bodies (21), Plantation (16), Open land (8) and Crop field (7) (Table 4, Figure 6). Rarefaction estimation was found to be less than absolute species richness, but it was very close to the absolute species richness.

4.3.4. Diversity index

The vegetation sampling of 390 plots showed that the tree and shrub vegetation communities were comprised of 27 families, 65 genera and 81 species. Appendix 1 showed most common shrubs and trees and sampled plants in the study area. The Shannon H' log base 10 index for tree vegetation was highest in Mix forest (1.25), followed by Scrub land (1.18), Sal mix (1.05), Land near to water bodies (0.89), Plantation (0.85), Sal (0.68) and Crop field (0.58) (Table 5, Figure 7). The Hill's number H 1 for the tree vegetation was highest in Mix forest (90.98), followed by Scrub land (72.47), Sal mix (47.06), Land near to water bodies (28.09), Plantation (24.27), Sal (13.83) and Crop field (10.49) (Table 5, Figure 8). Similarly the Simpson diversity (1/D) was highest in Mix forest (12.48), followed by Scrub land (9.5), Plantation (6.06), Land near to water bodies (5.68), Sal mix (5.68), Crop field (4.13) and Sal (2.39) (Table 5, Figure 9). All these diversity indices showed that Mix forest was highly diverse, followed by Scrub land, Sal mix, Land near to water bodies, Plantation, Sal and Crop field landuse categories.

The Shannon H' log base 10 index for shrub types was highest in Mix forest (1.05), followed by Sal mix (1.05), Land near to Water bodies (1.04), Plantation (0.99), Scrub land (0.97), Sal (0.89), Crop field (0.59) and Open land

(0.34) (Table 6, Figure 10). The Simpson diversity index was found highest in Land near to water bodies (7.77), followed by Plantation (7.17), Sal mix (5.72), Mix forest (5.64), Scrub land (4.99), Sal (4.97), Crop field (3.34) and Open land (1.49) (Figure 11).The Hill's number H1 was found to be the highest in Mix forest (47.72), followed by Sal mix (46.46), Land near to water bodies (45.57), Plantation (39.07), Scrub land (36.38), Sal (27.24), Crop field (10.07) and Open land (4.49) (Figure 12). All these diversity indices showed that shrub diversity was highest in Mix forest, followed by Sal mix, Land near to water bodies, Plantation, Scrub land, Sal, Crop field and Open land.

4.3.7. Cluster analysis for shrubs and trees

Cluster analysis for shrubs at minimum distance showed maximum similarity between Sal and Sal mix forests, followed by Mix forest and Scrub land, Mix forest and Sal, Crop field and Land near to water bodies, Crop field and Plantation, Crop field and Open land and Mix forest and Crop field (Table 7, Figure 13).

Maximum similarity among different vegetation types was found at minimum distance in Sal and Sal mix forests (Table 8, Figure 14). Then maximum association was between Sal and Mix forest, followed by Mix forest and Scrub land, Mix forest and Land near to water bodies, Mix forest and Plantation, and Mix forest and Crop field. Hence maximum similarity was found between Sal and Sal mix forest and lowest similarity was found between Mix forest and Crop field.

4.3.7. Tree density in villages

Density of trees per hectare in the villages located in Pendra and Marwahi ranges estimated using plot less sampling i.e. nearest 10 tree method was 9.85 trees per hectare. The range of tree density in different villages was estimated to be 1.01-52.5 trees per hectare.

4.3.7. Density of shrubs

Density of shrubs in different habitat types was estimated to know the cover thickness. More shrub density indicated either degradation of the habitat or healthiness of the habitat like in tropical forest.

In Mix forest, estimated density of all shrub species was 2167.84 per hectare, but the mean density was 43.36±17.39 per hectare. Individual shrub density per hectare was highest for *Diospyros melanoxylon* (783.33), followed by *Gardenia lucida* (392.22), *Wrightia arborea* (109.51), *Butea monosperma* (116.21) and *Phoenix acualis* (115.10) (Table 9). In Sal forest, density of all shrubs was 2694.03 per hectare and the mean density was 92.89±38.66 per hectare. Individual shrub density per hectare was highest for *Diospyros melanoxylon* (802.08), followed by *Phoenix acualis* (629.87) and *Shorea robusta* (625.15) (Table 10). In Sal mix habitat, *Diospyros melanoxylon* and *Phoenix acualis* had 1033.03 shrubs/ha and 312.68 shrubs/ha respectively. The cummulative density of all shrubs was 2777.07 hectare and the mean density was 75.06±29.33 per shrubs per hectare (Table 11). Total density of shrub plants in the Crop field was estimated 321.01per hectare, and the mean density was

45.86±20.29 shrubs per hectare (Table 12). Only two species, *Diospyros melanoxylon* and *Butea monosperma* showed high density of 122.29 shrubs/ha and 117.20 shrubs/ha respectively in Crop field.

Table 13 showed that the density of shrubs in Scrub land was 1705.27 per hectare, and the mean density was 121.0±19.01 shrubs per hectare. Species with high density were *Diospyros melanoxylon* (668.79/ha), *Gardenia lucida* (208.45/ha) and *Ipomea carnea* (237.41/ha). In Open land, density of all shrub species was 973. 35 per hectare, and the mean shrub density was 121.62±96.69 shrubs per hectare (Table 14). Species with high density were *Diospyros melanoxylon* (794.9/ha), *Butea monosperma* (61.15/ha) and *Wrightia arborea* (40.76/ha). Table 15 showed that the total density of shrubs in Land near to water bodies was 1588.0 per hectare and mean density was 75.62±104.01 shrubs per hectare. Species with high density were *Diospyros melanoxylon* (424.63/ha), *Wrightia arborea* (271.76/ha) and *Butea monosperma* (152.87/ha). Total density of shrubs in Plantation was found to be 991.81 per hectare and, the mean density was 61.98±18.65 shrubs per hectare (Table 16). Species with high density were *Diospyros melanoxylon* (309.37/ha), *Shorea robusta* (100/ha), and *Ziziphus nummularia* (109.19/ha).

4.3.8. Tree density in different habitat types

Among all the habitat types, trees in Sal forest were found more abundant (408.70/ha), followed by Sal mix (365.37/ha), Mix forest (227.40/ha), Plantation (168.33/ha), Land near to water bodies (135.89/ha), Scrub land (94.82/ha) and Crop field (15.29/ha) (Table 17). Estimated mean density in different habitats was 202.39 trees per hectare.

4.3.9. Importance Value Index of plants

Importance value index for each plant species was estimated in different habitat types (Table 18). The value index analysis of plants showed that *Tamirandus indica* had the highest IVI (62.4) in Mix forest. Other species with high IVI were *Lagerstroemia parviflora* (28.25), *Anogeissus latifolia* (24.35), *Lannea coromendalica* (17.27), *Buchanania lanzan* (13.9) and *Madhuca indica* (14.82). Species with high Ab/F ratio were *Gmalina arborea* (4.56), *Simanea saman* (2.28) and *Eucalyptus* sp. (2.28). Among the Sal forest vegetation, *Shorea robusta* showed highest IVI (92.85) (Table 19). Other species showing high IVI value were *Buchanania lanzan* (21.62), *Terminalia alata* (19.22), *Semecarpus anacardium* (16.62), Diospyros *melanoxylon* (14.94) and *Boswellia serrata* (14.77). Species, which had high Ab/F ratio, was *Ficus virens*. In Sal mix forest, *Shorea robusta* had the highest IVI (61.95). Other species with high IVI were *Madhuca indica* (22.96), *Buchanania lanzan* (18.75), *Boswellia serrata* (16.29), *Anogeissus latifolia* (15.23), *Diospyros melanoxylon* (13.25) and *Wrightia arborea* (10.68). The Ab/F ratio was highest for *Acacia auriculiformes*, which indicated rare occurrence of the species (Table 20). In Crop field vegetation, *Madhuca indica* showed the maximum IVI value (134.50), followed by *Terminalia bellirica* (49.98), *Butea monosperma* (67.65), *and Buchanania lanzan* (24.62) and *Shorea robusta* (23.25) (Table 21).

In Scrub land, *Lagerstroemia parviflora* got the maximum IVI (45.35) (Table 22). Other species with high IVI were *Shorea robusta* (23.62), *Butea* *monosperma* (23.02), *Madhuca indica* (17.46), *Mangifera indica* (15.49), *Lannea coromandelica* (13.12), *Ficus virens* (12.66) and *Boswellia serrata* (12.71). Among the rare species, *Eucalyptus* sp., *Randia dumetorum* and *Boswellia serrata* showed 1.72, 1.76 and 3.52 Ab/F ratios respectively. Table 23 showed that species with high IVI value in Land near to water bodies habitat were *Ficus racemosa* (38.34), *Lannea coromandelica* (26.57), *Syzygium cumini* (16.19), *Shorea robusta* (33.97), *Terminalia arjuna* (41.78), *Diospyros melanoxylon* (23.68) and *Madhuca indica* (27.44). In Plantation habitat type, *Butea monosperma* got the highest IVI value (49.46) (Table 24). Other species with high index value were *Shorea robusta* (40.98), *Eucalyptus sp.* (33.12), *Mangifera indica* (26.00), *Azadirachta indica* (28.32), *Lagerstroemia parviflora* (31.92) and *Dalbergia latifolia* (37.69). The Ab/F ratio was highest (1.82) for *Lagerstroemia parviflora*.

4.3.10. Community classification for tree vegetation in NBFD using Twinspan

Simple unscaled dendrogram was drawn following the methods of Forbes (1994) and Kala (1998). During this analysis, plant species which had <5% abundance (least occurred species) were omitted for better representation of plant community. Altogether 7 tree communities were classified using Twinspan analysis in NBFD. All 27 tree species were comprised into 7 clusters (Figure 15).

Cluster 1. *Semecarpus anacardium*, *Pterocarpus marsupium*, *Madhuca indica* and *Terminalia arjuna*.

Cluster 2. *Shorea robusta, Cleistanthus collinus, Syzygium cumuni* and *Buchanania lanzan.*

Cluster 3. *Tectona grandis. Terminalia alata, Terminalia chebula* and *Emblica officinalis.*

Cluster 4. *Diospyros melanoxylon, Boswellia serrata, Schleichera oleosa, Millusa tomentosa,* and *Wrightia arborea.*

Cluster 5. *Acacia acculiformes* and *Anogeissus latifolia.*

Cluster 6. *Lannea coromandelica, Cassia fistula, Ficus virens. Azadirachta indica and Mitragyna parviflora.*

Cluster 7. *Eucalyptus* sp., *Butea monosperma and Lagerstroemia parviflora.*

Tree species of cluster 1 and 2 species showed close proximity to each other. Cluster 2 species were Sal forest species and cluster 7 represented the plantation species. There were many forest patches of planted *Eucalyptus sp., Butea monosperma and Lagerstroemia parviflora* in Pendra and Marwahi ranges.

4.3.11. Community classification for trees and shrubs vegetation using Twinspan

Using Twinspan analysis, the dendrogram drawn for tree and shrub vegetation comprised of 13 clusters of different communities in NBFD (Figure 16). The details of all tree and shrub communities are as follows.

Cluster 1. *Madhuca indica* and *Terminalia chebula.*

Cluster 2. *Shorea robusta, Milusa tomentosa, Wrightia arborea* and *Cleistanthus collinus.*

Cluster 3. *Lantena camera, Breynia vitisidae, Mitragyna parvifolia, Phoenix acualis, Buchanania lanzan, Semecarpus anacardium and Alangium salviifolium.*

Cluster 4. *Dendrocalamus strictus, Emblica officinalis. Antidesma acidum* and *Terminalia alata.*

Cluster 5. *Terminalia arjuna, Woodfordia fruticosa, Chloroxylon swietenia* and *Bauhinia purpurea*

Cluster 6. *Lannea coromandellica* and *Anogeissus latifolia.*

Cluster 7. *Schleichera oleosa, Ziziphus xylopyrus* and *Cassia fistula.*

Cluster 8. *Abrus precatorius, Grewia hirsuta, Gardenia lucida* and *Mimusops elengi.*

Cluster 9. *Diospyros melanoxylon, Carrisa spinarum, Casearia elliptica. Aegle marmelos* and *Sesbania grandiflora.*

Cluster 10. *Lagerstroemia parviflora* and *Casearia elliptica.*

Cluster 11. *Ziziphus nummularia, Tectona grandis, Eucalyptus* sp. and *Anona squamosa.*

Cluster 12. *Azadirachta indica, careya arborea, Cordia oblique* and *Syzygium cumini.*

Cluster 13. *Ipomea carnea* and *Butea monosperma.*

Tree and shrub communities were found to be heterogeneous because eigenvalues were not uniformly decreased from parent plots to subsequent plots. Cluster 1 species were generally found in the village land. Species of cluster 2 represented the Sal forest community. Cluster 3, 8, 9 and 12 comprised of species belonging to the shrub community. Whereas, cluster 1, 2, 6 and 13 were comprised of the tree species that showed the regeneration in the study area. Species of cluster 14 were mainly distributed in the Land near to water bodies or Crop field. Cluster 12 species were mainly used for the plantation.

4.3.0. Discussion

In Pendra and Marwahi ranges of NBFD, the forest cover was found to be fragmented and interspersed with human settlement and agricultural areas. Out of total 1395.72 km^2 land area, forest cover was only 343.79 km^2. We observed mosaic of land cover and landuse pattern throughout the study area. There were 16 broad landuse categories, which comprised of Sal > 60%, Sal 30-60%, Sal < 30% , Mixed sal > 60%, Mixed sal 30-60%, Mixed sal < 30%, Scrub land, Water bodies, Dry river course, Rocky out crops, Plantation, Mixed forest > 60%, Mixed forest < 30%, Habitation and agriculture and Riparian areas. Scrub land and human habitation and agriculture occupied the maximum areas. Scattered distribution of Sal forest patches revealed that this area had abundant Sal or Sal mix forests, but due to tremendous biotic pressure and forest fragmentation, vegetation pattern of the area has been changed over the period of time (Plate 2 & 3). The remote sensing data revealed very large area under Scrub land in NBFD. Perhaps the Scrub land and Mix type of the vegetation have replaced the Sal forest at many places as reported by local people e.g. Ghusariya and Ratga. National Remote Sensing Agency (NRSA) in its study of change in forest cover of India between 1972-75 and 1980-82 found that forest cover of the country decreased 16.89% of the geographical area (Sharma, 1986). This also indicated degradation of available habitats due to heavy biotic pressure. The rate with which the biotic pressure has been on the increase, it will soon lead to conversion of forest cover into Scrub land.

Rarefaction analysis represents the species richness in a community. Rarefaction values were found very close to the absolute species richness for tree and shrub vegetation both. This revealed high species richness among vegetation types, which could favourably support sloth bears by providing required food items in NBFD. In some cases, a given value of a diversity index may result from various combinations of species richness and evenness (Pielou, 1975). The Shannon index H' actually is the measure of average degree of 'uncertainty' in predicting as to what species of individual chosen at random forms a collection of S species of N individual. It was found that uncertainty was highest in Mix forest, Scrub land, and Sal mix forest. Rest of the vegetation types were also found to harbour high species richness, hence they showed high value of Shannon index.

Simpson's index gives the probability that two individuals drawn at random from a population belong to the same species. Simply stated if the probability is high that both individuals belong to the same species, then the diversity of the community is low. Simpson diversity was found to be high in Mix forest, followed by Scrub land, Plantation, Sal mix, Land near to water bodies, Crop field and Sal forest. Hill effective number of a species is a measure of the degree to which proportional abundance is distributed among the species. In other words, the effective number of species is the measure of species in the sample where each species is weighted by its abundance. For tree vegetation, it was highest in Mix forest, followed by Scrub land, Sal mix, Land near to water bodies, Plantation, Sal forest and Crop field.

Diversity indices of shrub vegetation revealed that Mix forest, Sal mix, Land near to water bodies, Plantation and Scrub land had almost the similar value, which indicated that the shrub species were equally abundant in these areas. Almost similar patterns have been shown by Hill's number H1 and Simpson's diversity index for shrub vegetation. Cluster analysis (Single link) of Biodiversity Pro shows that if the two communities have maximum cluster distance between them, they would have minimum similarity value. Whereas minimum distance will indicate more similarity between the vegetation types. Cluster analysis of tree vegetation showed that altogether 6 clusters were formed out of 7 landuse categories. Distance between cluster 1 and 6 was highest. In other words, the 1st cluster was divided at higher distance and it further decreased at the subsequent division. The Sal and Sal mix vegetation showed maximum similarity, which indicated that both vegetation types were more similar to each other. Cluster 5 showed minimum similarity, which indicated that both the types were not having similar species.

Similarly, altogether 7 clusters were made following the shrub analysis. Almost similar type of relationship has been developed between the shrub vegetation types. First cluster divided the two most dissimilar types at first division and subsequently divided at minimum distance and vegetation type, which made the clusters to show maximum similarity to each other. Cluster 5, 6, and 7 got the minimum distance value. Hence the vegetation types which made these clusters showed the maximum similarity. The Sal and Sal mix vegetation of cluster 7 showed maximum similarity, and Mix forest and Crop field of cluster 1 showed minimum similarity. Twinspan is the robust analysis to classify the vegetation types of any study area. Due to fragmentation of forests, small forest patches and interspersion of human settlement, Twinspan could not classify the vegetation of Pendra and Marwahi distinguishably. Hence type of vegetation was determined on the basis of tree species, fell in the sampling plots. Although it divided the whole tree community into 7 clusters of plant communities. Cluster 2 and 3 showed close association between the clusters and represented species of Sal mix and Sal forest categories. Cluster 7 species *Lagerstroemia parviflora*, *Eucalyptus* sp. and Butea *monosperma* were generally found in the planted forest.

When tree and shrub species were classified using Twinspan, some clusters 1, 2, 6 and 13 represented the regeneration and occupied separate place from the pure shrub species clusters 3, 5, 8, and 9. All the clusters shown through dendrogram are unscaled and such a method has already been used by Forbes (1994) and Kala (1998). Twinspan classification of the tree species revealed that the nature of vegetation in the study area was heterogeneous because clusters were formed getting more eigenvalue than the parent plots.

Sampling for trees, shrubs and herbs was done within 390 plots along the transects. Maximum 114 plots fell in Mix forest category, followed by Scrub land (88), Sal mix (55), Sal forest (54), Crop field (25), Open land (25), Land near to water bodies (15) and Plantation (14). The Sal forest was found highly dense, followed by Sal mix, Mix forest, Plantation, Land near to water bodies, Scrub land and Crop field. The Sal forest and Sal mix were found denser because most of Sal trees were of low girth class and had straight pole in length which in fact enabled the dense growth of trees. Among all the tree species in the Chakrata Himalyas the maximum mean basal area was estimated for *Pinus wallichiana* by Singhal *et al.* (1986). However, most of tree species were randomly distributed.

Shrub density represents the ground cover of the area. Maximum density of shrubs was found in Sal mix and Sal forest, followed by Mix forest, Scrub land, Land near to water bodies, Plantation, Open land and Crop field. Most important observation of shrub density estimation was that the tendu (*Diospyros melanoxylon*) made the large proportion of the shrub density in each habitat type.

Importance Value Index (IVI) consists of three components i.e. relative density, relative frequency and relative basal area. Species with high IVI value will be more dominating in a given area as compared to other species with low value. Hence the test is important tool to measure dominance of species over the other species in a particular area or community. In Mix forest, *Tamarindus indica* got the maximum IVI value, but this species occurred only in one plot with large girth size or more basal area in comparison to other species. So the species did not represent truly the entire community of the Mix forest. Other species, which had the high IVI value, were senha (*Lagerstroemia parviflora*), mahua (*Madhuca indica*), dhawa (*Anogeissus latifolia*) and bhelwa (*Semecarpus anacardium*). Ab/F represents the abundance and distribution of the species in the area; high value of Ab/F indicates the occurrence of many individuals in very few plots i.e. rareness of the species. Species growing in clusters in few plots would have more value than the equally abundant species in many of the plots. Species with high Ab/F ratio in Mix forest were *Gmelina arborea, Samanea saman* and *Eucalyptus* species, which showed their abundance in the forest. In Sal vegetation type, obviously *Shorea robusta* had the highest IVI value, followed by *Buchanania lanzan, Terminalia alata, Semecarpus anacardium* and *Diospyros melanoxylon*. In Sal mix forest, dominant species was *Shorea robusta,* followed by *Madhuca indica*, *Boswellia serrata*, *Anogeissus latifolia* and *Buchanania lanzan*. In some areas, there were many individuals or clusters of *Acacia auriculiformes*.

In Crop field, five species *Madhuca indica*, *Terminalia bellirica*, *Butea monosperma*, *Buchanania lanzan* and *Shorea robusta* with high IVI value occurred in large numbers as compared to the species of other landuse categories. The high IVI value in Crop field was due to high girth class of the sampled trees. Most of these species were protected by the owner of the crop fields, which resulted in high girth class, whereas in the forests, there was lot of regeneration of trees to form the cover.

In Scrub land vegetation, species *Diospyros melanoxylon*, *Lagerstroemia parviflora*, *Shorea robusta*, *Madhuca indica* and *Butea monosperma* with high IVI value occurred in large numbers in clusters. *Chloroxylon swietenia* and *Boswellia serrata* with high Ab/F were in abundance. In the areas along the water bodies, dominant species with high IVI value were *Ficus racemosa*, *Shorea robusta*, *Terminalia alata* and *Madhuca indica*.

In Plantation, *Butea monosperma* was found more dominant, and followed by *Lagerstroemia parviflora*, *Tectona grandis* and *Eucalyptus sp.* Except *Tectona grandis,* all the species were abundant with almost similar Ab/F ratio. Other abundant species with high Ab/F ratio were *Gmalina arborea*, *Simanea saman* and *Eucalyptus* sp., but frequency of occurrence of these four species was very low in the sampling plots. Perhaps it could be one of the reasons behind the high value of Ab/F ratio. This also shows that the basal area values of various tree species were not very high. There was degradation of the vegetation cover as the tree species show very low IVI value as compared to the high values shown in the study conducted by Roy *et al.* (1993).

Table 1. Interpretation criteria of vegetation/landuse categories of North Bilaspur forest division.

S.No.	Vegetation type	Tone	Texture	Pattern and distribution
1	Sal forest	Deep red	Smooth	Hill slopes, undulating forest but patchy near habitation.
2	Sal mix	Dull red	Smooth	Hill slopes, undulating forest but patchy near habitation
3	Mixed forest	Brownish red	Medium to fine	Hillocks, Patchy in between habitations
4	Scrub, Revenue blank and Revenue scrub	Light yellow (muddy)	Medium to coarse	In and around reserve forest, scattered between villages.
5	Fallow, Agriculture and Village tree land	Bluish grey	Coarse to rough	Highly scattered
6	Shallow water bodies	Sky blue	Smooth patchy	In and around habitation
7	Large water bodies	Deep blue	Smooth patchy	Catchment areas along hillocks and undulating plain.
8	Rocky out crop	Dark grey and black	Coarse to rough	Hills and undulating terrain, bouldery patch
9	Plantation	Deep pink	Smooth patchy	In forest as well as in revenue land

Table 2. Landuse pattern in North Bilaspur forest division based on Remote sensing data.

Vegetation/landuse category	Area (km^2)	Sal forest (km^2)	Mix forest (km^2)	Total forest area (km^2)
Sal > 60 %	34.59	34.59	34.23	148.40
Sal 30-60 %	6.59	6.59	103.61	195.40
Sal < 30 %	0.35	0.35	57.54	
Mixed sal > 60 %	59.44	59.44		
Mixed sal 30-60 %	38.74	38.74		
Mixed sal < 30 %	8.69	8.69		
Scrub land	580.02			
Water bodies	14.86			
Dry river course	20.74			
Rocky out crops	15.91			
Plantation	1.83			
Mixed forest > 60 %	34.23			
Mixed forest 30-60 %	103.62			
Mixed forest < 30 %	57.54			
Habitation and agriculture	418.24			
Riparian	0.32			
Total area	1395.71	148.40	195.40	343.79

Table 3. Rarefaction estimation for tree vegetation.

Vegetation type	Absolute species richness	Rarefaction value
Mix forest	43	42.78
Sal	24	23.97
Sal mix	31	30.91
Crop field	5	4.75
Scrub land	35	34.62
Land near to water bodies	13	12.77
Plantation	11	10.88

Table 4. Rarefaction estimation for shrub vegetation.

Vegetation type	Absolute species richness	Rarefaction value
Mix forest	50	49.96
Sal	29	28.95
Sal mix	37	36.95
Crop field	7	6.9
Scrub land	38	37.96
Open land (Blank)	8	7.94
Land near to water bodies	21	20.8
Plantation	16	15.83

Table 5. Diversity indices for trees in different vegetation types.

Index	Mix forest	Sal	Sal mix	Crop field	Scrub land	Land near to water bodies	Plantation
Shannon H' log base 10.	1.25	0.68	1.05	0.59	1.18	0.89	0.85
Shannon Hmax log base 10.	1.63	1.38	1.49	0.70	1.54	1.11	1.04
Simpson's diversity (1/D)	12.48	2.39	5.68	4.13	9.45	5.68	6.06
Hill's number H1	90.98	13.83	47.06	10.15	72.47	28.10	24.27

Table 6. Diversity indices for shrub in different vegetation types.

Index	Mix forest	Sal	Sal mix	Crop field	Scrub land	Open land	Land near to water bodies	Plantation
Shannon H' log base 10.	1.05	0.89	1.05	0.59	0.97	0.34	1.04	0.99
Shannon Hmax log base 10.	1.70	1.46	1.57	0.85	1.58	0.90	1.32	1.20
Hill's number H1	47.72	27.25	46.46	10.07	36.38	4.49	45.57	39.07
Simpson's diversity (1/D)	5.64	4.97	5.72	3.34	4.99	1.49	7.77	7.17

Table 7. Cluster analysis for shrub in different vegetation types.

Step	Cluster	Distance	Similarity	Joined 1	Joined 2
1	7	29.68	70.31	Sal	Sal mix
2	6	36.28	63.72	Mix forest	Scrub land
3	5	39.89	60.10	Mix forest	Sal
4	4	47.67	52.33	Crop field	Plantation
5	3	54.72	45.27	Crop field	Land near to water bodies
6	2	60	40	Crop field	Open land or blank
7	1	71.79	28.20	Mix forest	Crop field

Similarity matrix

	Mix forest	Sal	Sal mix	Crop field	Scrub land	Open land	Land near to water bodies	Plantation
Mix forest	*	44.79	60.10	6.29	63.72	17.84	16.65	9.47
Sal	*	*	70.31	10.29	44.22	28.20	23.63	13.27
Sal mix	*	*	*	9.83	57.21	27.34	24.96	13.15
Crop field	*	*	*	*	9.99	31.49	44.00	52.33
Scrub land	*	*	*	*	*	27.90	22.85	14.14
Open land	*	*	*	*	*	*	39.68	40.00
Land near to water bodies	*	*	*	*	*	*	*	45.27
Plantation	*	*	*	*	*	*	*	*

Table 8. Cluster analysis for trees in different vegetation types.

Step	Cluster	Distance	Similarity	Joined 1	Joined 2
1	6	29.50	70.50	Sal	Sal mix
2	5	51.77	48.23	Mix forest	Sal
3	4	55.97	44.03	Mix forest	Scrub land
4	3	69.57	30.43	Mix forest	Land near to water bodies
5	2	82.53	17.47	Mix forest	Plantation
6	1	86.84	13.16	Mix forest	Crop field

Similarity matrix

	Mix forest	Sal	Sal mix	Crop field	Scrub land	Land near to water bodies	Plantation
Mix forest	*	37.82	48.23	2.91	44.03	13.90	6.53
Sal	*	*	70.50	3.12	28.60	14.00	5.74
Sal mix	*	*	*	3.43	35.63	16.45	11.95
Crop field	*	*	*	*	8.15	13.16	6.98
Scrub land	*	*	*	*	*	30.43	17.47
Land near to water bodies	*	*	*	*	*	*	5.80
Plantation	*	*	*	*	*	*	*

Figure 15. **Association between the tree communities (Twinspan classification).**

Figure 16. **Association between the tree and shrub communities (Twinspan classification).**

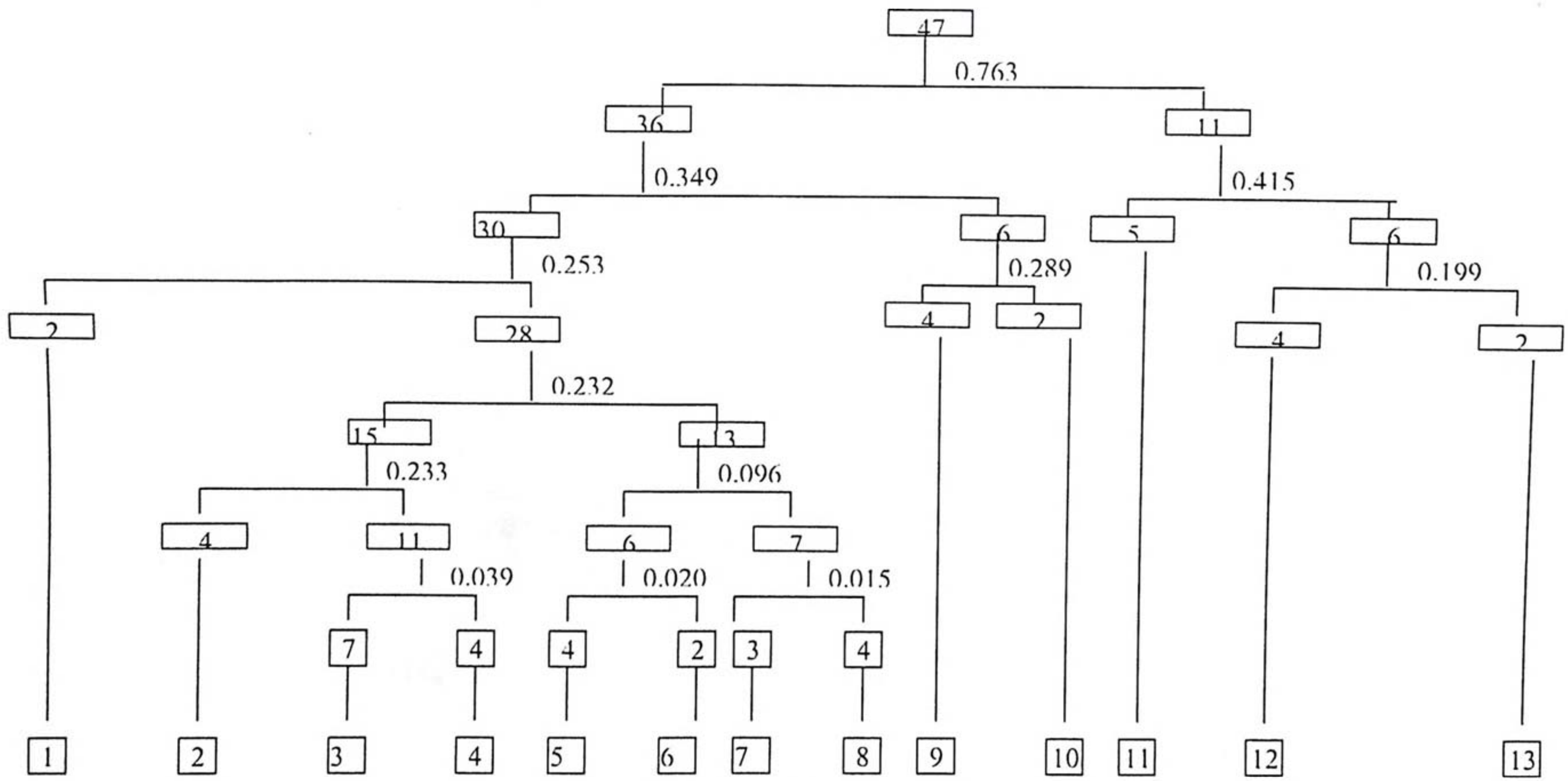


Table 9. Shrub density in Mix forest.

S.No.	Species	Density/ha
1	Anona squamosa	27.94
2	*Abrus precatorius*	1.12
3	*Sesbania grandiflora*	22.35
4	*Albizia lebbeck*	1.12
5	*Cassia fistula*	7.82
6	*Terminalia arjuna*	6.70
7	*Bauhinia purpurea*	1.12
8	*Aegle marmelos*	5.59
9	*Ziziphus mauritiana*	15.64
10	*Wrightia arborea*	109.51
11	*Casearia elliptica*	11.17
12	*Semecarpus anacardium*	6.70
13	*Chloroxylon swietenia*	5.59
14	*Woodfordia fruticosa*	2.23
15	*Butea monosperma*	116.21
16	*Butea superba*	2.23
17	*Buchanania lanzan*	12.29
18	*Phoenix acaulis*	115.10
19	*Anogeissus latifolia*	49.17
20	*Emblica officinalis*	3.35
21	*Eucalyptus*	21.23
22	*Ziziphus xylopyrus*	36.88
23	*Grewia hirsuta*	3.35
24	*Lannea coromandelica*	2.23
25	*Terminalia chebula*	1.12
26	*Ipomea carnea*	78.22
27	*Syzygium cumini*	4.47
28	*Antidesma acidum*	2.23
29	*Flacourtia indica*	1.12
30	*Mitragyna parvifolia*	3.35
31	*Millusa tomentosa*	20.11
32	*Carrisa spinarum*	13.41
33	*Cleistanthus collinus*	52.52
34	*Briedelia squamosa*	1.12

35	*Breynia vitisidaeai*	11.17
36	*Schleichera oleosa*	6.70
37	*Lantana camara*	4.47
38	*Madhuca indica*	21.23
39	*Diospyros malabarica*	2.23
40	*Ziziphus oenoplia*	1.12
41	*Gardenia lucida*	392.22
42	*Randia dumetorum*	6.70
43	*Azadirachta indica*	2.23
44	*Ficus virens*	1.12
45	*Mimusops hexandra*	1.12
46	*Terminalia alata*	22.35
47	*Shorea robusta*	43.58
48	*Lagerstroemia parviflora*	100.57
49	*Tamarindus indica*	3.35
50	*Diospyros melanoxylon*	783.33

Mean shrub density/ha	43.36
Standard error	17.39
Total shrub density/ha	2167.84

Table 10. Shrub density in Sal forests.

S.No.	Species	Density/ha
1	*Cassia fistula*	2.36
2	*Ziziphus mauritiana*	23.59
3	*Wrightia arborea*	63.69
4	*Semecarpus anacardium*	21.23
5	Woodfordia fruticosa	18.87
6	*Butea monosperma*	89.64
7	*Buchanania lanzan*	96.72
8	*Phoenix acaulis*	629.87
9	*Anogeissus latifolia*	42.46
10	*Emblica officinalis*	4.72
11	*Eucalyptus sp.*	7.08
12	*Lannea coromandelica*	7.08
13	*Terminalia chebula*	9.44
14	*Syzygium cumini*	11.80

15	*Antidesma acidum*	11.80
16	*Mitragyna parvifolia*	2.36
17	*Millusa tomentosa*	7.08
18	*Carrisa spinarum*	25.95
19	*Cleistanthus collinus*	23.59
20	*Lantena camara*	2.36
21	*Madhuca indica*	11.80
22	*Gardenia lucida*	51.90
23	*Terminalia alata*	56.62
24	*Shorea robusta*	625.15
25	*Lagerstroemia parviflora*	18.87
26	*Diospyros melanoxylon*	802.08
27	*Dendrocalamus strictus*	2.36
28	*Careya arborea*	21.23
29	*Azadirachta indica*	2.36

Mean shrub density/ha	92.90
Standard error	38.66
Total shrubs density/ha	2694.03

Table 11. Shrub density in Sal mix forests.

S.No.	Species	Density/ha
1	Anona squamosa	32.43
2	*Bauhinia purpurea*	11.58
3	*Aegle marmelos*	2.32
4	*Ziziphus mauritiana*	67.17
5	*Wrightia arborea*	92.65
6	*Casearia elliptica*	4.63
7	*Semecarpus anacardium*	27.79
8	*Chloroxylon swietenia*	4.63
9	*Woodfordia fruticosa*	4.63
10	*Butea monosperma*	62.54
11	*Buchanania lanzan*	46.32
12	*Phoenix acaulis*	312.68
13	*Anogeissus latifolia*	39.37
14	*Emblica officinalis*	57.90
15	*Grewia hirsuta*	4.63

16	*Ipomea carnea*	6.95
17	*Syzygium cumini*	4.63
18	*Antidesma acidum*	2.32
19	*Flacourtia indica*	2.32
20	*Mitragyna parvifolia*	6.95
21	*Millusa tomentosa*	30.11
22	*Carrisa spinarum*	53.27
23	*Cleistanthus collinus*	106.54
24	*Schleichera oleosa*	2.32
25	*Madhuca indica*	64.85
26	*Gardenia lucida*	122.76
27	*Randia dumetorum*	2.32
28	*Mimusops hexandra*	25.48
29	*Terminalia alata*	74.12
30	*Shorea robusta*	338.16
31	*Lagerstroemia parviflora*	85.70
32	*Diospyros melanoxylon*	1033.01
33	*Careya arborea*	2.32
34	*Alangium salviifolium*	30.11
35	*Pterocarpus marsupium*	6.95
36	*Pongamia pinnata*	2.32
37	*Bauhinia malabaricum*	2.32

Mean shrub density/ha	75.06
Standard error	29.33
Total shrub density/ha	2777.07

Table 12. Shrub density in Crop field.

S.No.	Species	Density/ha
1	*Terminalia arjuna*	5.10
2	*Ziziphus mauritiana*	5.10
3	*Wrightia arborea*	10.19
4	*Butea monosperma*	117.20
5	*Carrisa spinarum*	5.10
6	*Gardenia lucida*	56.05
7	*Diospyros melanoxylon*	122.29

Mean shrub density/ha	45.86
Standard error	20.29
Total shrub density/ha	321.02

Table 13. Shrub density in Scrub land.

S.No.	Species	Density/ha
1	*Anona squamosa*	20.27
2	*Abrus precatorius*	8.69
3	*Sesbania grandiflora*	44.88
4	*Cassia fistula*	5.79
5	*Aegle marmelos*	11.58
6	*Ziziphus mauritiana*	10.13
7	*Wrightia arborea*	34.74
8	*Casearia elliptica*	24.61
9	*Semecarpus anacardium*	2.90
10	*Chloroxylon swietenia*	13.03
11	*Woodfordia fruticosa*	14.48
12	*Butea monosperma*	157.79
13	*Butea superba*	1.45
14	*Randia ulginosa*	1.45
15	*Buchanania lanzan*	4.34
16	*Phoenix acaulis*	17.37
17	*Anogeissus latifolia*	11.58
18	*Eucalyptus sp.*	10.13
19	*Lannea coromandelica*	1.45
20	*Terminalia chebula*	1.45

21	*Ipomea carnea*	237.41
22	*Syzygium cumini*	2.90
23	*Millusa tomentosa*	5.79
24	*Carrisa spinarum*	15.92
25	*Schleichera oleosa*	5.79
26	*Madhuca indica*	4.34
27	*Ziziphus oenoplia*	1.45
28	*Gardenia lucida*	208.45
29	*Terminalia alata*	4.34
30	*Shorea robusta*	15.92
31	*Lagerstroemia parviflora*	66.59
32	*Diospyros melanoxylon*	668.79
33	*Dendrocalamus strictus*	14.48
34	*Azadirachta indica*	10.13
35	*Alangium salviifolium*	2.90
36	*Acacia nilotica*	1.45
37	*Cordia obliqua*	1.45
38	*Tectona grandis*	39.09

Mean shrubs density/ha	44.88
Standard error	19.01
Total shrub density/ha	1705.27

Table 14. Shrub density in Open land.

S.No.	Species	Density/ha
1	*Anona squamosa*	15.29
2	*Wrightia arborea*	40.76
3	*Butea monosperma*	61.15
4	*Gardenia lucida*	10.19
5	*Shorea robusta*	15.29
6	*Lagerstroemia parviflora*	30.57
7	*Diospyros melanoxylon*	794.90
8	*Azadirachta indica*	5.10

Mean shrub density/ha	121.62
Standard error	96.69
Total shrub density/ha	973.35

Table 15. Shrub density in the Land near to water bodies.

S.No.	Species	Density/ha
1	*Terminalia arjuna*	42.46
2	*Ziziphus mauritiana*	42.46
3	*Wrightia arborea*	271.76
4	*Woodfordia fruticosa*	16.99
5	*Butea monosperma*	152.87
6	*Butea superba*	8.49
7	*Buchanania lanzan*	42.46
8	*Phoenix acaulis*	76.43
9	*Anogeissus latifolia*	8.49
10	*Ziziphus xylopyrus*	8.49
11	*Ipomea carnea*	59.45
12	*Syzygium cumini*	16.99
13	*Carrisa spinarum*	161.36
14	*Cleistanthus collinus*	8.49
15	*Madhuca indica*	8.49
16	*Gardenia lucida*	67.94
17	*Terminalia alata*	42.46
18	*Shorea robusta*	101.91
19	*Diospyros melanoxylon*	424.63
20	*Psidium guawa*	8.49
21	*Ficus racemosa*	16.99

Mean shrub density/ha	75.62
Standard error	22.70
Total shrub density/ha	1588.11

Table 16. Shrub density in Plantation.

S.No.	Species	Density/ha
1	Anona squamosa	18.20
2	*Aegle marmelos*	9.10
3	*Ziziphus mauritiana*	109.19
4	*Wrightia arborea*	72.79
5	*Casearia elliptica*	18.20
6	*Butea monosperma*	63.69
7	*Eucalyptus sp.*	100.09
8	*Syzygium cumini*	18.20
9	*Madhuca indica*	9.10
10	*Gardenia lucida*	100.09
11	*Shorea robusta*	18.20
12	*Lagerstroemia parviflora*	36.40
13	*Diospyros melanoxylon*	309.37
14	*Azadirachta indica*	18.20
15	*Cordia obliqua*	63.69
16	*Dalbergia latifolia*	27.30

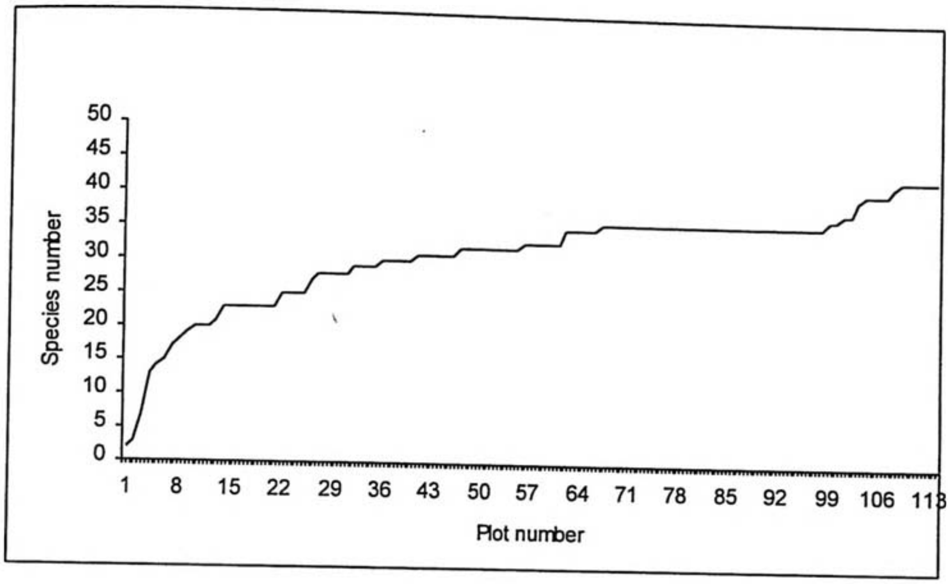
Mean shrub density/ha	61.99
Standard error	18.65
Total shrub density/ha	991.81

Table 17. Tree density in different vegetation types.

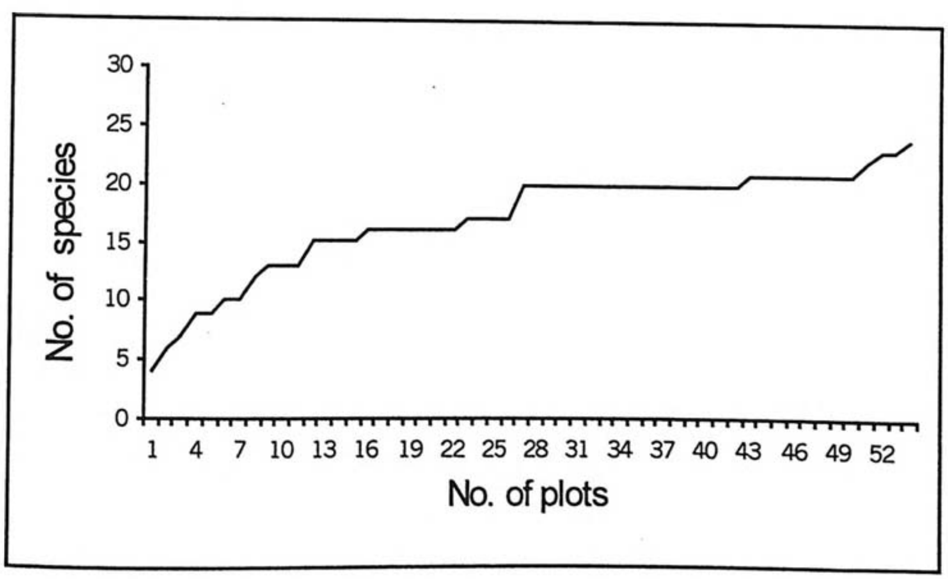
S.No.	Habitat type	Tree density ± SE (Per hectare)
1	Mix forest	227.40 ± 8.45
2	Sal forest	408.70 ± 52.4
3	Sal mix	365.37 ± 24.99
4	Crop field	15.27 ± 2.48
5	Scrub land	94.82 ± 4.53
6	Open land (blank)	0
7	Land near water to bodies	135.89 ± 13.13
8	Plantation	168.33 ± 15.56

*Overall tree density: 202.40/ha.

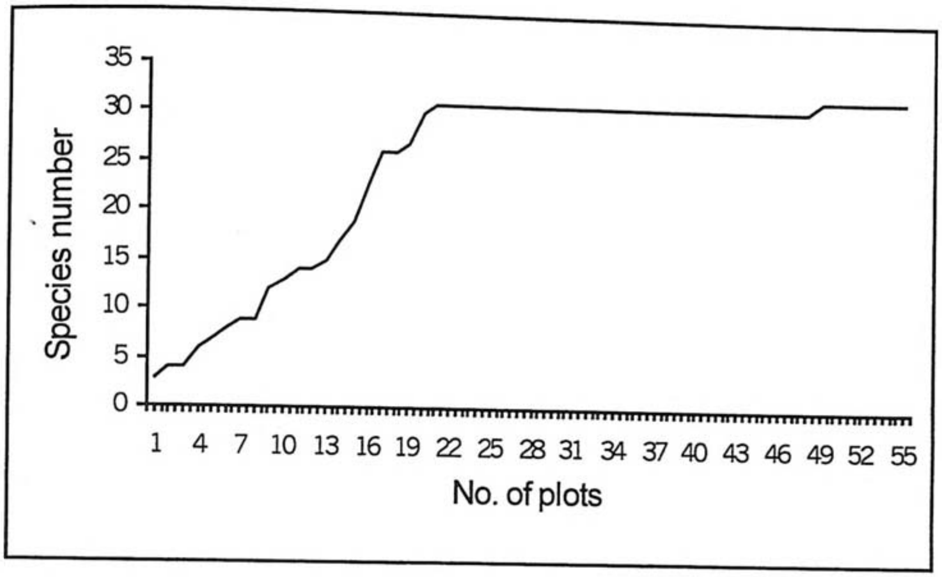
Figure 3. Species area curve for tree vegetation in North Bilaspur forest division



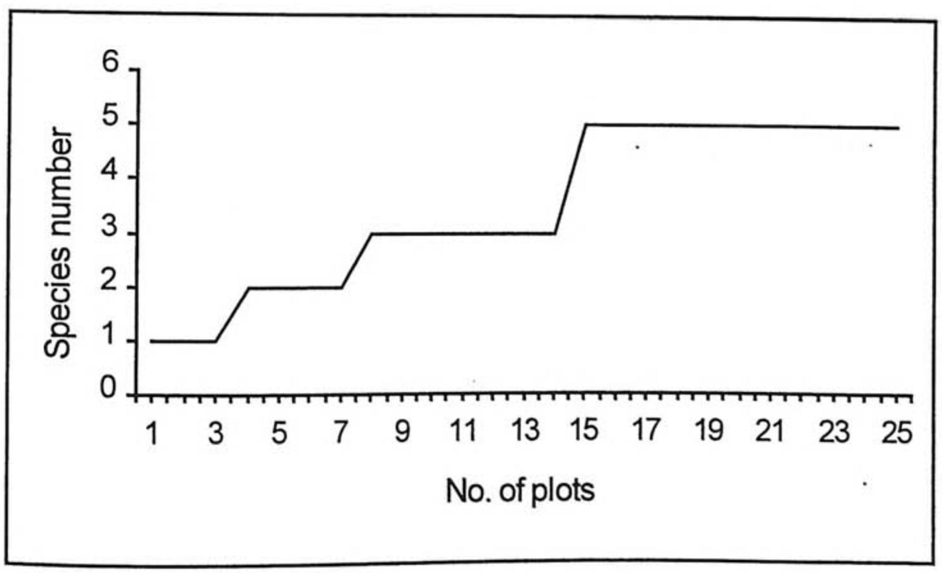
Species area curve in Mix forest



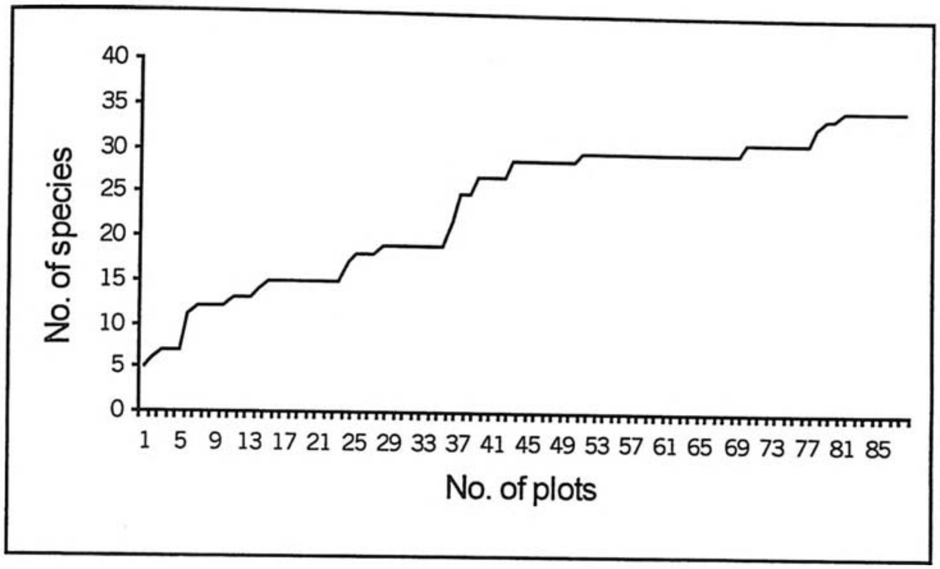
Species area curve in Sal forest



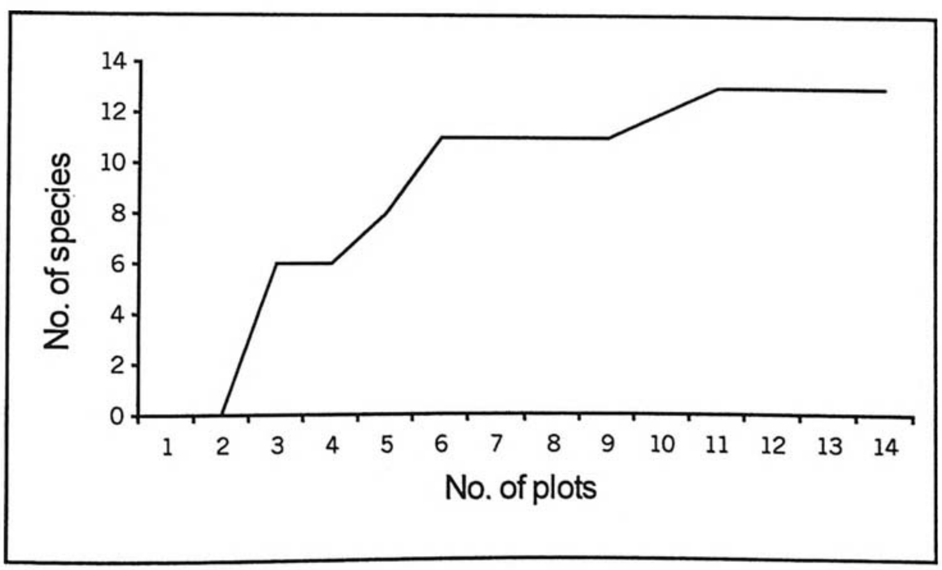
Species area curve in Sal mix forest



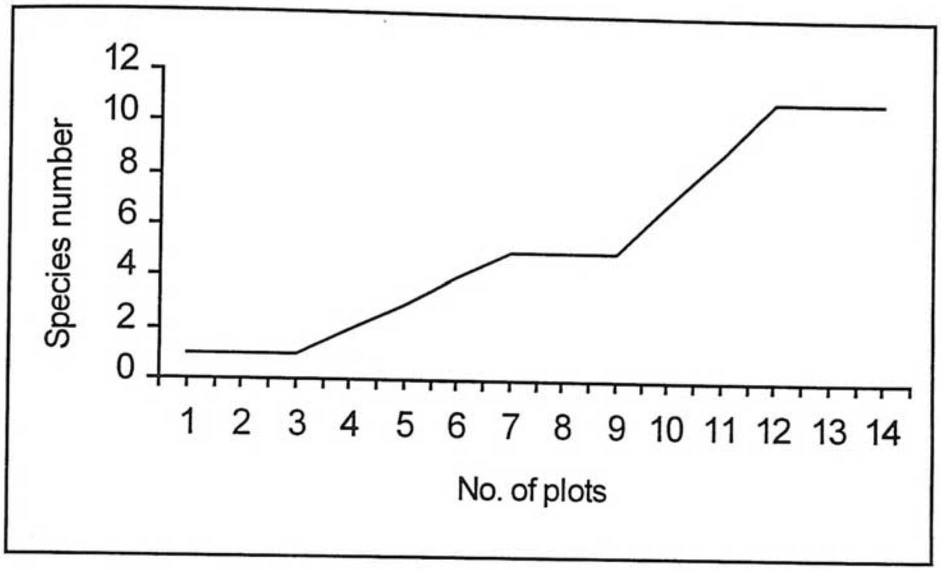
Species area curve in Crop field



Species area curve in Scrub land

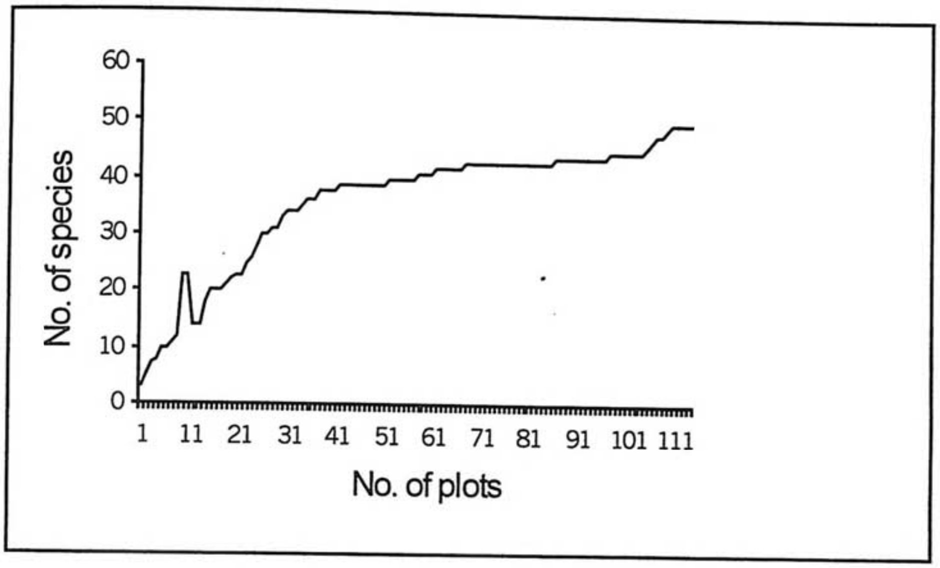


Species area curve in Land near to water bodies

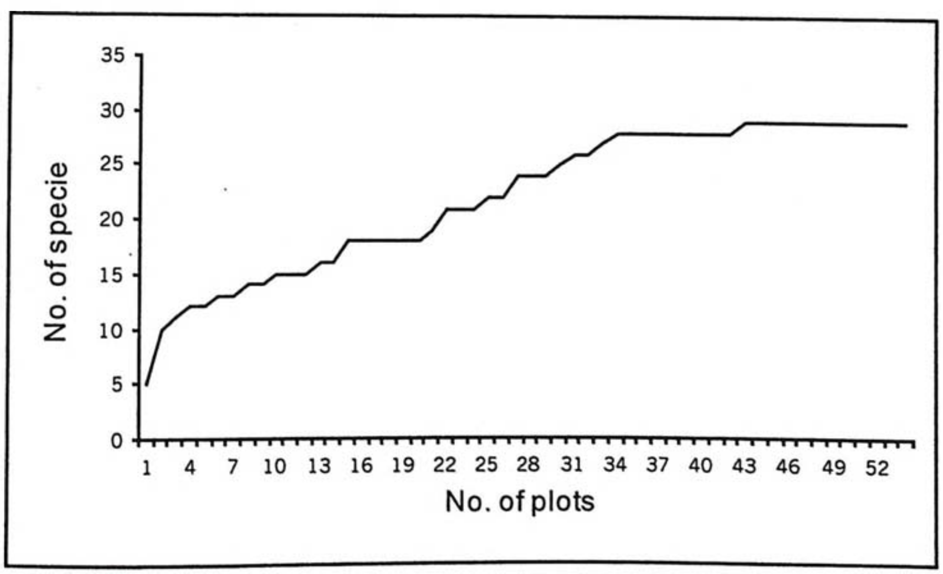


Species area curve in Plantation

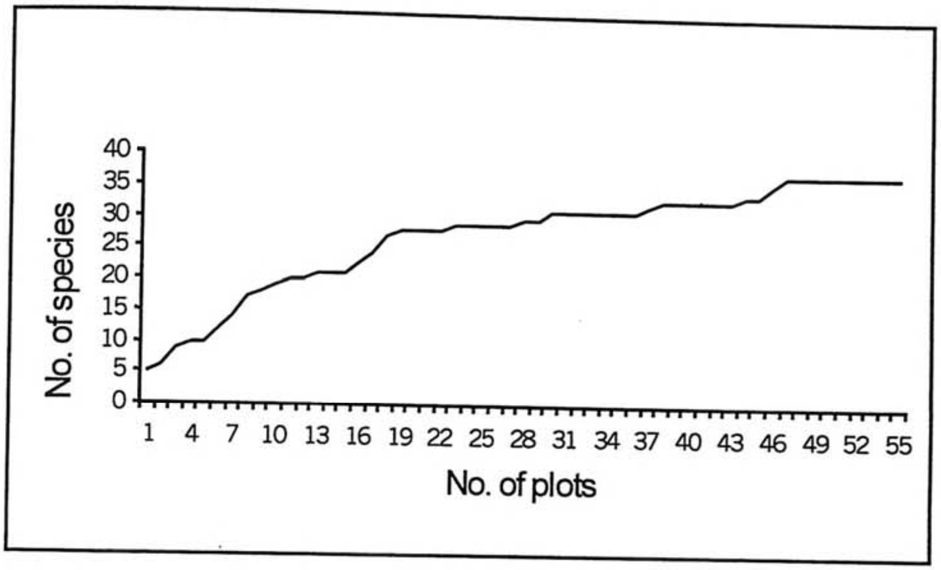
Figure 4. Species area curve for shrub in North Bilaspur forest division.



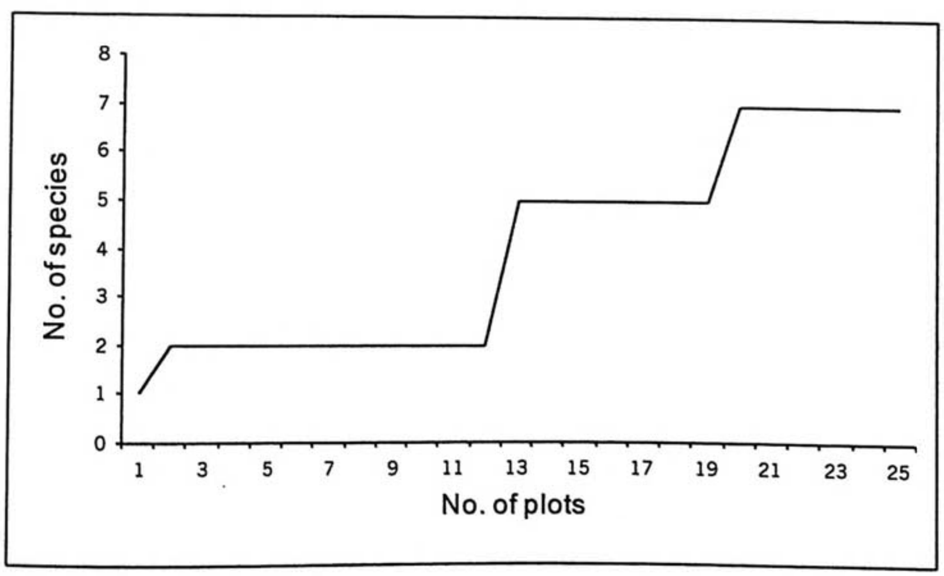
Species area curve in Mix forest



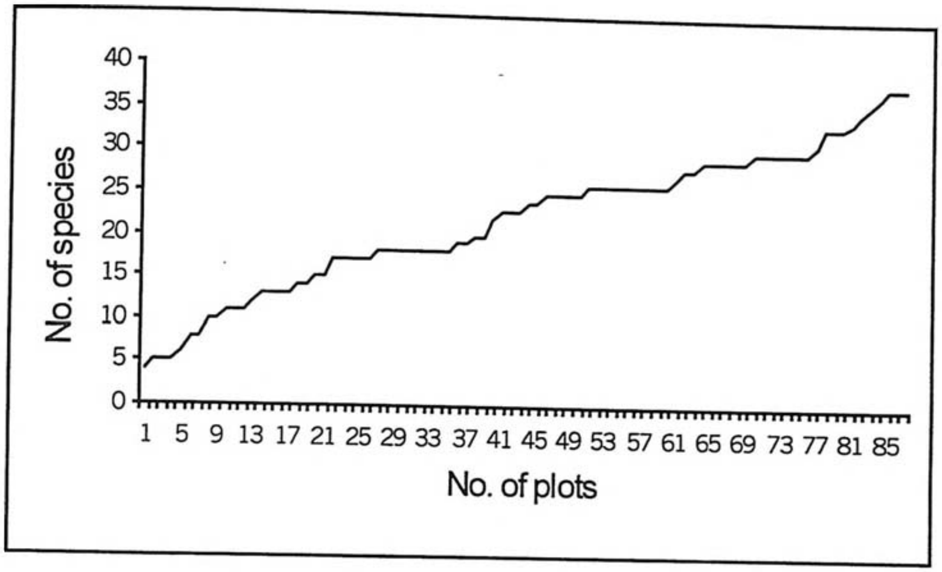
Species area curve in Sal forest



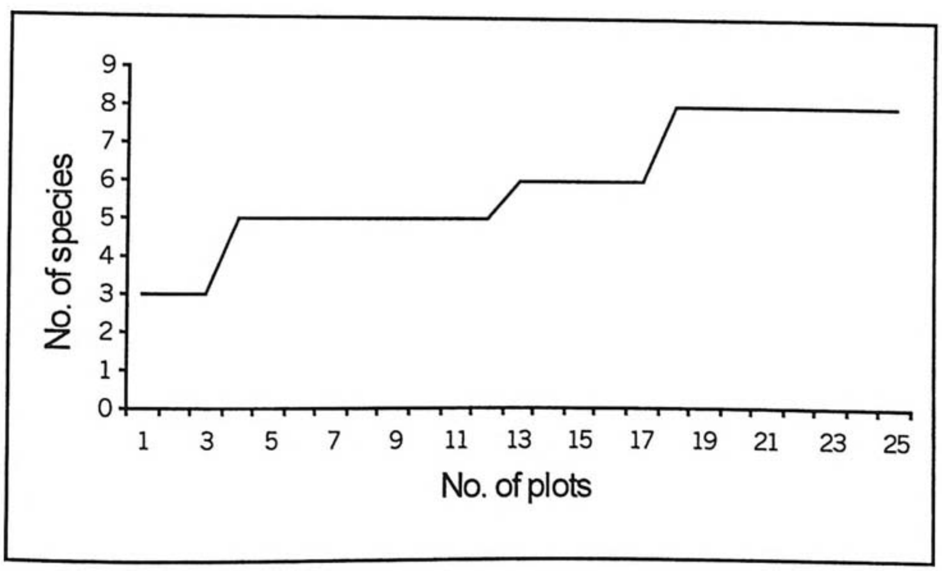
Species area curve in Sal mix forest



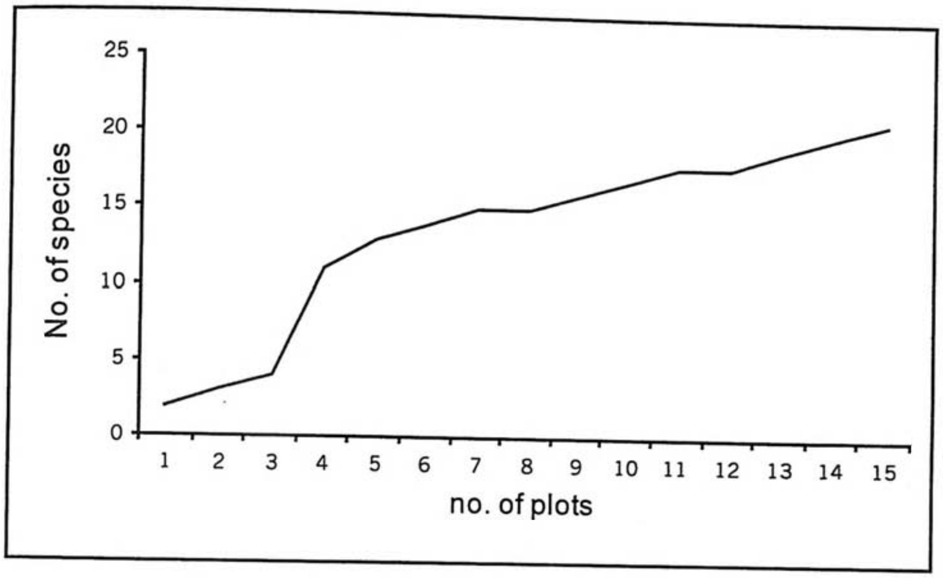
Species area curve in Crop field



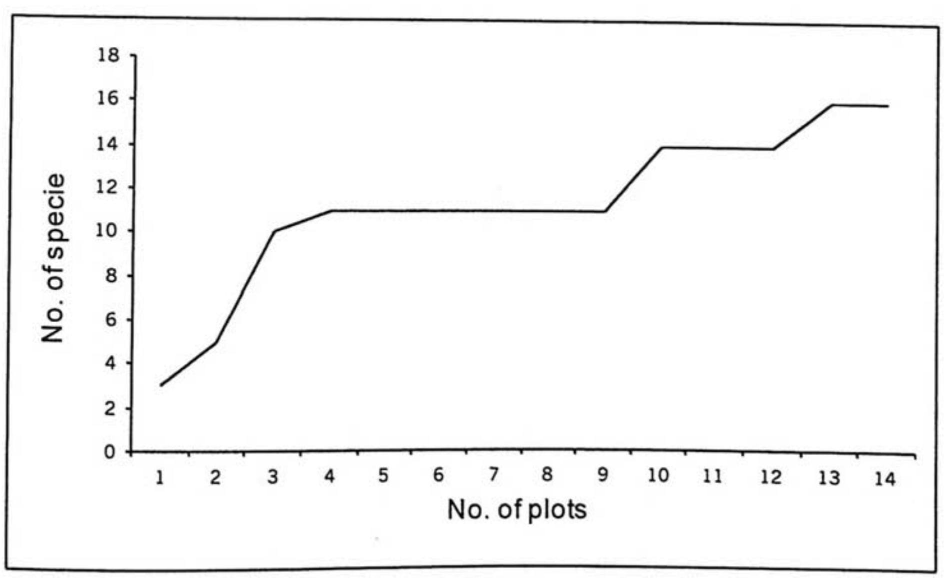
Species area curve in Scrub land



Species area curve in Open land



Species area curve in land near to water bodies



Species area curve in Plantation

Figure 5. Rarefaction estimation for trees.

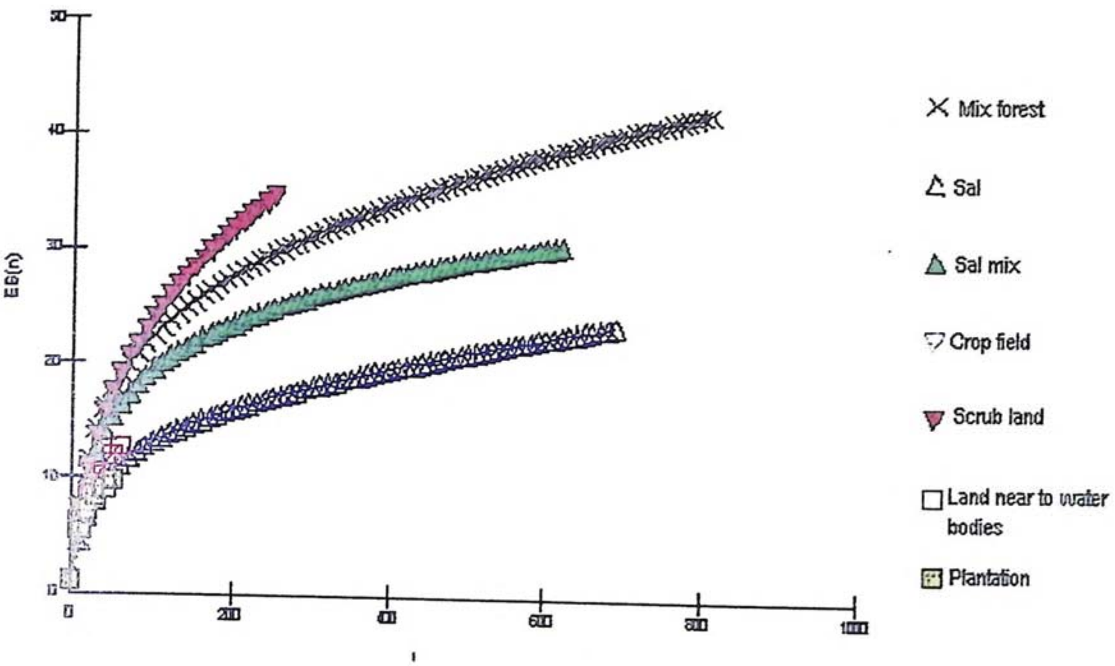


Figure 6. Rarefaction estimation for shrub.

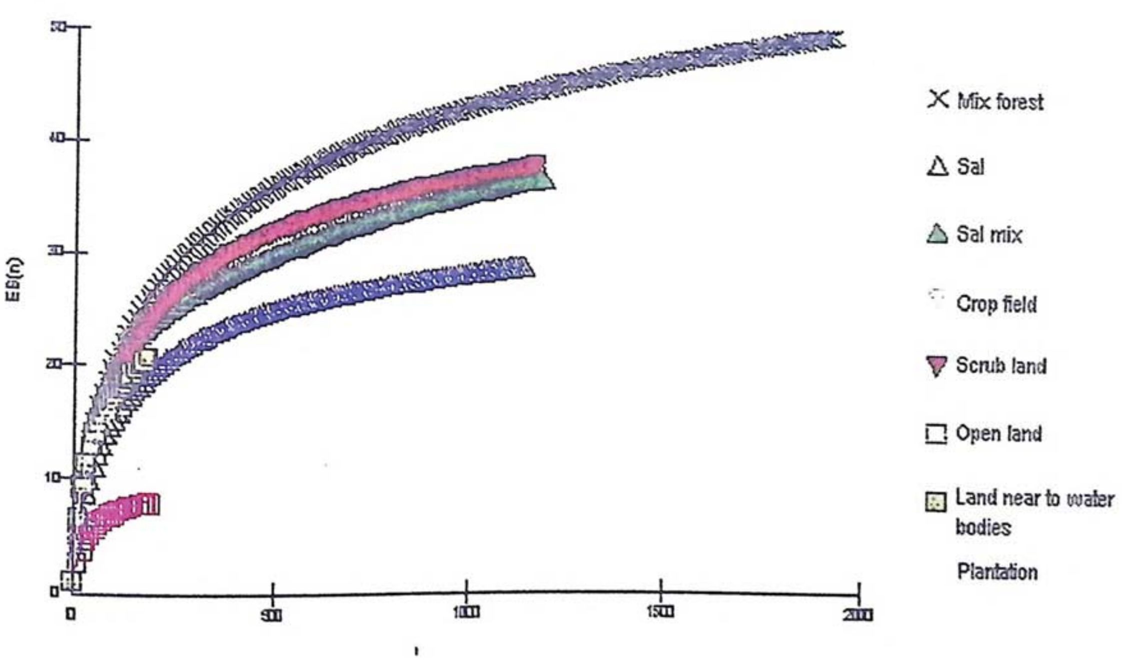


Figure 7. Shannon index values for trees.

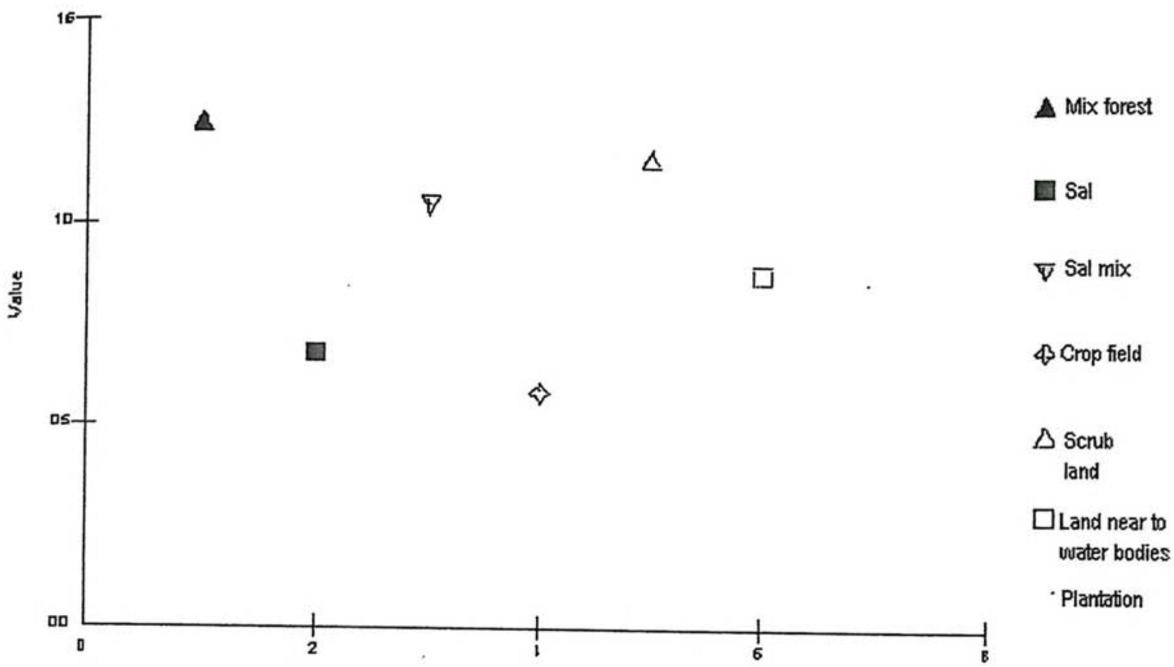


Figure 8. Simpsons values for trees.

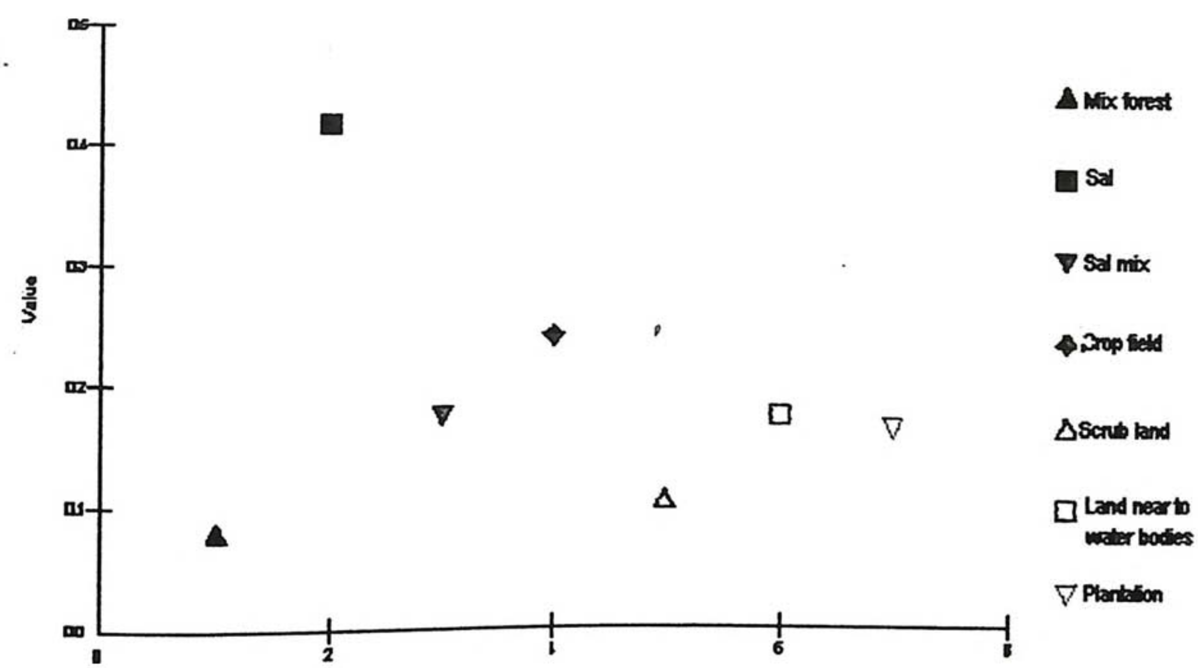


Figure 9. Hill's number values for trees .

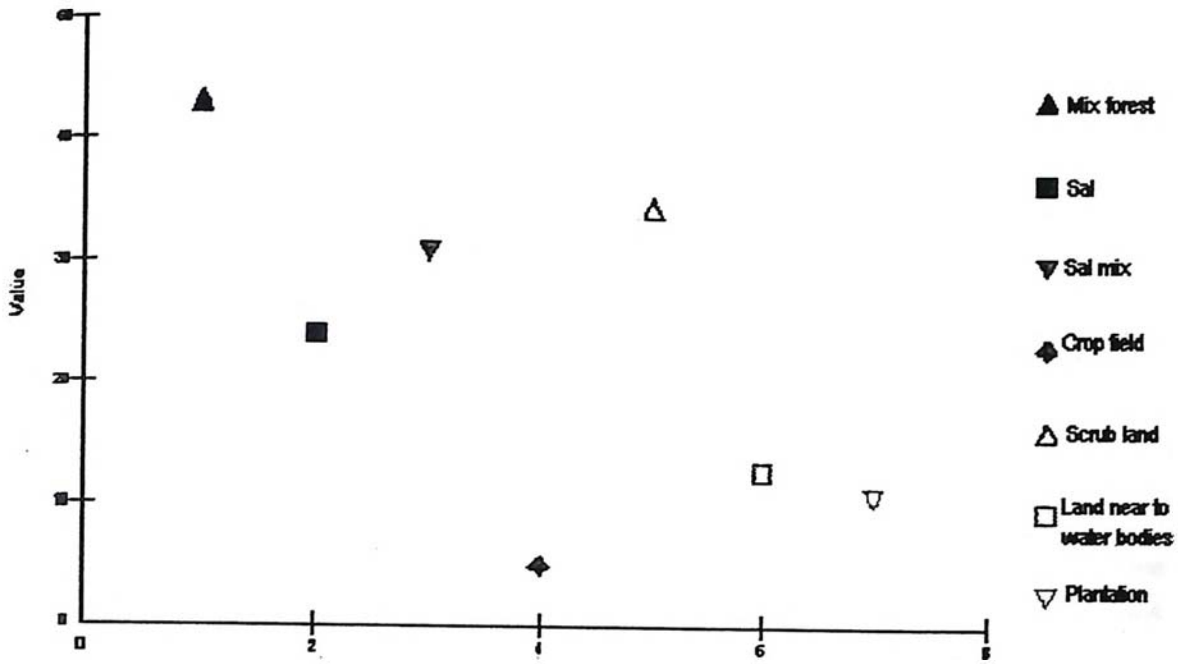


Figure 10. Shannon index values for shrub.

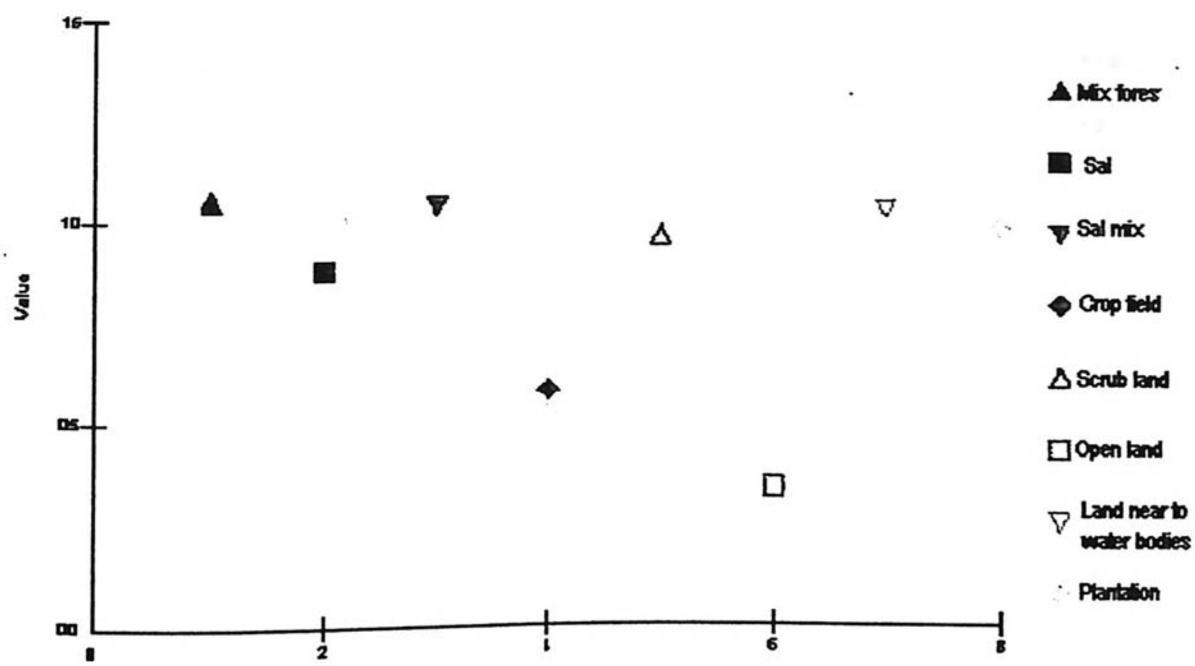


Figure 11. Simpson index values for shrub.

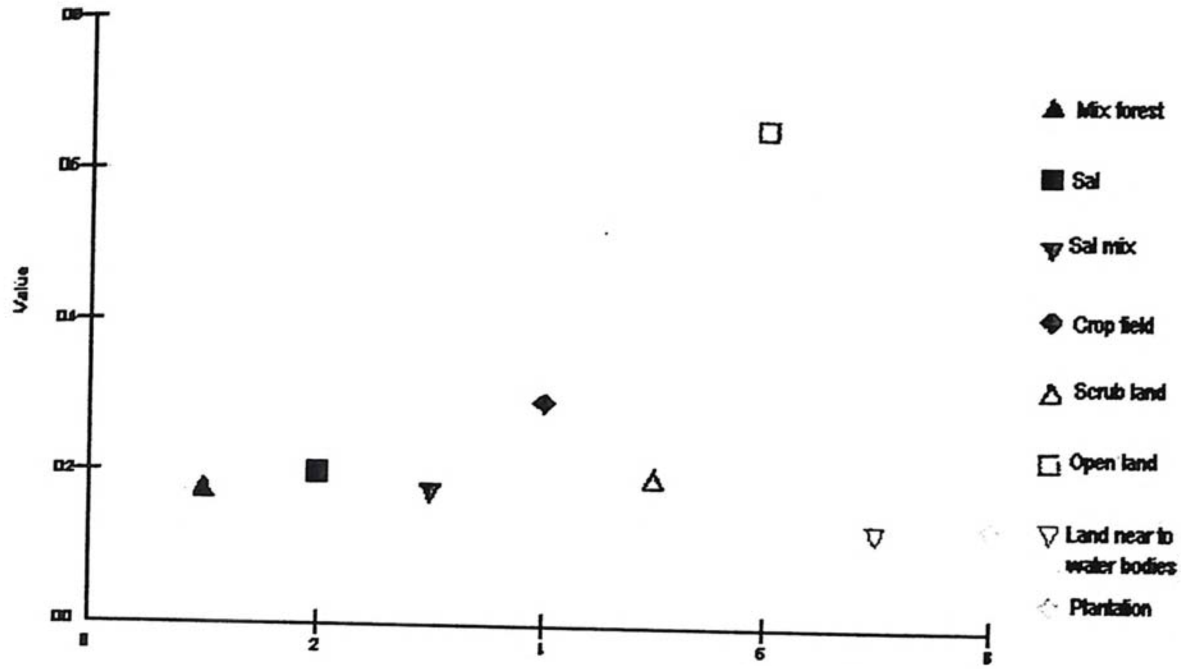


Figure 12. Hill's number values for shrub.

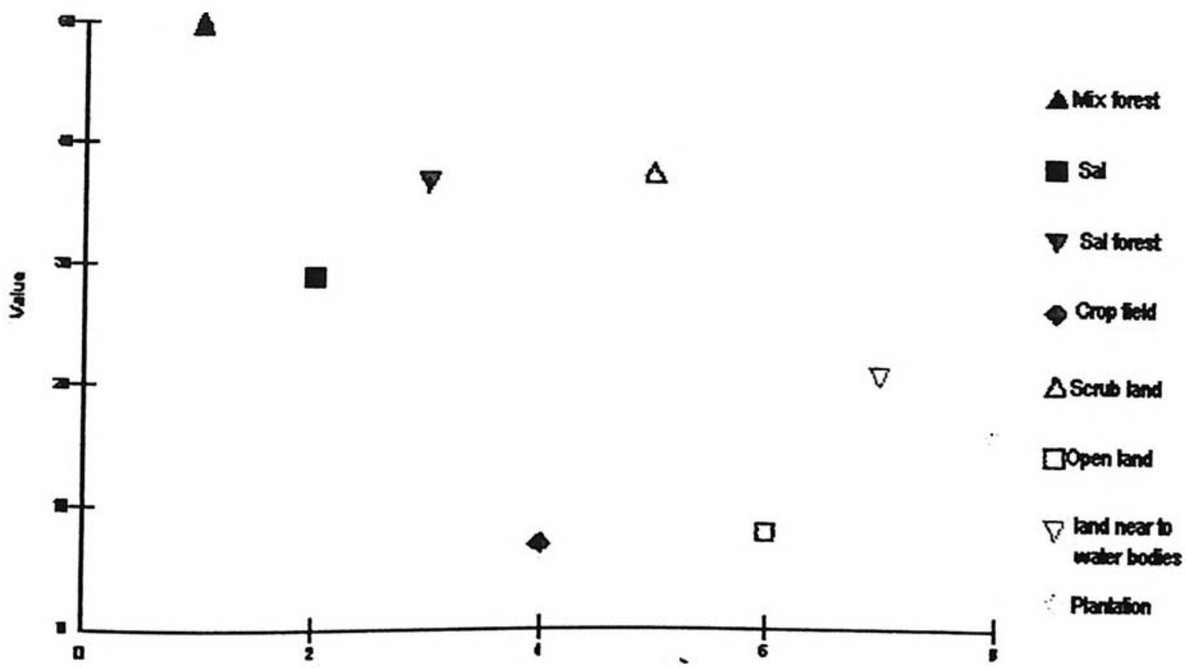


Figure 13. Cluster analysis for shrub.

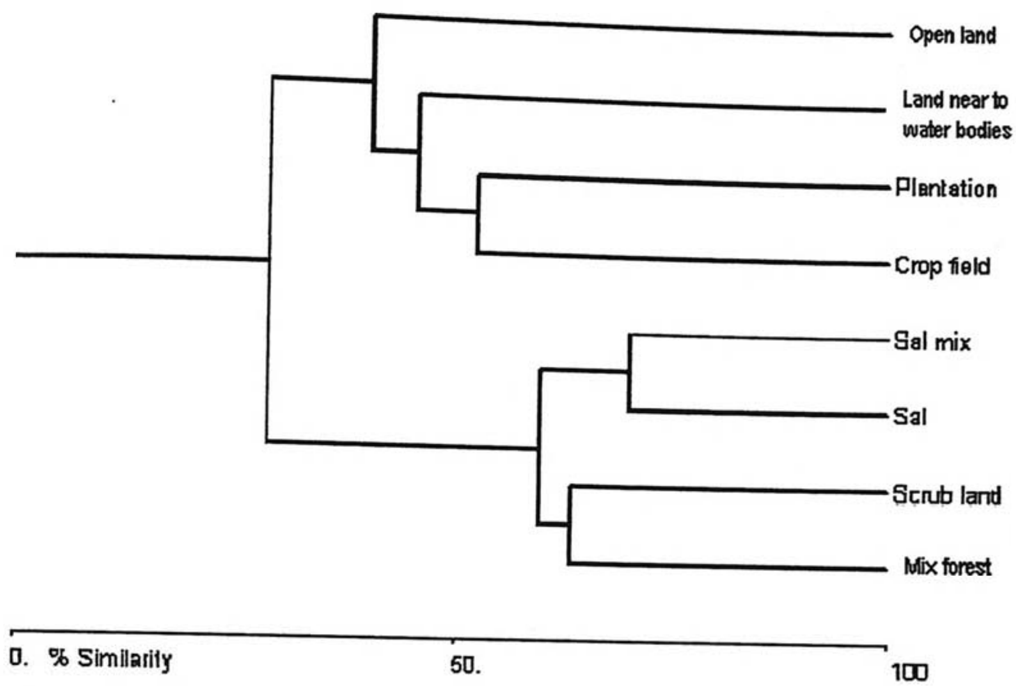


Figure 14. Cluster analysis for trees.

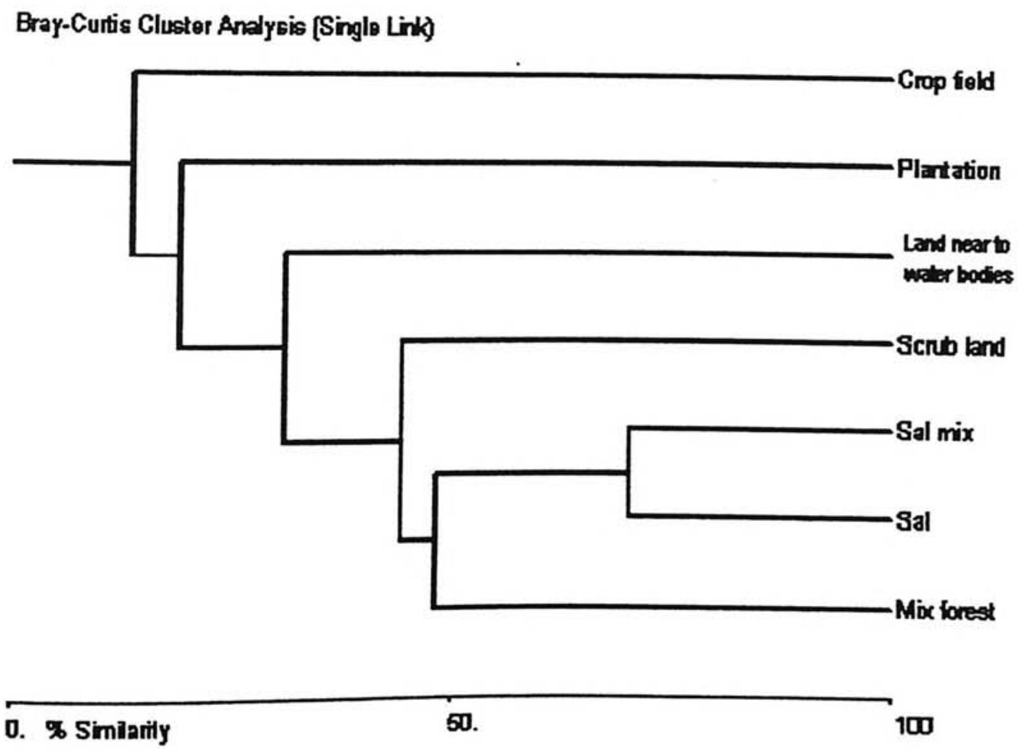


Table 18. Vegetation parameters and Importance Value Index of tree species in Mix forest.

S.No.	Tree species	Frequency of occurrence	No. of plants	Abundance	Av. GBH (m)	Basal area/ha	Frequency percent	Density/ha	Relative frequency	Relative density	Relative basal area	IVI	Ab/F
1	*Acacia nilotica*	1	1	1.00	0.40	0.004	0.88	0.28	0.24	0.12	0.41	0.77	1.14
2	*Acacia auriculiformes*	1	1	1.00	0.40	0.004	0.88	0.28	0.24	0.12	0.41	0.77	1.14
3	*Aegle marmelos*	2	3	1.50	0.58	0.008	1.75	0.84	0.47	0.37	0.88	1.72	0.86
4	*Anogeissus latifolia*	39	117	3.00	0.56	0.007	34.21	32.69	9.18	14.37	0.80	24.35	0.09
5	*Anona squamosa*	3	8	2.67	0.32	0.002	2.63	2.23	0.71	0.98	0.26	1.95	1.01
6	*Azadirachta indica*	1	2	2.00	0.30	0.002	0.88	0.56	0.24	0.25	0.23	0.71	2.28
7	*Bombex ceiba*	1	1	1.00	0.30	0.002	0.88	0.28	0.24	0.12	0.23	0.59	1.14
8	*Boswellia serrata*	17	25	1.47	1.11	0.027	14.91	6.98	4.00	3.07	3.18	10.25	0.10
9	*Buchanania lanzan*	32	46	1.44	0.53	0.006	28.07	12.85	7.53	5.65	0.72	13.90	0.05
10	*Butea monosperma*	17	34	2.00	0.88	0.017	14.91	9.50	4.00	4.18	1.99	10.17	0.13
11	*Cassia fistula*	7	7	1.00	0.40	0.004	6.14	1.96	1.65	0.86	0.41	2.92	0.16
12	*Chloroxylon sweitenia*	1	1	1.00	0.45	0.005	0.88	0.28	0.24	0.12	0.52	0.88	1.14
13	*Cleistanthus collinus*	11	30	2.73	0.46	0.005	9.65	8.38	2.59	3.69	0.55	6.82	0.28
14	*Diospyros melanoxylon*	39	70	1.79	0.38	0.003	34.21	19.56	9.18	8.60	0.37	18.15	0.05
15	*Emblica officinalis*	2	2	1.00	0.36	0.003	1.75	0.56	0.47	0.25	0.33	1.05	0.57
16	*Eucalyptus sp.*	1	2	2.00	0.30	0.002	0.88	0.56	0.24	0.25	0.23	0.71	2.28
17	*Ficus begalensis*	1	1	1.00	0.30	0.002	0.88	0.28	0.24	0.12	0.23	0.59	1.14
18	*Ficus racemosa*	1	1	1.00	1.20	0.032	0.88	0.28	0.24	0.12	3.72	4.08	1.14
19	*Ficus religiosa*	1	1	1.00	0.90	0.018	0.88	0.28	0.24	0.12	2.09	2.45	1.14
20	*Ficus virens*	1	1	1.00	0.90	0.018	0.88	0.28	0.24	0.12	2.09	2.45	1.14
21	*Flacourtia indica*	1	1	1.00	0.30	0.002	0.88	0.28	0.24	0.12	0.23	0.59	1.14
22	*Gardenia lucida*	1	1	1.00	0.30	0.002	0.88	0.28	0.24	0.12	0.23	0.59	1.14
23	*Gmalina arborea*	1	4	4.00	0.40	0.004	0.88	1.12	0.24	0.49	0.42	1.15	4.56
24	*Grewia tiliifolia*	1	1	1.00	0.70	0.011	0.88	0.28	0.24	0.12	1.27	1.62	1.14
25	*Lagerstroemia parviflora*	47	137	2.91	0.38	0.003	41.23	38.27	11.06	16.83	0.36	28.25	0.07

26	*Lannea coromandelica*	34	66	1.94	0.67	0.010	29.82	18.44	8.00	8.11	1.16	17.27	0.07
27	*Madhuca indica*	28	43	1.54	1.07	0.025	24.56	12.01	6.59	5.28	2.95	14.82	0.06
28	*Miliusa tomentosa*	14	21	1.50	0.47	0.005	12.28	5.87	3.29	2.58	0.57	6.45	0.12
29	*Mitragyna parviflora*	10	14	1.40	0.30	0.002	8.77	3.91	2.35	1.72	0.23	4.31	0.16
30	*Pterocarpus marsupium*	4	7	1.75	0.56	0.007	3.51	1.96	0.94	0.86	0.82	2.62	0.50
31	*Samanea saman*	1	2	2.00	0.75	0.013	0.88	0.56	0.24	0.25	1.45	1.93	2.28
32	*Schleichera oleosa*	10	11	1.10	0.60	0.008	8.77	3.07	2.35	1.35	0.93	4.63	0.13
33	*Semecarpus anacardium*	21	40	1.90	0.55	0.007	18.42	11.17	4.94	4.91	0.77	10.63	0.10
34	*Shorea robusta*	14	37	2.64	0.45	0.005	12.28	10.34	3.29	4.55	0.53	8.37	0.22
35	*Sterculia urens*	1	1	1.00	0.20	0.001	0.88	0.28	0.24	0.12	0.10	0.46	1.14
36	*Syzygium cumini*	5	5	1.00	0.63	0.009	4.39	1.40	1.18	0.61	1.03	2.82	0.23
37	*Tamarindus indica*	1	1	1.00	4.90	0.534	0.88	0.28	0.24	0.12	62.05	62.40	1.14
38	*Teminalia alata*	25	31	1.24	0.56	0.007	21.93	8.66	5.88	3.81	0.81	10.50	0.06
39	*Teminalia arjuna*	2	4	2.00	0.53	0.006	1.75	1.12	0.47	0.49	0.71	1.67	1.14
40	*Teminalia bellirica*	2	2	1.00	0.72	0.012	1.75	0.56	0.47	0.25	1.34	2.06	0.57
41	*Terminalia chebula*	8	9	1.13	0.70	0.011	7.02	2.51	1.88	1.11	1.26	4.25	0.16
42	*Wrightia arborea*	14	21	1.50	0.34	0.003	12.28	5.87	3.29	2.58	0.30	6.18	0.12
43	*Ziziphus xylopyrus*	1	1	1.00	0.55	0.007	0.88	0.28	0.24	0.12	0.78	1.14	1.14
Total		**425**	**814**	**67.15**	**27.65**	**0.861**	**372.81**	**227.40**	**100.00**	**100.00**	**100.00**	**300.00**	

Table 19. Vegetation parameters and Importance Value Index (IVI) of tree species in Sal forest.

S.No.	Tree species	Frequency of occurrence	No. of plants	Abundance	Av. GBH (m)	Basal area/ha	Frequency percent	Density/ha	Relative frequency	Relative density	Relative basal area	IVI	Ab/F
1	*Anogeissus latifolia*	10	20	2.00	0.53	0.013	18.52	11.80	4.83	2.89	3.56	11.27	0.11
2	*Azadirachta indica*	1	1	1.00	0.40	0.008	1.85	0.59	0.48	0.14	2.06	2.69	0.54
3	*Boswellia serrata*	3	3	1.00	1.00	0.047	5.56	1.77	1.45	0.43	12.89	14.77	0.18
4	*Buchanania lanzan*	26	42	1.62	0.48	0.011	48.15	24.77	12.56	6.06	3.00	21.62	0.03
5	*Butea monosperma*	5	8	1.60	0.40	0.008	9.26	4.72	2.42	1.15	2.07	5.64	0.17
6	*Cassia fistula*	1	1	1.00	0.60	0.017	1.85	0.59	0.48	0.14	4.64	5.27	0.54
7	*Cleistanthus collinus*	6	18	3.00	0.50	0.012	11.11	10.62	2.90	2.60	3.28	8.78	0.27
8	*Diospyros melanoxylon*	17	28	1.65	0.46	0.010	31.48	16.51	8.21	4.04	2.68	14.94	0.05
9	*Emblica officinalis*	1	1	1.00	0.30	0.004	1.85	0.59	0.48	0.14	1.16	1.79	0.54
10	*Ficus virens*	1	2	2.00	0.65	0.020	1.85	1.18	0.48	0.29	5.45	6.22	1.08
11	*Careya arborea*	1	1	1.00	0.90	0.038	1.85	0.59	0.48	0.14	10.44	11.07	0.54
12	*Lagerstroemia parviflora*	8	16	2.00	0.48	0.011	14.81	9.44	3.86	2.31	3.02	9.19	0.14
13	*Lannea coromandelica*	12	14	1.17	0.58	0.016	22.22	8.26	5.80	2.02	4.34	12.15	0.05
14	*Madhuca indica*	15	25	1.67	0.66	0.021	27.78	14.74	7.25	3.61	5.68	16.54	0.06
15	*Mitragyna parviflora*	1	1	1.00	0.30	0.004	1.85	0.59	0.48	0.14	1.16	1.79	0.54
16	*Pterocarpus marsupium*	1	1	1.00	0.40	0.008	1.85	0.59	0.48	0.14	2.06	2.69	0.54
17	*Ougeinia oogeinensis*	1	1	1.00	0.80	0.030	1.85	0.59	0.48	0.14	8.25	8.88	0.54
18	*Semecarpus anacardium*	19	35	1.84	0.43	0.009	35.19	20.64	9.18	5.05	2.39	16.62	0.05
19	*Shorea robusta*	52	442	8.50	0.55	0.014	96.30	260.67	25.12	63.78	3.95	92.85	0.09
20	*Syzygium cumini*	4	4	1.00	0.50	0.012	7.41	2.36	1.93	0.58	3.16	5.67	0.14
21	*Teminalia alata*	17	24	1.41	0.76	0.027	31.48	14.15	8.21	3.46	7.54	19.22	0.04
22	*Teminalia arjuna*	1	1	1.00	0.30	0.004	1.85	0.59	0.48	0.14	1.16	1.79	0.54
23	*Terminalia chebula*	3	3	1.00	0.62	0.018	5.56	1.77	1.45	0.43	4.90	6.78	0.18
24	*Wrightia arborea*	1	1	1.00	0.30	0.004	1.85	0.59	0.48	0.14	1.16	1.79	0.54
Total		**207**	**693**	**40.45**	**12.91**	**0.364**	**383.33**	**408.70**	**100.00**	**100.00**	**100.00**	**300.00**	

Table 20. Vegetation parameters and Importance Value Index (IVI) of tree species in Sal mix forest.

S.No.	Tree species	Frequency of occurrence	No. of plants	Abundance	Av. GBH (m)	Basal area/ha	Frequency percent	Density/ha	Relative frequency	Relative Density	Relative basal area	IVI	Ab/F
1	*Acacia auriculiformes*	1	7	7.00	0.34	0.005	1.82	4.05	0.40	1.11	1.29	2.80	3.85
2	*Alangium salviifolium*	1	2	2.00	0.57	0.015	1.82	1.16	0.40	0.32	3.63	4.34	1.10
3	*Teminalia arjuna*	1	1	1.00	0.40	0.007	1.82	0.58	0.40	0.16	1.79	2.34	0.55
4	*Sesbania grandiflora*	1	1	1.00	0.30	0.004	1.82	0.58	0.40	0.16	1.01	1.56	0.55
5	*Pterocarpus marsupium*	2	3	1.50	0.53	0.013	3.64	1.74	0.79	0.48	3.18	4.45	0.41
6	*Wrightia arborea*	4	6	1.50	0.30	0.004	7.27	3.47	1.58	0.95	1.02	3.55	0.21
7	*Semecarpus anacardium*	12	22	1.83	0.47	0.010	21.82	12.74	4.74	3.49	2.45	10.68	0.08
8	*Chloroxylon sweitenia*	1	1	1.00	0.40	0.007	1.82	0.58	0.40	0.16	1.79	2.34	0.55
9	*Butea monosperma*	7	10	1.43	0.57	0.015	12.73	5.79	2.77	1.58	3.65	8.00	0.11
10	*Cassia fistula*	2	2	1.00	0.38	0.006	3.64	1.16	0.79	0.32	1.57	2.68	0.28
11	*Buchanania lanzan*	24	42	1.75	0.48	0.011	43.64	24.32	9.49	6.66	2.61	18.75	0.04
12	*Anogeissus latifolia*	18	28	1.56	0.57	0.015	32.73	16.21	7.11	4.44	3.68	15.23	0.05
13	*Emblica officinalis*	10	13	1.30	0.36	0.006	18.18	7.53	3.95	2.06	1.42	7.44	0.07
14	*Hardwickia binata*	1	2	2.00	0.70	0.023	1.82	1.16	0.40	0.32	5.48	6.19	1.10
15	*Lannea coromandelica*	9	16	1.78	0.56	0.014	16.36	9.26	3.56	2.54	3.47	9.57	0.11
16	*Terminalia chebula*	6	9	1.50	0.76	0.027	10.91	5.21	2.37	1.43	6.47	10.27	0.14
17	*Syzygium cumini*	1	1	1.00	0.35	0.006	1.82	0.58	0.40	0.16	1.37	1.92	0.55
18	*Mitragyna parviflora*	2	2	1.00	0.38	0.006	3.64	1.16	0.79	0.32	1.57	2.68	0.28
19	*Milusa tomentosa*	5	6	1.20	0.46	0.010	9.09	3.47	1.98	0.95	2.41	5.33	0.13
20	*Cleistanthus collinus*	7	39	5.57	0.52	0.012	12.73	22.58	2.77	6.18	2.97	11.92	0.44
21	*Schleichera oleosa*	2	4	2.00	0.32	0.005	3.64	2.32	0.79	0.63	1.12	2.55	0.55
22	*Wendlandia exserta*	1	1	1.00	0.70	0.023	1.82	0.58	0.40	0.16	5.48	6.03	0.55
23	*Madhuca indica*	28	45	1.61	0.65	0.020	50.91	26.06	11.07	7.13	4.76	22.96	0.03
24	*Mangifera indica*	1	1	1.00	0.65	0.019	1.82	0.58	0.40	0.16	4.72	5.28	0.55
25	*Randia dumetorum*	2	2	1.00	0.35	0.006	3.64	1.16	0.79	0.32	1.37	2.48	0.28

26	*Ficus relegiosa*	1	1	1.00	0.50	0.012	1.82	0.58	0.40	0.16	2.80	3.35	0.55
27	*Teminalia alata*	13	16	1.23	0.63	0.018	23.64	9.26	5.14	2.54	4.38	12.05	0.05
28	*Shorea robusta*	50	244	4.88	0.56	0.015	90.91	141.29	19.76	38.67	3.52	61.95	0.05
29	*Boswellia serrata*	9	14	1.56	0.97	0.043	16.36	8.11	3.56	2.22	10.52	16.29	0.10
30	*Lagerstroemia parviflora*	9	21	2.33	0.53	0.013	16.36	12.16	3.56	3.33	3.09	9.97	0.14
31	*Tectona grandis*	4	39	9.75	0.60	0.017	7.27	22.58	1.58	6.18	4.03	11.79	1.34
32	*Diospyros melanoxylon*	18	30	1.67	0.35	0.006	32.73	17.37	7.11	4.75	1.38	13.25	0.05
Total		**253**	**631**	**66.94**	**16.20**	**0.412**	**460.00**	**365.37**	**100.00**	**100.00**	**100.00**	**300.00**	

Table 21. Vegetation parameters and Importance Value Index (IVI) of tree species in Crop field.

S.No.	Tree species	Frequency of occurrence	No. of plants	Abundance	Av. GBH (m)	Basal area/ha	Frequency percent	Density/ha	Relative frequency	Relative density	Relative basal area	IVI	Ab/F
1	*Buchanania lanzan*	1	1	1.00	0.70	0.0497	4.00	1.27	11.11	8.33	5.18	24.62	0.25
2	*Butea monosperma*	2	4	2.00	1.07	0.1161	8.00	5.10	22.22	33.33	12.10	67.65	0.25
3	*Madhuca indica*	4	5	1.25	2.14	0.4645	16.00	6.37	44.44	41.67	48.39	134.50	0.08
4	*Shorea robusta*	1	1	1.00	0.60	0.0365	4.00	1.27	11.11	8.33	3.80	23.25	0.25
5	*Teminalia chebula*	1	1	1.00	1.70	0.2931	4.00	1.27	11.11	8.33	30.54	49.98	0.25
Total		**9**	**12**	**6.25**	**6.21**	**0.9599**	**36.00**	**15.29**	**100.00**	**100.00**	**100.00**	**300.00**	

Table 22. Vegetation parameters and Importance Value Index (IVI) of tree species in Scrub land

S.No.	Tree species	Frequency of occurrence	No. of plants	Abundance	Av. GBH (m)	Basal area/ha	Frequency percent	Density/ha	Relative frequency	Relative density	Relative basal area	IVI	Ab/F
1	*Acacia nilotica*	1	1	1.00	0.30	0.003	1.14	0.36	0.65	0.38	0.687	1.71	0.88
2	*Aegle marmelos*	2	3	1.50	0.68	0.013	2.27	1.09	1.29	1.15	3.478	5.91	0.66
3	*Alangium salviifolium*	1	1	1.00	0.30	0.003	1.14	0.36	0.65	0.38	0.687	1.71	0.88
4	*Anogeissus latifolia*	3	5	1.67	0.62	0.011	3.41	1.81	1.94	1.91	2.903	6.75	0.49
5	*Anona squamosa*	1	1	1.00	0.30	0.003	1.14	0.36	0.65	0.38	0.687	1.71	0.88
6	*Azadirachta indica*	1	1	1.00	0.85	0.021	1.14	0.36	0.65	0.38	5.515	6.54	0.88
7	*Boswellia serrata*	1	4	4.00	1.18	0.040	1.14	1.45	0.65	1.53	10.539	12.71	3.52
8	*Buchanania lanzan*	8	10	1.25	0.66	0.013	9.09	3.62	5.16	3.82	3.318	12.30	0.14
9	*Butea monosperma*	17	22	1.29	0.69	0.014	19.32	7.96	10.97	8.40	3.659	23.02	0.07
10	*Cassia fistula*	4	6	1.50	0.31	0.003	4.55	2.17	2.58	2.29	0.722	5.59	0.33
11	*Chloroxylon sweitenia*	1	7	7.00	0.31	0.003	1.14	2.53	0.65	2.67	0.720	4.04	6.16
12	*Cordia obliqua*	1	1	1.00	0.35	0.004	1.14	0.36	0.65	0.38	0.935	1.96	0.88
13	*Diospyros melanoxylon*	17	27	1.59	0.49	0.007	19.32	9.77	10.97	10.31	1.806	23.08	0.08
14	*Emblica officinalis*	1	1	1.00	0.40	0.005	1.14	0.36	0.65	0.38	1.221	2.25	0.88
15	*Eucalyptus sp.*	1	2	2.00	0.30	0.003	1.14	0.72	0.65	0.76	0.687	2.10	1.76
16	*Ficus religiosa*	1	1	1.00	0.35	0.004	1.14	0.36	0.65	0.38	0.935	1.96	0.88
17	*Ficus virens*	6	8	1.33	0.87	0.022	6.82	2.90	3.87	3.05	5.733	12.66	0.20
18	*Lagerstroemia parviflora*	31	63	2.03	0.41	0.005	35.23	22.80	20.00	24.05	1.302	45.35	0.06
19	*Lannea coromandelica*	8	13	1.63	0.63	0.011	9.09	4.70	5.16	4.96	2.996	13.12	0.18
20	*Madhuca indica*	6	6	1.00	1.22	0.043	6.82	2.17	3.87	2.29	11.299	17.46	0.15
21	*Mangifera indica*	2	3	1.50	1.31	0.049	2.27	1.09	1.29	1.15	13.050	15.49	0.66
22	*Milusa tomentosa*	3	3	1.00	0.30	0.003	3.41	1.09	1.94	1.15	0.687	3.77	0.29
23	*Mimusops hexandra*	1	1	1.00	0.30	0.003	1.14	0.36	0.65	0.38	0.687	1.71	0.88
24	*Mitragyna parviflora*	2	2	1.00	0.65	0.012	2.27	0.72	1.29	0.76	3.225	5.28	0.44
25	*Pterocarpus marsupium*	1	1	1.00	0.50	0.007	1.14	0.36	0.65	0.38	1.908	2.94	0.88

26	*Randia dumetorum*	1	2	2.00	0.38	0.004	1.14	0.72	0.65	0.76	1.073	2.48	1.76
27	*Samanea saman*	1	1	1.00	0.50	0.007	1.14	0.36	0.65	0.38	1.908	2.94	0.88
28	*Schleichera oleosa*	5	5	1.00	0.91	0.024	5.68	1.81	3.23	1.91	6.322	11.46	0.18
29	*Semecarpus anacardium*	2	4	2.00	0.39	0.004	2.27	1.45	1.29	1.53	1.161	3.98	0.88
30	*Shorea robusta*	11	36	3.27	0.60	0.010	12.50	13.03	7.10	13.74	2.781	23.62	0.26
31	*Sterculia urens*	1	1	1.00	0.50	0.007	1.14	0.36	0.65	0.38	1.908	2.94	0.88
32	*Syzygium cumini*	3	3	1.00	0.53	0.008	3.41	1.09	1.94	1.15	2.171	5.25	0.29
33	*Teminalia alata*	1	1	1.00	0.30	0.003	1.14	0.36	0.65	0.38	0.687	1.71	0.88
34	*Terminalia chebula*	1	1	1.00	0.50	0.007	1.14	0.36	0.65	0.38	1.908	2.94	0.88
35	*Wrightia arborea*	8	15	1.88	0.30	0.003	9.09	5.43	5.16	5.73	0.691	11.58	0.21
Total		**155**	**262**	**55.44**	**19.16**	**0.377**	**176.14**	**94.82**	**100.00**	**100.00**	**100.000**	**300.00**	

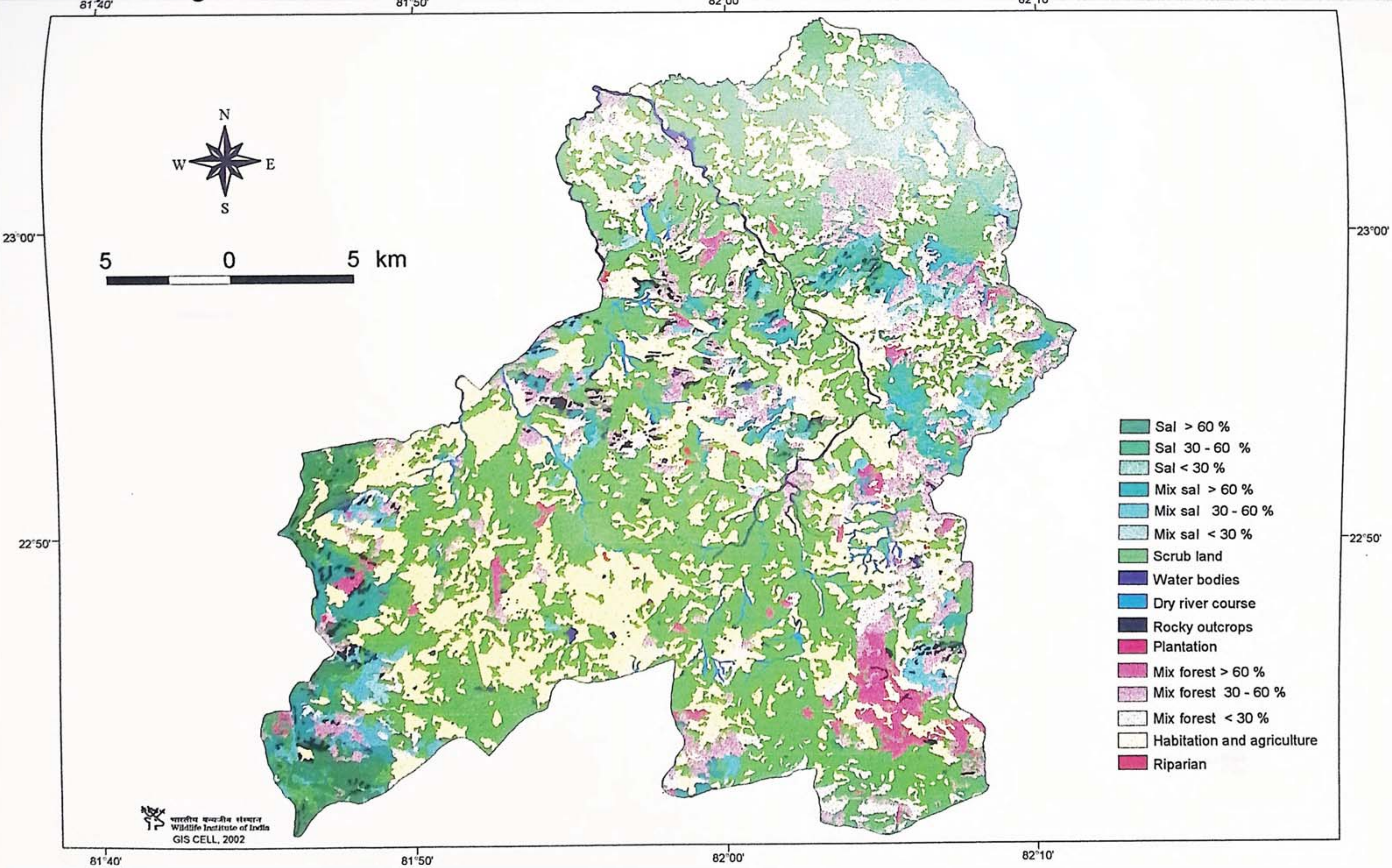
Table 23. Vegetation parameters and Importance Value Index (IVI)of tree species in Land near to water bodies.

S.No.	Tree species	Frequency of occurrence	No. of plants	Abundance	Av. GBH (m)	Basal area/ha	Frequency percent	Density/ha	Relative frequency	Relative density	Relative basal area	IVI	Ab/F
1	*Bombex ceiba*	1	1	1.00	0.30	0.015	6.67	2.12	3.57	1.56	1.22	6.35	0.15
2	*Buchanania lanzan*	1	1	1.00	0.70	0.083	6.67	2.12	3.57	1.56	6.63	11.76	0.15
3	*Cassia fistula*	1	1	1.00	0.30	0.015	6.67	2.12	3.57	1.56	1.22	6.35	0.15
4	*Diospyros melanoxylon*	3	5	1.67	0.41	0.028	20.00	10.62	10.71	7.81	2.26	20.78	0.25
5	*Emblica officinalis*	1	1	1.00	0.30	0.015	6.67	2.12	3.57	1.56	1.22	6.35	0.15
6	*Ficus racemosa*	2	4	2.00	1.33	0.301	13.33	8.49	7.14	6.25	24.05	37.44	0.30
7	*Lannea coromandelica*	3	7	2.33	0.62	0.064	20.00	14.86	10.71	10.94	5.14	26.80	0.35
8	*Madhuca indica*	3	3	1.00	0.67	0.075	20.00	6.37	10.71	4.69	6.01	21.42	0.15
9	*Miliusa tomentosa*	2	6	3.00	0.44	0.032	13.33	12.74	7.14	9.38	2.59	19.11	0.45
10	*Shorea robusta*	4	24	6.00	0.63	0.067	26.67	50.96	14.29	37.50	5.40	57.18	0.90
11	*Syzygium cumini*	2	3	1.50	0.38	0.024	13.33	6.37	7.14	4.69	1.90	13.73	0.23
12	*Teminalia alata*	4	7	1.75	0.76	0.097	26.67	14.86	14.29	10.94	7.74	32.96	0.26
13	*Teminalia arjuna*	1	1	1.00	1.60	0.433	6.67	2.12	3.57	1.56	34.63	39.77	0.15
Total		**28**	**64**	**24.25**	**8.43**	**1.250**	**186.67**	**135.88**	**100.00**	**100.00**	**100.00**	**300.00**	

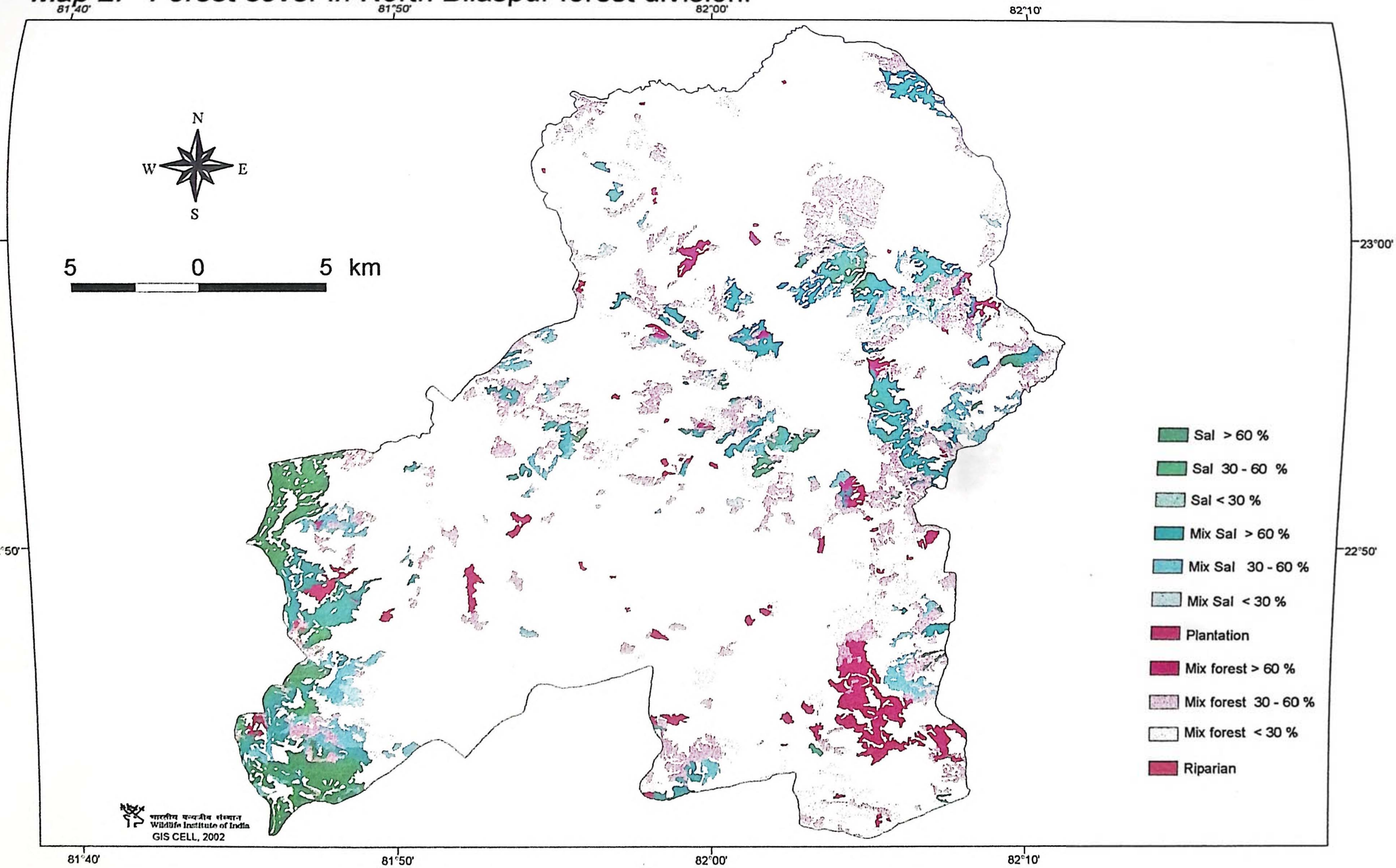
Table 24. Vegetation parameters and Importance Value Index (IVI) of tree species in Plantation.

S.No.	Tree species	Frequency of occurrence	No. of plants	Abundance	Av. GBH (m)	Basal area/ha	Frequency percent	Density/ha	Relative frequency	Relative density	Relative basal area	IVI	Ab/F
1	*Acacia auriculiformes*	2	4	2.00	0.38	0.0258	14.29	9.10	11.76	5.41	1.86	19.03	0.14
2	*Azadirachta indica*	2	4	2.00	0.93	0.1550	14.29	9.10	11.76	5.41	11.15	28.32	0.14
3	*Buchanania lanzan*	1	1	1.00	0.50	0.0453	7.14	2.27	5.88	1.35	3.26	10.49	0.14
4	*Butea monosperma*	1	1	1.00	1.80	0.5868	7.14	2.27	5.88	1.35	42.22	49.46	0.14
5	*Dalbergia latifolia*	2	18	9.00	0.35	0.0222	14.29	40.95	11.76	24.33	1.60	37.69	0.63
6	*Eucalyptus sp.*	3	8	2.67	0.60	0.0647	21.43	18.20	17.65	10.81	4.66	33.12	0.12
7	*Lagerstroemia parviflora*	2	19	9.50	0.52	0.0492	14.29	43.22	11.76	25.68	3.54	40.98	0.67
8	*Mangifera indica*	1	1	1.00	1.20	0.2608	7.14	2.27	5.88	1.35	18.77	26.00	0.14
9	*Peltoforum pterocarpum*	1	2	2.00	0.50	0.0453	7.14	4.55	5.88	2.70	3.26	11.84	0.28
10	*Shorea robusta*	1	3	3.00	0.31	0.0170	7.14	6.82	5.88	4.05	1.23	11.16	0.42
11	*Tectona grandis*	1	13	13.00	0.81	0.1177	7.14	29.57	5.88	17.57	8.47	31.92	1.82
Total		**17**	**74**	**46.17**	**7.88**	**1.3898**	**121.43**	**168.33**	**100.00**	**100.00**	**100.00**	**300.00**	

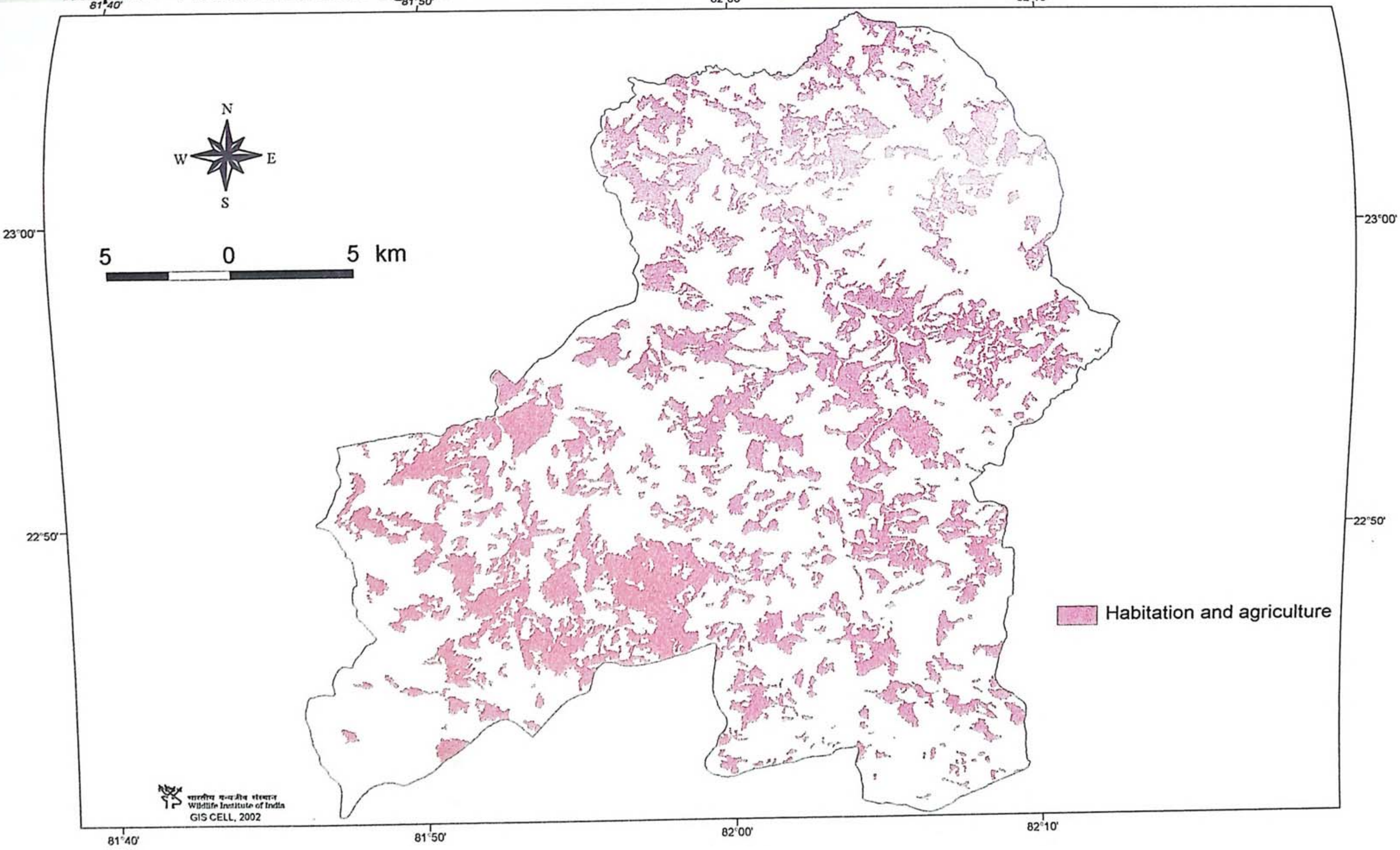
Map 1. Vegetation/landuse cover of North Bilaspur forest division.



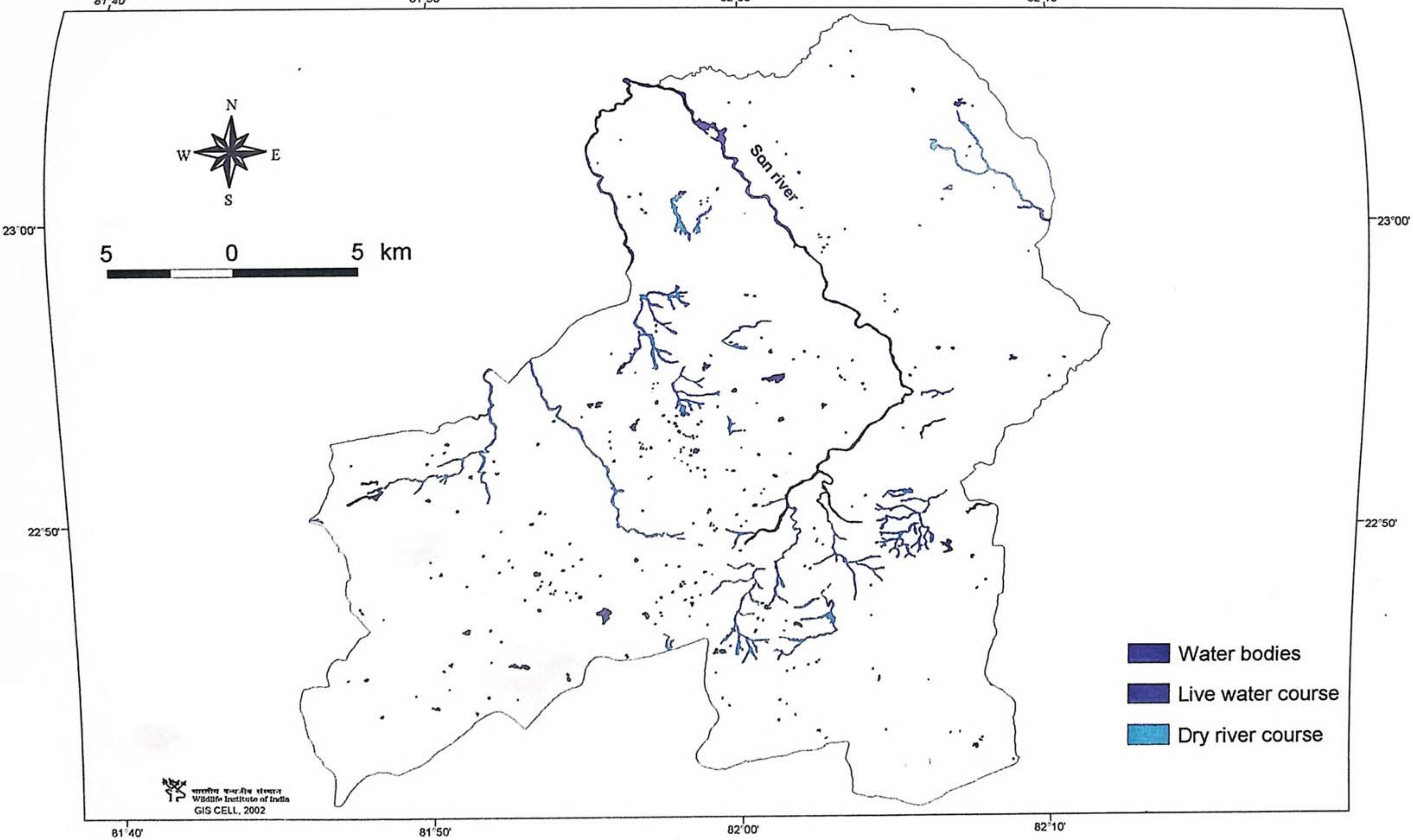
Map 2: Forest cover in North Bilaspur forest division.



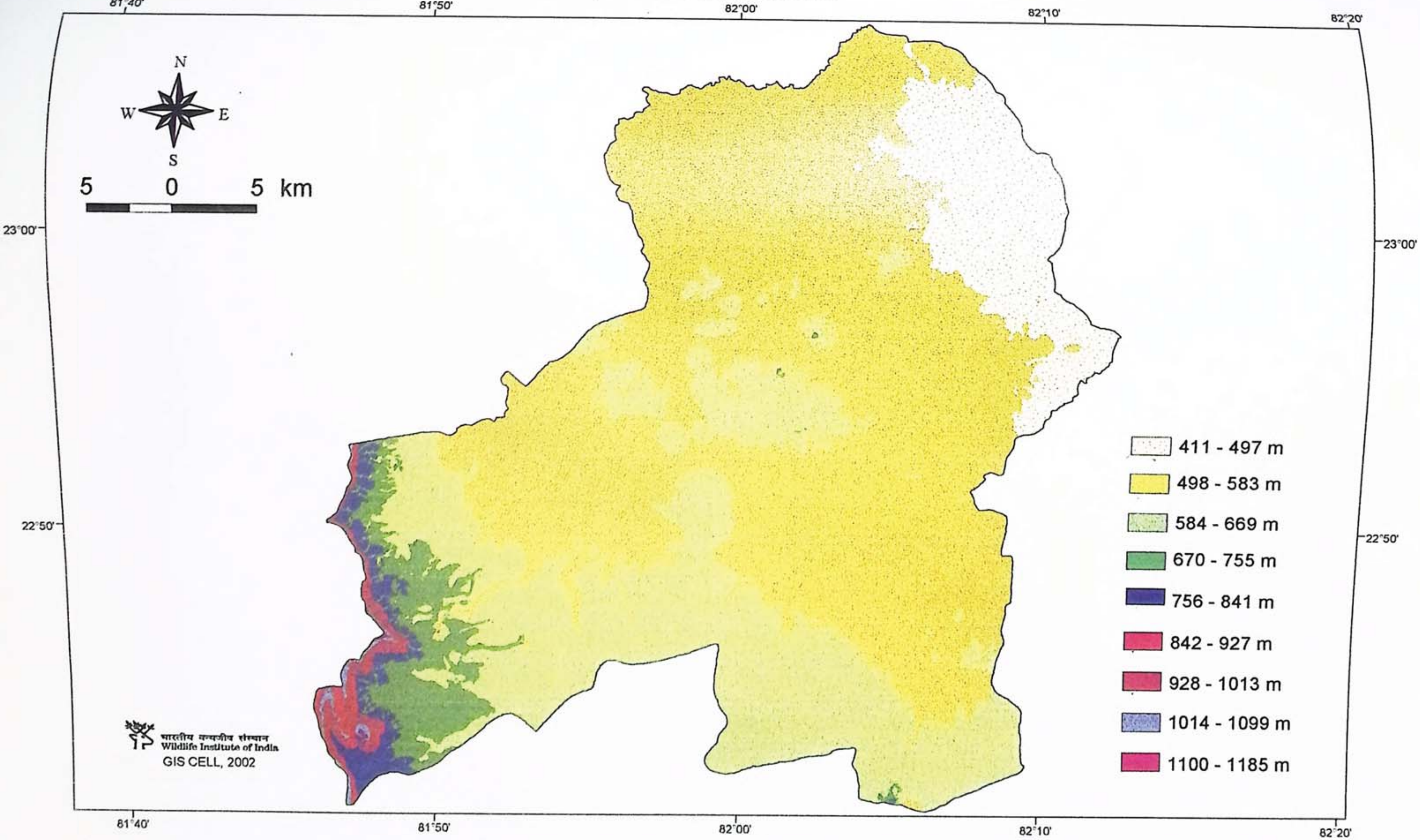
Map 3. Habitation and agriculture areas of North Bilaspur forest division.



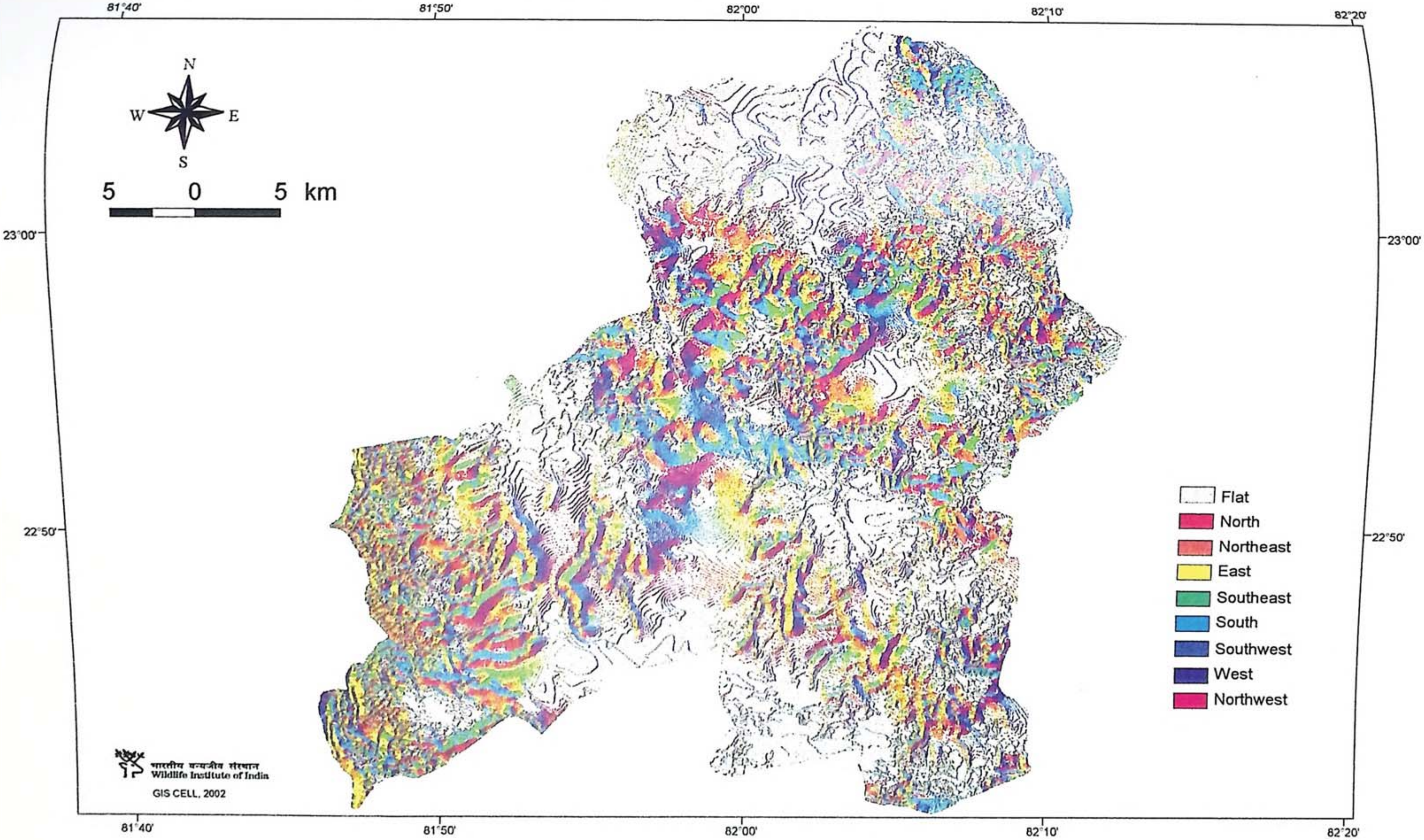
Map 4: Distribution of water bodies in North Bilaspur forest division.



Map 5: Area elevations in North Bilaspur forest division.



Map 6: Aspects of North Bilaspur forest division.



Annexure 1. Checklist of flora of North Bilaspur forest division.

Common Name	Genus	Species	Family	Type of plant
Indrajata	*Petalidium*	*barleriodes*	Acanthaceae	S
Bantulsi	*Daedalacanthus*	*purpurascens*	Acanthaceae	S
Akol	*Alangium*	*salviifolium*	Alaginaceae	S
	Limnophyton	*obtusifolium*	Alaginaceae	H
	Sagittaria	*guayanensis*	Alaginaceae	H
	Tenagocharis	*latifolia*	Alaginaceae	H
Chichdi	*Achyranthes*	*aspera*	Amaranthaceae	H
	Achyranthes	*lanata*	Amaranthaceae	H
Kaju	*Anacardium*	*occidentale*	Anacardaceae	ST
Char	*Buchanania*	*lanzan*	Anacardaceae	ST
Aam	*Mangifera*	*indica*	Anacardaceae	T
Bhelwa	*Semecarpus*	*anacardium*	Anacardaceae	T
Gunja	*Lannea*	*coromandelica*	Anacardaceae	ST
Munga, Sehjan	*Moringa*	*oleifera*	Anacardaceae	ST
Sitaphal, Shareefa	*Anona*	*squamosa*	Annonaceae	ST
Kari	*Miliusa*	*tomentosa*	Annonaceae	ST
Tejraj	*Peucedanum*	*nagpurense*	Apiaceae	H
	Pimpinella	*wallichiana*	Apiaceae	H
	Alstonia	*venenata*	Apocynaceae	S
Dudhi, Kuro	*Holarrhena*	*antidysenterica*	Apocynaceae	Weed
	Ichnocarpus	*frutescens*	Apocynaceae	C
Bhuin-kurai	*Rauvolfia*	*serpentina*	Apocynaceae	H
	Vallaris	*solanacea*	Apocynaceae	C
Berri	*Wrightia*	*arborea*	Apocynaceae	ST
Berri	*Wrightia*	*tinctoria*	Apocynaceae	T
Karonda	*Carrisa*	*spinarum*	Apocynaceae	S
	Aponogeton	*natans*	Aponogetonaceae	H
	Pistia	*stratiotes*	Araceae	H
	Plesmonium	*margaritiferum*	Araceae	RT
Chindi	*Phoenix*	*acaulis*	Araceae	H
Khajuri	*Phoenix*	*sylvestris*	Araceae	T
	Aristolochia	*indica*	Aristolochiaceae	H
	Calotropis	*procera*	Aristolochiaceae	S
	Acanthospermum	*hispidum*	Asteraceae	H
	Ageratum	*conyzoides*	Asteraceae	H

Rasna -jadi	*Blepharispermum*	*subsessile*	Asteraceae	S
Mothi	*Bernonia*	*roxbughii*	Asteraceae	S
Kardhan Mundi	*Sphaeranthus*	*indicus*	Asteraceae	H
	Eclipta	*alba*	Asteraceae	H
Kathua	*Xanthium*	*strumarium*	Asteraceae	H
Barah masi	*Vernonia*	*pyramidale*	Asteraceae	H
	Vernonia	*divergens*	Asteraceae	H
	Vernonia	*cinerea*	Asteraceae	H
Barah masi	*Erigeron*	*asteroides*	Asteraceae	H
	Elephantopus	*scaber*	Asteraceae	H
Gul-menhdi	*Impatiens*	*balsamina*	Balsaminaceae	H
	Begonia	*picta*	Begoniaceae	H
Chota Padar	*Stereospermum*	*suaveolens*	Begoniaceae	T
Padar,Katori	*Stereospermum*	*tetragonum*	Begoniaceae	T
Semar Kanda	*Bombex*	*ceiba*	Bombacaceae	T
Lasora	*Cordia*	*obliqua*	Boraginaceae	ST
Dahiman, Lasora	*Cordia*	*dichotoma*	Boraginaceae	T
Rai	*Brassica*	*juncea*	Brassicaceae	H
Sarson	*Brassica*	*rapa*	Brassicaceae	H
	Rorippa	*indica*	Brassicaceae	H
Karawa	*Capparis*	*zeylanica*	Brassicaceae	H
Salai	*Boswellia*	*serrata*	Burseracea	T
	Opuntia	*stricta*	Cactaceae	S
Son Patta	*Bauhinia*	*malabarica*	Caesalpiniaceae	ST
Koliar	*Bauhinia*	*purpurea*	Caesalpiniaceae	ST
Sehra	*Bauhinia*	*semla*	Caesalpiniaceae	ST
Mahul	*Bauhinia*	*vahlii*	Caesalpiniaceae	C
Amaltas	*Cassia*	*fistula*	Caesalpiniaceae	ST
Ban chironta	*Cassia*	*occidentalis*	Caesalpiniaceae	H
Chakora	*Cassia*	*tora*	Caesalpiniaceae	H
Gul-mohar	*Delonix*	*regia*	Caesalpiniaceae	H
Anjan	*Hardwickia*	*binata*	Caesalpiniaceae	T
	Peltophorum	*pterocarpum*	Caesalpiniaceae	T
Imli	*Tamarindus*	*indica*	Caesalpiniaceae	T
	Lobelia	*alsinoides*	Campanulaceae	H
	Polycarpaea	*aurea*	Caryophyllaceae	H
	Polycarpaea	*corymbosa*	Caryophyllaceae	H
Apang, Pheng	*Celastrus*	*paniculatus*	Celastraceae	C

Chaulai	*Chenopodium*	*murale*	Chenopodiaceae	H
Silvair Bhaji	*Celosia*	*argentea*	Chenopodiaceae	H
Gengal	*Cochlospemum*	*religiosum*	Cochlospermaceae	ST
Dhawa,Safed dhanwala	*Anogeissus*	*latifolia*	Combretaceae	T
Pai Bel	*Combretum*	*decandrum*	Combretaceae	C
Saja	*Terminalia*	*alata*	Combretaceae	T
Kohwa	*Terminalia*	*arjuna*	Combretaceae	T
Bahera	*Terminalia*	*bellirica*	Combretaceae	T
Harra	*Terminalia*	*chebula*	Combretaceae	T
Nagbel	*Cryptolepis*	*buchananii*	Combretaceae	C
	Commelina	*paludosa*	Commelinaceae	H
	Commelina	*suffruticosa*	Commelinaceae	H
	Cyanotis	*cristata*	Commelinaceae	H
Amarbel	*Cuscuta*	*reflexa*	Convolvulaceae	Par
	Ipomoea	*aquatica*	Convolvulaceae	C
	Ipomoea	*carnea*	Convolvulaceae	C
	Evolvulus	*alsinoides*	Convolvulaceae	H
	Cucumis	*callosus*	Cucurbitaceae	CH
Karela	*Momordica*	*charantia*	Cucurbitaceae	CH
Ban-karela	*Momordica*	*dioica*	Cucurbitaceae	CH
	Cyperus	*compressus*	Cyperaceae	Se
	Cyperus	*cyperoides*	Cyperaceae	Se
	Cyperus	*diaphanus*	Cyperaceae	Se
	Cyperus	*iria*	Cyperaceae	Se
	Cyperus	*kyllingia*	Cyperaceae	Se
	Cyperus	*niveus*	Cyperaceae	Se
	Cyperus	*nutans*	Cyperaceae	Se
	Cyperus	*pangorei*	Cyperaceae	Se
	Cyperus	*pilosus*	Cyperaceae	Se
	Cyperus	*pseudokyllingioides*	Cyperaceae	Se
	Cyperus	*pumilus*	Cyperaceae	Se
	Cyperus	*pygmaeus*	Cyperaceae	Se
Motha	*Cyperus*	*rotundus*	Cyperaceae	Se
	Cyperus	*triceps*	Cyperaceae	Se
	Eleocharis	*acutangula*	Cyperaceae	Se
	Eleocharis	*congesta*	Cyperaceae	Se
	Eleocharis	*dulcis*	Cyperaceae	Se
	Fimbristylis	*aestivalis*	Cyperaceae	Se

	Fimbristylis	*alboviridis*	Cyperaceae	Se
	Fimbristylis	*dichotoma*	Cyperaceae	Se
	Fimbristylis	*falcatus*	Cyperaceae	Se
	Fimbristylis	*ovata*	Cyperaceae	Se
	Fimbristylis	*tetragona*	Cyperaceae	Se
Baichandi	*Dioscorea*	*bulbifera*	Dioscoreaceae	C
	Dioscorea	*oppositifolia*	Dioscoreaceae	C
	Dioscorea	*glabra*	Dioscoreaceae	C
Baichandi	*Dioscorea*	*daemona*	Dioscoreaceae	Weed
	Dioscorea	*puber*	Dioscoreaceae	C
Sal	*Shorea*	*robusta*	Dipterocarpaceae	T
Makar Tendu	*Diospyros*	*malabarica*	Ebenaceae	ST
Tendu	*Diospyros*	*melanoxylon*	Ebenaceae	T
	Diospyros	*montana*	Ebenaceae	ST
	Bergia	*ammannioides*	Elatinaceae	H
	Eriocaulon	*achiton*	Eriocaulaceae	H
	Acalypha	*ciliata*	Euphorbiaceae	H
	Acalypha	*indica*	Euphorbiaceae	H
Amoori	*Antidesma*	*acidum*	Euphorbiaceae	S
Amthi	*Antidesma*	*ghaesembilla*	Euphorbiaceae	S
	Breynia	*vitisidaea*	Euphorbiaceae	S
Kargai	*Briedelia*	*retusa*	Euphorbiaceae	ST
Kasai	*Briedelia*	*squamosa*	Euphorbiaceae	ST
Karra	*Cleistanthus*	*collinus*	Euphorbiaceae	ST
Aonwala	*Emblica*	*officinalis*	Euphorbiaceae	ST
	Euphorbia	*chamaesyce*	Euphorbiaceae	H
	Euphorbia	*dracunculoides*	Euphorbiaceae	H
	Euphorbia	*heterophylla*	Euphorbiaceae	H
	Euphorbia	*hirta*	Euphorbiaceae	H
	Euphorbia	*hypericifolia*	Euphorbiaceae	H
	Euphorbia	*neriifolia*	Euphorbiaceae	H
	Euphorbia	*orbiculata*	Euphorbiaceae	H
Sindoori	*Mallotus*	*philippensis*	Euphorbiaceae	ST
	Phyllanthus	*debilis*	Euphorbiaceae	H
	Phyllanthus	*urinaria*	Euphorbiaceae	H
Arandi	*Ricinus*	*communis*	Euphorbiaceae	ST
	Sauropus	*quadrangularis*	Euphorbiaceae	H
Dengla	*Securinega*	*virosa*	Euphorbiaceae	T
Ratti, Gumchi	*Abrus*	*precatorius*	Fabaceae	C

Karua Kanda	*Diosocorea*	*daemona*	Fabaceae	C
Palas, Dhak	*Butea*	*monosperma*	Fabaceae	T
Palas Bel	*Butea*	*superba*	Fabaceae	C
Nasbel	*Butea*	*parviflora*	Fabaceae	Par
Arhar	*Cajanus*	*cajan*	Fabaceae	S
Chana	*Cicer*	*arietinum*	Fabaceae	H
	Crotalaria	*albida*	Fabaceae	H
	Crotalaria	*hirta*	Fabaceae	H
	Crotalaria	*linifolia*	Fabaceae	H
	Crotalaria	*prostrata*	Fabaceae	H
Shishum	*Dalbergia*	*latifolia*	Fabaceae	T
Dhobin	*Dalbergia*	*paniculata*	Fabaceae	T
	Desmodium	*brachystachyum*	Fabaceae	S
	Desmodium	*dichotomum*	Fabaceae	H
	Desmodium	*gangeticum*	Fabaceae	H
	Desmodium	*heterocarpon*	Fabaceae	H
	Desmodium	*laxiflorum*	Fabaceae	S
	Desmodium	*motorium*	Fabaceae	H
	Desmodium	*pulchellum*	Fabaceae	S
	Desmodium	*triangulare*	Fabaceae	S
Aenti	*Desmodium*	*latifolium*	Fabaceae	H
Gurar	*Millettia*	*auriculata*	Fabaceae	C
	Millettia	*extensa*	Fabaceae	S
	Felmingia	*microphylla*	Fabaceae	S
	Felmingia	*strobilifera*	Fabaceae	S
	Lathyrus	*aphaca*	Fabaceae	H
	Lathyrus	*sativa*	Fabaceae	H
	Macrotyloma	*uniflorum*	Fabaceae	H
Karanj	*Pongamia*	*pinnata*	Fabaceae	ST
Bija sal	*Pterocarpus*	*marsupium*	Fabaceae	T
	Sesbania	*bispinosa*	Fabaceae	H
Gaachh-munga, Aenti	*Sesbania*	*grandiflora*	Fabaceae	ST
	Uraria	*alopecuroides*	Fabaceae	H
Vishnu-jadi	*Uraria*	*picta*	Fabaceae	H
Tinsa, Sandham	*Ougenia*	*oogeinensis*	Fabaceae	T
Pajri	*Erythrina*	*suberosa*	Fabaceae	T
Akra	*Vicia*	*sativa*	Fabaceae	H
Sakuli Bel	Atylosia	*scarabaeoides*	Fabaceae	C

Gurari	*Mucuna*	*pruriens*	Fabaceae	S
Kakai	*Flacourtia*	*indica*	Flacourtiaceae	ST
Bhairon	*Casearia*	*elliptica*	Flacourtiaceae	S
Gulchi	*Casearia*	*graveolens*	Flacourtiaceae	ST
Bhuin neem	*Canscora*	*diffusa*	Gentianaceae	H
	Curculigo	*orchioides*	Hypoxidaceae	RT
Amera	*Colebrookea*	*oppositifolia*	Lamiaceae	Weed
Gummi Bhaji	*Leucas*	*cephalotes*	Lamiaceae	H
Kumbi	*Careya*	*arborea*	Lecythidaceae	T
	Lemna	*perpusila*	Lemnaceae	H
	Spirodela	*polyrhiza*	Lemnaceae	H
Dash-mool	*Asparagus*	*racemosus*	Liliaceae	C
	Chlorophytum	*arundinaceum*	Liliaceae	H
Safed Musli	*Chlorophytum*	*tuberosum*	Liliaceae	H
	Gloriosa	*superba*	Liliaceae	H
Banda	*Dendrophthoe*	*falcata*	Loranthaceae	H
	Viscum	*orientale*	Loranthaceae	Par
	Loranthus	*falcata*	Loranthaceae	Par
	Lagerstroemia	*reginae*	Lythraceae	S
Lendia,Senha	*Lagerstroemia*	*parviflora*	Lythraceae	T
Menhdi	*Lawsonia*	*inermis*	Lythraceae	ST
Dhanwai, Birhul	*Woodfordia*	*fruticosa*	Lythraceae	S
	Ludwigia	*adscendens*	Lythraceae	H
	Ludwigia	*prostrata*	Lythraceae	H
	Abelmoschus	*crinitus*	Malvaceae	H
	Abelmoschus	*esculentus*	Malvaceae	H
Barkanghi	*Abutilon*	*hirtum*	Malvaceae	H
Kanghi	*Abutilon*	*indicum*	Malvaceae	H
	Hibiscus	*lobatus*	Malvaceae	H
	Hibiscus	*radiatus*	Malvaceae	H
	Sida	*acuta*	Malvaceae	H
	Sida	*cordata*	Malvaceae	H
	Thespesia	*lampas*	Malvaceae	T
	Thespesia	*populnea*	Malvaceae	T
Bariyari	*Malvastrum*	*coromandelianum*	Malvaceae	S
Neem	*Azadirachta*	*indica*	Meliaceae	T
Rohan	*Soymida*	*febrifuga*	Meliaceae	ST
	Acacia	*auriculiformis*	Mimosaceae	ST
	Acacia	*donaldi*	Mimosaceae	ST

	Acacia	*leucopholea*	Mimosaceae	ST
Kirkich	*Acacia*	*pennata*	Mimosaceae	C
Babool	*Acacia*	*nilotica*	Mimosaceae	T
Chirol, Chilbil	*Holoptelea*	*intergrifolia*	Mimosaceae	T
	Albizia	*amara*	Mimosaceae	T
Chichwa	*Albizia*	*odoratissima*	Mimosaceae	T
Siris	*Albizia*	*lebbeck*	Mimosaceae	T
Safed siris	*Albizia*	*procera*	Mimosaceae	T
Subabool	*Leucaena*	*leucocephala*	Mimosaceae	ST
	Neptunia	*oleracea*	Mimosaceae	H
	Prosopis	*julifera*	Mimosaceae	ST
Bhirhi	*Samanea*	*saman*	Mimosaceae	T
Ael	*Acacia*	*pennata*	Mimosaceae	.
Lajwanti	*Mimosa*	*pudica*	Mimosaceae	S
Suriya	*Xylia*	*xylocarpa*	Mimosaceae	T
	Ficus	*amplissima*	Moraceae	T
Bar, Bargad	*Ficus*	*bengalensis*	Moraceae	T
	Ficus	*heterophylla*	Moraceae	S
Bhuin Gular	*Ficus*	*hispida*	Moraceae	S
Gular	*Ficus*	*racemosa*	Moraceae	T
Peepal	*Ficus*	*religiosa*	Moraceae	T
	Ficus	*glomerata*	Moraceae	T
Doomar	*Ficus*	*semicardata*	Moraceae	T
*tauli	*Ficus*	*tinctoria*	Moraceae	ST
Gasti	*Ficus*	*virens*	Moraceae	T
	Ardisia	*solanacea*	Myrsinaceae	S
Bauywadin	*Embelia*	*robusta*	Myrsinaceae	S
Jamun	*Syzygium*	*cumini*	Myrtaceae	T
	Syzygium	*heyneanum*	Myrtaceae	ST
Khat Jamun	*Eugenia*	*heyneana*	Myrtaceae	ST
	Najas	*graminea*	Najadaceae	H
	Najas	*indica*	Najadaceae	H
Kamal	*Nelumbo*	*nucifera*	Nymphaeaceae	H
Safed ratalu	*Nymphaea*	*pubescens*	Nymphaeaceae	H
Lal ratalu	*Nymphaea*	*rubra*	Nymphaeaceae	H
	Ochna	*obtusata*	Ochnaceae	H
Kharsi	*Nyctanthes*	*arbor-tristis*	Oleaceae	ST
Mokha,Ghata	*Schrebera*	*swietenioides*	Oleaceae	T
	Eulophia	*herbacea*	Orchidaceae	H

	Eulophia	*nuda*	Orchidaecae	H
Banda	*Vanda*	*parviflora*	Orchidaecae	OR
Banda	*Vanda*	*roxburghii*	Orchidaecae	OR
Banda	*Vanda*	*tessellata*	Orchidaecae	OR
	Orobanche	*aegyptica*	Orobanchaceae	Par
	Orobanche	*indica*	Orobanchaceae	Par
	Biophytum	*reinwardtii*	Oxalidaceae	H
	Oxalis	*richardiana*	Oxalidaceae	H
Tal makhar	*Argemone*	*mexicana*	Papaveraceae	H
Ulat Kanta	*Martynia*	*annua*	Pedaliaceae	H
	Acrachne	*racemosa*	Poaceae	G
	Aristida	*adscensionis*	Poaceae	G
	Arundinella	*pumila*	Poaceae	G
	Arundinella	*setosa*	Poaceae	G
	Bambusa	*arundinacea*	Poaceae	G
	Cenchrus	*ciliaris*	Poaceae	G
	Chrysopogon	*fulvus*	Poaceae	G
	Chrysopogon	*verticillatus*	Poaceae	G
	Cymbopogon	*martinii*	Poaceae	G
	Cynodon	*arcuatus*	Poaceae	G
Doob	*Cynodon*	*dactylon*	Poaceae	G
	Dactyloctenium	*aegyptium*	Poaceae	G
	Dendrocalamus	*strictus*	Poaceae	G
	Dichanthium	*annulatum*	Poaceae	G
	Digitaria	*abludens*	Poaceae	G
	Eragrostis	*atrovirens*	Poaceae	G
	Eragrostis	*ciliata*	Poaceae	G
	Eragrostis	*nutans*	Poaceae	G
Bhurbhusi	*Eragrostis*	*tenella*	Poaceae	G
	Eragrostis	*zeylanica*	Poaceae	G
	Hemarthria	*compressa*	Poaceae	G
Sukla gahs, Lapa	*Heteropogon*	*contortus*	Poaceae	G
	Hygroryza	*alstata*	Poaceae	G
Chir ghas, Moa, Siru	*Imperata*	*cylindrica*	Poaceae	G
	Panicum	*notatum*	Poaceae	G
	Panicum	*psilopodium*	Poaceae	G
	Panicum	*sumatrense*	Poaceae	G

Kodo	*Paspalum*	*scrobiculatum*	Poaceae	G
Kodela	*Paspalum*	*flavidum*	Poaceae	G
	Setaria	*intermedia*	Poaceae	G
	Setaria	*pumila*	Poaceae	G
Bhandol	*Themeda*	*triandra*	Poaceae	G
	Themeda	*quadrivalvis*	Poaceae	G
Khas	*Vetiveria*	*zizanioides*	Poaceae	G
Sabai	*Eulaliopsis*	*binata*	Poaceae	G
Phulbahri	*Thysanolaena*	*maxima*	Poaceae	G
	Andropogon	*contortus*	Poaceae	G
Nal	*Phragmites*	*karka*	Poaceae	G
Dubala	*Andropogan*	*bladhii*	Poaceae	G
Kanta behri	*Anthistiria*	*imberbis*	Poaceae	G
	Panicum	*flavidum*	Poaceae	G
Sava	*Brachiaria*	*ramosa*	Poaceae	G
	Bothriochloa	*bladhii*	Poaceae	G
	Pennisetum	*pedicellatum*	Poaceae	G
Mova grass	*Saccharum*	*spontaneum*	Poaceae	G
	Polygonum	*hydropiper*	Polygonaceae	H
	Portulaca	*oleracea*	Portulacacea	H
	Potamogeton	*crispus*	Potamogetonaceae	H
Keonti, Lal-bel	*Ventilago*	*denticulata*	Rhamnaceae	S
Kasibel(Keoti)	*Ventilago*	*calyculata*	Rhamnaceae	C
	Ziziphus	*glaberrima*	Rhamnaceae	ST
Ber	*Ziziphus*	*jujuba*	Rhamnaceae	ST
Ber	*Ziziphus*	*mauritiana*	Rhamnaceae	ST
Makoiya	*Ziziphus*	*oenoplia*	Rhamnaceae	C
Jhad Beri	*Ziziphus*	*nummularia*	Rhamnaceae	S
Gothar	*Ziziphus*	*xylopyrus*	Rhamnaceae	ST
Haldu	*Adina*	*cordifolia*	Rubiaceae	T
Kadam	*Anthocephalus*	*cadamba*	Rubiaceae	T
Bhenrmal	*Hymenodictyon*	*orixene*	Rubiaceae	T
	Ixora	*arborea*	Rubiaceae	ST
	Ixora	*pavetta*	Rubiaceae	ST
Mundi, Kalmi	*Mitragyna*	*parviflora*	Rubiaceae	T
Phetra kala	*Randia*	*uliginosa*	Rubiaceae	ST
Mainphal, Manhar	*Randia*	*dumetorum*	Rubiaceae	T
Safed panpra	*Gardenia*	*latifolia*	Rubiaceae	T

Dikamali,Mahlin	*Gardenia*	*lucida*	Rubiaceae	Weed
Phetra safed	*Gardenia*	*turgida*	Rubiaceae	ST
	Pavetta	*tomentosa*	Rubiaceae	ST
Manhar	*Xeromphis*	*spinosa*	Rubiaceae	ST
Tilwa	*Wendlandia*	*exserta*	Rubiaceae	ST
Kurru, Malhin	*Gardenia*	*gummifera*	Rubiaceae	S
Bel	*Aegle*	*marmelos*	Rutaceae	T
Bhirrah	*Chloroxylon*	*swietenia*	Rutaceae	ST
Khair	*Limonia*	*acidissima*	Rutaceae	T
Meeta neem	*Murraya*	*koenigii*	Rutaceae	ST
Kusum	*Schleichera*	*oleosa*	Sapindaceae	T
Mohwa	*Madhuca*	*indica*	Sapotaceae	T
Reul	*Mimusops*	*hexandra*	Sapotaceae	ST
Maharukh	*Ailanthus*	*excelsa*	Simaroubaceae	ST
Ram-datoon	*Smilax*	*zeylanica*	Smilacaceae	C
Dathura	*Dathura*	*inoxia*	Solanaceae	S
	Dathura	*metel*	Solanaceae	S
Ber Kateli	*Solanum*	*surattense*	Solanaceae	H
	Solanum	*anguivi*	Solanaceae	S
Kullu	*Sterculia*	*urens*	Sterculiaceae	T
	Sterculia	*villosa*	Sterculiaceae	T
Bagh-mochh	*Tacca*	*leontopetaloides*	Taccaceae	H
	Corchorus	*aestuans*	Tiliaceae	H
	Corchorus	*capsularis*	Tiliaceae	H
	Corchorus	*triocularis*	Tiliaceae	H
Bhansuri	*Grewia*	*abutilifolia*	Tiliaceae	S
Ban-sulai	*Grewia*	*helectrifolia*	Tiliaceae	S
Dhman	*Grewia*	*tiliifolia*	Tiliaceae	T
Gursakri	*Grewia*	*hirsuta*	Tiliaceae	Weed
	Triumfetta	*pilosa*	Tiliaceae	H
	Trapa	*natans*	Trapaceae	H
	Typha	*angustata*	Typhaceae	H
	Celtis	*tetrandra*	Ulmaceae	T
	Trema	*orientalis*	Ulmaceae	T
	Trema	*politoria*	Ulmaceae	ST
	Girardinia	*zeylanica*	Urticaceae	H
Khamar	*Gmalina*	*arborea*	Verbenaceae	T
Sagon	*Tectona*	*grandis*	Verbenaceae	T
	Lantana	*camara*	Verbenaceae	S

	Hybanthus	*enneaspermus*	Violaceae	H
	Cayratia	*trifolia*	Vitaceae	C
Doker bel	*Cissus*	*repanda*	Vitaceae	C
	Vitis	*tomentosa*	Vitaceae	C
Jungli Aungur	*Ampelocissus*	*latifolia*	Vitaceae	C
	Costus	*speciosus*	Zingiberaceae	RT
	Zingiber	*capitatum*	Zingiberaceae	RT
	Zingiber	*roseum*	Zingiberaceae	RT
Tikhur	*Curcuma*	*aromatica*	Zingiberaceae	H
Gokhru	*Tribulus*	*terrestris*	Zygophyllaceae	H

S = Shrub, H = herb, ST = short trees, T = tree C = climber, Se = sedges,
Par = parasite, Or = orchid, RT = root tuber G = grasses

Plate - 1

1. **Landuse pattern showing hillocks with den site, forest patches, scattered trees and crop fields in Marwahi range.**

2. **View of Land cover from the top of a den site in Surungtola. Sparse vegetation cover interspersed with crop fields and water bodies.**

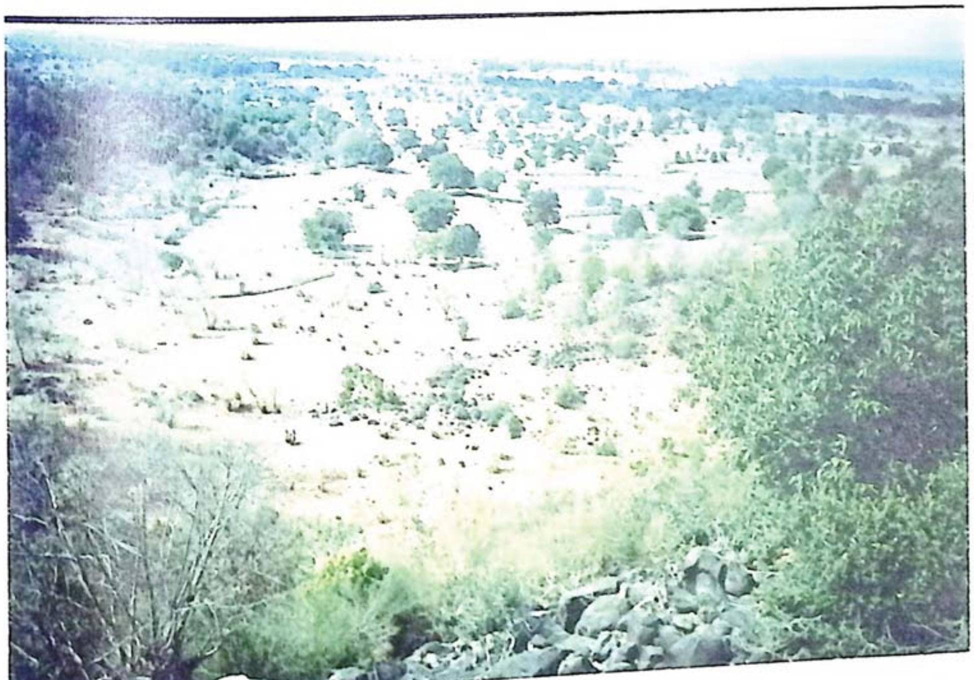


Plate - 2

3. Sal forest adjacent to bear den sites near Tauli village.

4. Mahua trees in Open land near Khanta Village, which is the preferred habitat of sloth bear.

Plate - 3

5. Hillock with bear den sites next to Barbasan village.

6. Crop fields with scattered boulders and trees. Bear use these boulders as temporary shelter.

Chapter V. Impact of biotic pressures on Bear habitat

5.1.0. Introduction

Major threats to biodiversity include habitat alternation, over harvesting of resources pollution, climate change and increase in human population. The habitat loss, fragmentation and degradation are the primary factors. About 4.5 % of the India's geographical area is under protection for in-situ biodiversity conservation. Through the protection, availability of biotic components i.e. food, water and shelter in a habitat is ensured. These components should be sufficient in an ideal habitat to nourish animals without any human intervention. Impact of biotic pressures depends on the extent of resource utilization by the human society in and around the habitat. Over the period of time, most of animals species have been acclimatized themselves according to the changing environment, and some species who could not adjust, are facing serious threats to their survival. Animals are unable to cope up with the rate of environmental changes.

With the increase of human population, requirements for the space and resources are also increasing. Forest cover is decreasing day by day. More and more land is being converted into agriculture land. Developmental activities and exploitation of natural resources like water, oil and minerals and non-timber forest produce are exerting their combined effect on species, and in such situation, animals hardly have any option to avoid these pressures.

Impacts of biotic pressures might be less for species living in protected areas, but believed to be high for those species thriving outside in the man-altered situations. The studies on assessment of biotic pressures on tiger (Mathur *et al.*, 1995), goral (Roy *et al.*, 1995) and grizzly bear (Hood and Parker, 2001) enabled mapping of least affected areas from biotic pressures. In America, direct human caused mortality of grizzly bears was arguable cause of population decline (Craighead and Mitchell, 1982; Brown, 1985; Servheen, 1989 and Mattson, 1990). Presence of human beings and dogs in the proximity of brown bear dens has contributed to increased level of aggressiveness among bears in Scandinavia (Swenson *et al.,* 1999). Olander *et al.* (1998) studied the impacts of disturbance due to road construction in a sub tropical cloud forest in Luquillo, Puerto Rico. There was drastic reduction in the soil pH, soil moisture and accumulation of biomass because of anthropogenic pressure. This study envisages to assess the biotic pressures and their impacts on the sloth bear and range of habitats used by this species.

5.2.0. Methods

To assess impact of biotic pressures on sloth bear habitats, 78 linear transects were laid in the representative areas covering all the available habitats and landuse categories in North Bilaspur forest division. Each transect was 1 km in length and sample plots of 10 m radius at every 250 m interval were taken to assess the impact of biotic pressures on bear habitat and in total data were taken from 390 plots. There were in total 390 plots and evidence of biotic pressures such as cattle grazing (dung), cut/fell and lopped trees, collection of non-timber forest produce, distance from human habitation, disturbance from roads, stone mining and camping of graziers and other human activities were recorded in the predesigned formats (Annexure 1) and locations of the affected areas were transferred into toposheets. Then all information was finally transferred into study area map, divided into grids of 200x200 m each. The extent of biotic pressures was categorized as nil, low, moderate, high and very high (non-occupied by bears). Each grid on the map was assigned the value as per the category of biotic pressure and random checking of the some grids was done just to ensure the precision in marking each grid. After ground check, value of each grid was transferred into to Arc/Info and Arcview software of Sun GIS domain. Finally, area statistics of each category and map showing biotic pressures was generated in Arcview. In addition to transect methods, information on biotic pressures was also collected through village surveys of different areas over the period of three years.

5.3.0. Results

Impact of biotic pressures on sloth bear habitats has been estimated in terms of collection of non-timber forest produce, cut/fell trees, lopped trees, livestock camping and grazing (dung abundance), fuelwood collection, stone mining activity and man made forest fires.

5.3.1. Extent of biotic pressures

In Pendra and Marwahi ranges, vast stretches of land were interspersed with human habitation and cultivation areas. Forests were highly fragmented and impacted from biotic interference. Human population in the Pendra, Gaurela and Marwahi blocks of the two ranges was estimated to be 53,343, 72,688 and 96,694 respectively and livestock population in the same blocks was 44,633, 51,437 and 70,000 respectively (Table 1) as per the revenue department. About 46% area of NBFD was found as highly affected, whereas only 2.5% area without any biotic pressures, which was found as the most suitable area for sloth bear (Table 2, Map1). More than 27% area was severely affected and was not found to be occupied by the bears.

5.3.2. Collection of non-timber forest produce

All together 42 items of non-timber forest produce were identified, which were regularly collected by villagers from bear areas in NBFD (Table 3). Thirty two items were of plant origin, 3 of insects and 7 were mushrooms. All the items of forest produce belonged to 21 families, 28 genera and 32 species. Although people collected the forest produce throughout the year for different uses (Table 4), but intensity of collection was found to be manifold during the season of tendu patta (*Diospyros melanoxylon*) and mahua (*Madhuca indica*) fruit and flower collection from May-June and March-June respectively. Collection of the forest produce in high quantities (Table 5) exerts tremendous pressure on bear habitats and cause high disturbance for prolonged period.

5.3.3. Cut/fell trees

Number of cut /fell trees in different habitat types directly indicates the level of biotic pressure and disturbance in these areas. Table 6 shows the extent of biotic pressure in the form of cut/fell trees and increase in the pressure due to continued removal of trees. Maximum number of cut/fell trees per hectare was observed in Sal mix (143.02) habitat, followed by Sal forest (129.16), Mix forest (88), Plantation (79.62), Scrub land (43.79), Land near to water bodies (25.41) and Crop field (5.1). When sampling was repeated after one year to see the change in biotic pressure, it was found that maximum change was in Scrub land (15.97%), followed by Sal forest (15.77%), Plantation (12.50%), Land near water bodies (10.53%), Mix forest (7.08%) and Sal mix (4.63%). Altogether 8.31% increase was estimated in the number of cut/fell trees during one year period.

5.3.4. Lopped trees

Extent of lopped trees in different habitats was estimated as a measure of biotic pressure. Number of lopped trees per hectare was highest in Sal mix forest (191.67), followed by Mix forest (179.07), Sal (177.52), Plantation (95.54), Land near to water bodies (87.05), Scrub land (83.24) and Crop field (6.75) (Table 7). Increase in the number of lopped trees over a period of one year was maximum in Sal forest (20.58%), Sal mix (19.46%), Plantation (14.29%), Mix Forest (10.6%) Scrub land (9.60%) and Land near to water bodies (8.89%). An average of 10.43% increase in the lopping activity was recorded during one year interval.

5.3.5. Livestock grazing pressure

Presence of cattle dung in the bear areas is the most prominent disturbance factor. Biotic pressure caused due to livestock grazing was measured in terms of dung in different habitats in NBFD. Dung abundance per hectare was found to be maximum in Open land (197.45), followed by Plantation (179.71), Scrub land (158.87), Land near to water bodies (121.02), Mix forest (83.81), Crop field (75.13), Sal mix (58.98), and Sal (51.9). Except in

Sal and Crop field there was significant decrease in dung abundance in other bear habitats in the subsequent year. The decrease in dung abundance was found maximum in Open land (78.18%), followed by Plantation (54.90%) Mix forest (39.54%), Land near to water bodies (29.55%), Scrub land (28.36%) and Sal mix (27.32%). There was 30.62% and 11.11% increase in dung abundance in Crop field and Sal habitat respectively. On average, 115.85 % decrease in annual fall in dung density was observed in one year in North Bilaspur forest division (Table 8).

In summer, nomadic graziers from Gujarat visit Achanakmar wildlife sanctuary and NBFD to graze their sheep and goats, which cause tremendous pressure on bear habitats. They bring thousands of sheep and goats to these areas every year. A herd of sheep and goat stays at least for a month or so in NBFD halting at different places. They were frequently seen camping at Silpahri, Pakariya, Salekota, Lityasarai, Chullapani and Andhiyarkho forests, the important bear areas.

Dahiyan is a local community involved in selling of milk and milk product. They camp in the forests especially along highland of Amarkantak hills with large herds of buffaloes and cows. Dhaiyan were seen camping and grazing their cattle in Bedkudra and Karangra forest areas of Pendra range. Presence of Dahiyan and their cattle greatly impacted the habitats and bear activities.

5.3.6. Fuelwood collection

A section of people in Pendra and Marwahi ranges earn their livelihood by selling fueldwood. They inflict tremendous pressure on forests by regularly extracting fuelwood, and so also on bears and habitats. Impact of fuelwood extraction on habitats and wild animals has been well documented (Anonymous, 2001b, Gadgil *et al.*, 1989 and ECE, 1986).

5.3.7. Stone mining activity

During the fieldwork, we identified more than 109 den sites of sloth bear. All the den sites were located in the separate hillocks. These bouldary hillocks scattered throughout the ranges provide good shelter or resting sites to bears. Due to illegal stone mining activities, den sites such as Jhandi dongri of Surungtola (Masurikhar panchayat), Marakot in Marwahi, Jhandi and Bhuthi dongris of Barbasan in Pendra were being destroyed. This caused displacement of bears and they were increasingly moving out, and thus their survival was highly threatened. Mining along the dry streams of Karangra village and hill tract of Bedkhudra located on the border of NBFD and Shahdol district was also recorded. Bears were frequently seen moving in these areas.

5.3.8. Forest fires

During the summer season, forest fires were common in Pendra and Marwahi ranges. In the dry deciduous vegetation, accumulation of dry leaves on the ground was highly vulnerable to catch fire. In NBFD, forest fires did not impact much on trees, but it had adversely impacted the fruiting shrubs abundance. Occurrence of two wild fruit shrub species, namely, makoiya (*Ziziphus oenoplia*) and jungali ber (*Ziziphus nummularia*), important food species of bears was drastically reduced. Most of the fire incidences were found to be man made. The most fire prone areas were Silpahri, Ratga, Ghusariya, Lityasarai, Karhanhia, Chullapani and Rumga in Marwahi range, and Pakariya, Padwania and Amarkantak belt in Pendra range. These forest fires were found to destroy few shrubs species, which were important food plants for the bears. Apparently, the fires might be adversely affecting the habitat use by bears.

5.2.9. Encroachment on forest land

At many places in forest areas of Karangara, Padwania, Pakariya, Bedkhudra and Andhiyarkho in Pendra and Ghusariya, Madwahi, Charheri, Lityasarai, Silpahri, Chilan, and Chullapani in Marwahi, forest land was found encroached either for agriculture purpose or establishment of houses. Perhaps this could be one of the reason behind the degradation and losing of bear habitat which directly and indirectly lead to man-bear conflict.

5.4.0. Discussion

In Pendra and Marwahi ranges, the forest patches interspersed with human settlement and agriculture areas seem to be highly disturbed from biotic pressures. We found only 2.5% of the available habitats as least disturbed, 46% area was highly affected and more than 27% area was highly disturbed and severely affected by biotic pressures. Concentration of bears was mostly in areas with high biotic pressures and in least disturbed areas. The areas with maximum disturbance areas were not occupied by bears. Avoidance of these highly disturbed areas might be due to the absence of forest cover and hillocks, which could be considered as the limiting factors for bear distribution. And use of highly disturbed areas by bears was correlated with the availability of forests and dens as shelter places.

We identified 42 non-timber forest produce items, which were collected by the villagers from the bear areas. These forest produce items were of wide variety and extracted from different sources; 32 items were of plant origin, 3 of insect and 7 were mushrooms. The NTFP are very important for poor tribal people and other inhabitants because many of them get financial support for their sustenance. Economy of local people is based on agriculture and NTFP collection (Plate 4 & 5). Although the NTFP items have significance for livelihood of people but tendu patta and mahua flowers and seeds are very important in many ways. The NBFD is one major area for harvesting tendu patta and mahua flower and seeds. Collections of few NTFP have been nationalized by the government; villagers get wages for the collection of these items for the department. There were three agencies, namely, M.P forest department, State laghu van upaj samiti and Tribal cooperative marketing development federation of India (TRIFED) involved in the collection of the forest product for the revenue generation. Indiscriminate collection of NTFD in huge quantity from these areas exerts tremendous pressure on sloth bears and their habitats. The bear areas were found to be highly disturbed during the collection time of tendu patta and mahua. Many of the NTFP such as mahua flowers and fruit, char and bel fruit were the food items of bears and these were increasingly collected by the villagers. The forest cover, which was already disturbed, degraded and insufficient to sustain bear needs, was exploited by the people by collecting the food items of bear diet. Under these circumstances, competition for food and man-bear encounters was inevitable. These were the major casual factors for man-bear conflicts in the North Bilaspur forest division.

The rate of increase of biotic pressures in form of cutting/felling and lopping of trees in bear habitats was very high as estimated at one year interval. The increase in biotic pressures could be correlated with the increase of human and livestock population in these areas. The increase in biotic pressures was highly threatening to bear population. Cutting/felling of trees was highest in Sal mix forest, followed by Sal, Mix forest, Plantation, Scrub land, Land near to water bodies and Crop field. Likewise, maximum lopping of trees was in Sal mix forest, followed by Mix forest, Sal, Plantation, Land near to water bodies, Scrub land and Crop field. Digging signs were observed highest in Sal forest, followed by Land near to water bodies, Sal mix forest, Mix forest, Scrub land, Plantation, Open land and Crop field. When the cutting and lopping of trees was correlated with the abundance of bear signs, it was revealed that despite of the biotic pressures, bears were using the disturbed habitats. This might be due to the fact that there were no other areas than these disturbed habitats where bears could move and find resources for their survival (Plate 1, 2 & 3).

Reason of decrease in the dung density did not indicate reduction in the cattle population; the first assessment of biotic pressures was done during summer season when availability of fodder was found to be scant everywhere due to dry season and non-cropping season. The cattle covered larger areas including harvested crop fields, hence there was lots of dung everywhere. With the onset of monsoon season, and thereafter fodder was readily available in the vicinity of villages and cattle were not taken to forests frequently. So there was less dung density in forest.

Maximum density of dung was observed in Open land, followed by Plantation, Scrub land, Land near to water bodies, Mix forest, Crop field, Sal mix and Sal. When the presence of dung in different habitats was correlated with the extent of biotic pressures, it was found that bears used Open land, Plantation, Scrub land, Land near to water bodies, Sal, Sal mix and Mix forest inspite of high grazing pressure. Nomadic shepherd and Dhaiyan were found to exert tremendous pressure on bear habitats by taking their sheep and goat herds in the vicinity of den sites, staying in the forests and causing disturbance. In India, livestock population is very high; it has 15% of the world cattle, 10% sheep and goats and 50% of buffaloes in 4% of the global land area. Forest degradation due to livestock grazing pressure was found to be significant (Brandon and Ramankutty, 1993). The grazing pressure was estimated to be to about 5 livestock per ha of forest and pastureland. The heavy livestock pressure will affect the forest vegetation succession at potential shift of species driven by climatic parameters. Infrastructure factors such as human settlement, roads, other communication and artificial water bodies are likely to interfere with climatic change driven shifts in forests or species. As the human population is growing, pressure is increasing. Due to the encroachment on the forests, more and more land is being converted into agriculture land. Kothari *et al.* (1989) reported an average human and livestock density within the protected areas as 0.38/ha and 0.21/ha respectively. At the national level, livestock density was 5 livestock/ha. The North Bialspur forest division has less grazing pressure as it harbours only 1.18 animal/ha per hectare. This seems to be normal in area where sloth bears are thriving well. Although the livestock density here is less compared to the protected areas, but it is considered very high and may detrimental for sloth areas. Similarly the human population density in the NBFD was very high compared to the country's human population. Now the human population has nearly doubled during the last 30 years and the area under crop cultivation has nearly stabilized at around 140 million hectares since 1970 (Ravindranath and Hall, 1995). Further it gives the low productivity of food crops i.e. less than 2 tons/ha/year. The world's population has more than tripled in the 20th Century, and continued growth is assured over the next 50 years, especially in the developing countries. The issue of population is not only a matter of numbers, but also of patterns and levels of resource consumption. The average resident of an industrialised nation uses 15 times as much paper, 10 times as much steel, and 12 times as much fuel as a person in a developing country (Anonymous, 2001b). In NBFD, human and livestock population was highest in Marwahi block as compared to Gaurela and Pendra blocks since Marwahi was thickly populated both from human as well as bears, hence it was most vulnerable to human-bear conflicts.

Cutting and lopping of trees was mainly done for extraction of fuelwood and timber wood for home construction. Estimation of cut and lopped trees at the one year interval showed constant increase in the requirement of wood for fuel and other purpose at the rate of approximately 10% in North Bilaspur forest division. Zudeima *et al.* (1994) has projected that the areas under the forests would sharply decline in coming decade in India. Fuelwood is the dominant biomass in the forests. The current consumption level has been estimated to 224 metric tons (Ravindranath and Hall, 1995) and has been projected to increase to 350 metric tons by year 2005, which would make worse condition of the forests. Harvesting of shrubs and lopping of trees could affect the plant diversity in the lower canopy due to opening of canopies; it might lead to forest degradation and ultimately to invasion of pioneer(s) suppressing natural regeneration. In NBFD, the rate of increase of cutting and lopping trees per year was estimated 8.31 % and 10.43 % respectively. In NBFD, some forest land was given to the poor tribal community for agriculture purpose on lease with the condition that all the trees on the leased land would remain a government property and even one can not cut the tree(s) without the permission. But wood merchant are illegally luring the tribals to cut and sell the trees to them by offering money. But by doing so, tribals get some money and indirect benefits as their agriculture land becomes free from unwanted trees and they get more land for cultivation. Similarly, stone mining was found to be a direct threat to bear habitats and their survival. Mining at the den sites of bears at Barbasan and Mashurikhar was a serious practice and might have serious consequences in future. But it would certainly be disastrous to the survival of sloth bear population.

In NBFD, forest fires did not impact trees much, but it had adversely charred the fruiting shrubs and decreased their abundance. The number of two fruit shrub species, namely, makoiya (*Ziziphus oenoplia*) and jungali ber (*Ziziphus nummularia*) was drastically reduced. They were important food species of bears. However, changing of den sites by bears due to forest fires was not observed.

Table 1. Human and livestock population in NBFD.

Name of the blocks	Human population	Livestock population
Pendra	53343	44633
Gaurela	72688	51437
Marwahi	96694	70,000
	2,22,725	1,66,070

Source: Revenue department, Pendra, Marwahi and Gaurela

Table 2. Extent of biotic pressures and affected areas in NBFD.

Value designated	Extent of biotic pressures	Affected area in each category (km^2)	Area affected (%)
0	Nil	34.86	2.50
1	Low	112.06	8.03
2	Moderate	222.83	15.96
3	High	644.81	46.20
4	Very high*	381.17	27.31

* Very high- area not occupied by bears

Table 3. List of non-timber forest produce collected by people in NBFD.

S.No.	Common name	Scientific name		Family/class	Part collected
1	Sitaphal	*Anona*	*squamosa*	Anonaceae	Fruit
2	Mango	*Mangifera*	*indica*	Anacardaceae	Fruit
3	Bhelwa	*Semicarpus*	*anacardium*	Anacardaceae	Fruit
4	Chironji	*Buchanania*	*lanzan*	Anacardaceae	Fruit, kernel
5	Semel	*Bombex*	*ceiba*	Bombacaceae	Fruit
6	Bahera	*Terminalia*	*bellirica*	Combretaceae	Fruit
7	Harra	*Terminalia*	*chebula*	Combretaceae	Fruit
8	Kohwa	*Terminalia*	*arjuna*	Combretaceae	Fruit
9	Imli	*Tamarindus*	*indica*	Caesalpiniaceae	Fruit
10	Babool	*Acacia*	*nilotica*	Caesalpiniaceae	Fruit
11	Amaltas	*Cassia*	*fistula*	Caesalpiniaceae	Fruit
12	Chakora	*Cassia*	*tora*	Caesalpiniaceae	Fruit
13	Koliar	*Bauhinia*	*purpurea*	Caesalpiniaceae	Seed
14	Mahul	*Bauhinia*	*vahlii*	Caesalpiniaceae	Seed
15	Sal	*Shorea*	*robusta*	Dipterocarpaceae	Seed, leaves
16	Tendu	*Diospyros*	*melanoxylon*	Ebenaceae	Fruit
17	Aonwala	*Emblica*	*officinalis*	Euphorbiaceae	Fruit
18	Karanj	*Pongamia*	*pinnata*	Fabaceae	Fruit
19	Palas	*Butea*	*monosperma*	Papillionaceae	Flower, root
20	Kareel	*Dendroclamus*	*spp.*	Graminae	Rhizome
21	Senha	*Largerstroemia*	*parviflora*	Lytharaceae	Fruit
22	Musli	*Chlorophytum*	*spp.*	Liliaceae	Root
23	Bargad	*Ficus*	*bengalensis*	Moraceae	Bark
24	Acacia	*Acacia*	*auriculiformes*	Mimosaceae	Fruit
25	Jamun	*Syzygium*	*cumuni*	Myrtaceae	Bark
26	Bel	*Aegle*	*marmelos*	Rutaceae	Bark
27	Kusum	*Schleichera*	*oleosa*	Sapindaceae	Fruit, seed
28	Mahua	*Madhuca*	*indica*	Sapotaceae	Flower, seed
29	Palas	*Laccifer*	*lacca*	Orthopoda	Lac
30	Kusum	*Laccifer*	*lacca*	Orthopoda	Lac
31	Chindi	*Phoenix*	*acualis*	Palmaceae	Leaves, fruit
32	Grass	*Eragrostris*	*spp.*	Graminae	Leaves, fruit
33	Phulbehri	*Thysonolaena*	*maxima*	Graminae	Whole plant
34	Moa	*Imperata*	*cylindrica*	Graminae	Whole plant
35	Chirhoo Chatni	-	-	Basidomycetes	Whole plant
36	Pottu	*Lycoperdon*	*spp.*	Lycoperdaceae	Whole plant

37	Lamhitya	*Agaricus*	*spp.*	Basidomycetes	Whole plant
38	Kumbha	*Lentinus*	*subnudus*	Basidomycetes	Whole plant
39	Tithi	*Agaricus*	*spp.*	Basidomycetes	Whole plant
40	Gojaya	-	-	Unidentified	Whole plant
41	Dokra chatni	-	-	Basidomycetes	Whole plant
42	Kosa	*Bombyx*	*mori*	Insecta	Cocoon

Table 4. Time of collection and uses of non-timber forest produce.

S. No.	Common name	Season	Uses
1	Sitaphal	September-October	Eaten
2	Mango	April-May	Eaten
3	Bhelwa	November-January	Eaten, lubricant
4	Chironji	April	Eaten
5	Bahera	January	Medicinal, tanning
6	Harra	October-April	Tanning , medicinal
7	Kohwa	August-June	Medicinal
8	Imli	January	Medicinal, eaten, rich source of tartaric acid
9	Babool	October-April	Medicinal
10	Amaltas	Whole year	Medicinal
11	Chakora	November-December	Medicinal, leaves eaten
12	Koliar	October	Vegetable use
13	Mahul patta	April-May	Making pattal tray
14	Sal	July- August	confectionery, detergent
15	Tendu patta	May-June	Bidi
16	Tendu fruit	April	Eaten
17	Aonwala	November-February	Eaten, medicinal
18	Karanj	August-January	Medicinal
19	Palas flower	March-April	Making colour, medicinal
20	Palas root	Whole year	Making brush
21	Kareel	October	Vegetable
22	Senha	June	Medicinal
23	Bargad bark	May-June	Tying purpose
24	Acacia	July- August	Soap
25	Jamun	April-May	Eaten, medicinal
26	Bel	April-May	Eaten, medicinal
27	Kusum	May	Eaten, oil, medicinal
28	Mahua flower	March-April	Liquor

29	Mahua seeds	May-June	Cooking oil
30	Palas	May-June	Lac for sealing purpose
31	Kusum	May-June	Lac for sealing purpose
33	Grasses	October-November	medicinal, broom making
34	Bhakranda seeds	January	Lubricant
35	Kosa	October	Making silk cloths
36	Mashroom	June-September	Eaten
37	Musli	August-October	Skin infection, bruise, sprain, aphrodisiac
38	Semel silk	May-June	Pillow making

Table 5. Level of harvesting of different forest produce in NBFD.

Name	Quantity during 1999 (Quintal)
Tendu leaves	*70060
Mahul patta	5414
Bhelwa seed	272
Imli	50
Semel flower	50
Mushroom	10
Aonwala	16
Karanj fruit	5
Musli	5
Chironji	5
Lac	5
Acacia fruit	715
Mahua flower	10000
Mahua seed	3000
Sal seed	30

*Measured in the form of standard bags (year 2000)
Source: Forest department/Market survey

Table 6. Extent of biotic pressure in form of cut/fell trees in NBFD.

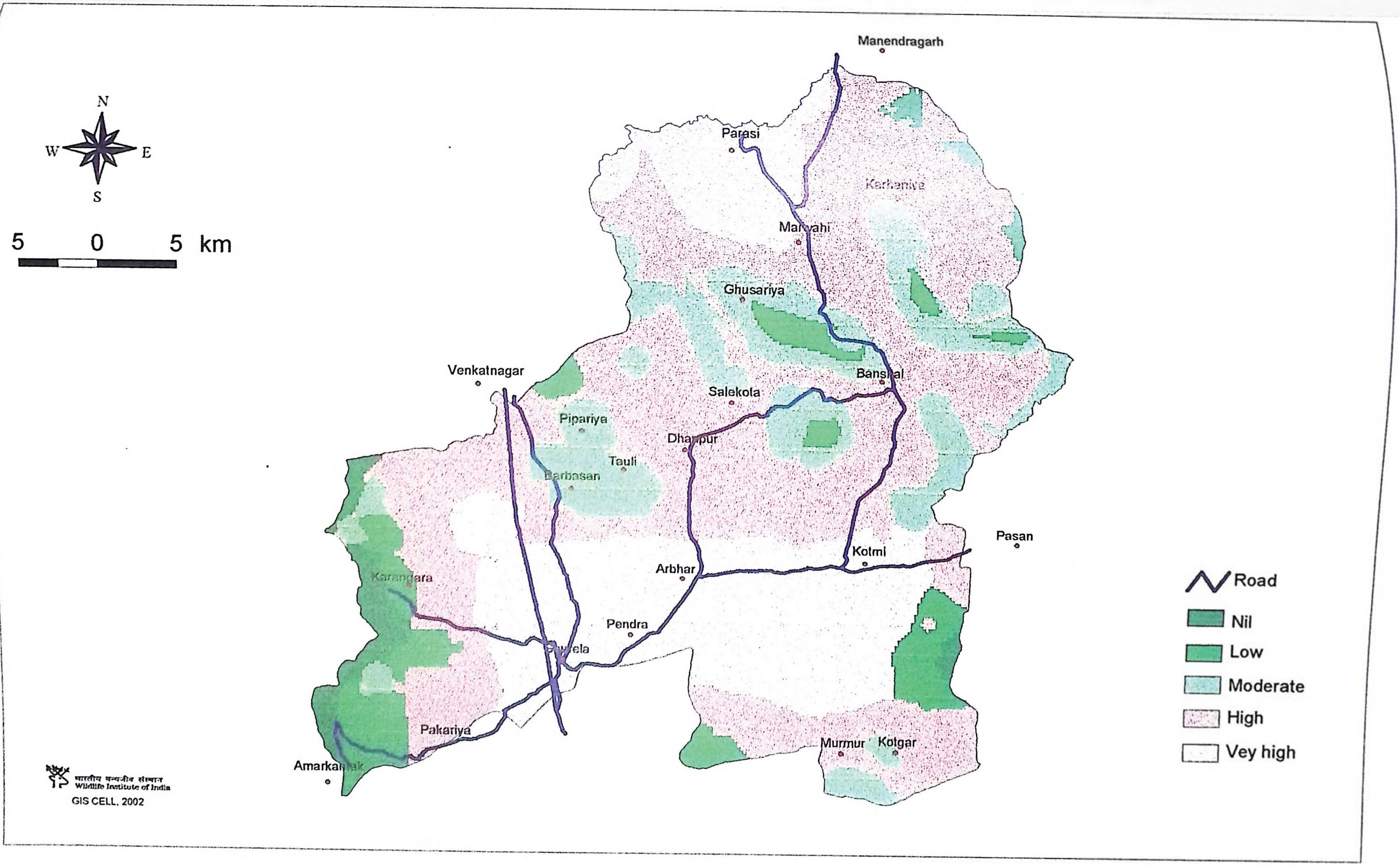
Habitat type	Cut/fell trees (per ha)	Cut/fell trees after one year (per ha)	Increase in cut/fell trees (per ha)	% Increase
Mix forest	88.00	94.70	6.70	7.08
Sal	129.16	153.34	24.18	15.77
Sal mix	143.02	149.97	6.95	4.63
Crop field	5.10	5.10	0.00	0.00
Scrub land	43.79	52.11	8.32	15.97
Land near to water bodies	25.48	28.48	3.00	10.53
Plantation	79.62	90.99	11.37	12.50
Average	64.27	71.84	7.57	8.31

Table 7. Extent of biotic pressure in form of lopped trees in NBFD.

Habitat type	Lopped trees/ha	Lopped trees /ha after one year	Increase in lopped trees/ha	% increase
Mix forest	179.07	200.30	21.23	10.60
Sal	177.52	223.52	46.00	20.58
Sal mix	191.67	237.98	46.31	19.46
Crop field	6.75	6.75	0.00	0.00
Scrub land	83.24	92.07	8.83	9.60
Blank or Open land	0.00	0.00	0.00	0.00
Land near to water bodies	87.05	95.54	8.49	8.89
Plantation	95.54	111.46	15.92	14.29
Average	102.61	120.95	18.35	10.43

Table 8. Extent of grazing pressure as indicated by dung abundance in NBFD.

Habitat type	Dung /ha	Dung/ha after one year	Variation in dung abundance	% variation
Mix forest	83.81	60.06	-23.75	39.54
Sal	51.90	58.39	6.49	11.11
Sal mix	58.98	46.32	-12.66	27.32
Crop field	75.13	108.28	33.15	30.62
Scrub land	158.87	123.77	-35.10	28.36
Blank or Open land	197.45	110.83	-86.62	78.16
Land near to water bodies	121.02	93.42	-27.60	29.55
Plantation	179.71	116.01	-63.70	54.90
Average	115.86	89.64	-26.22	27.01



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Vey high
Wildlife Institute of India
GIS CELL, 2002

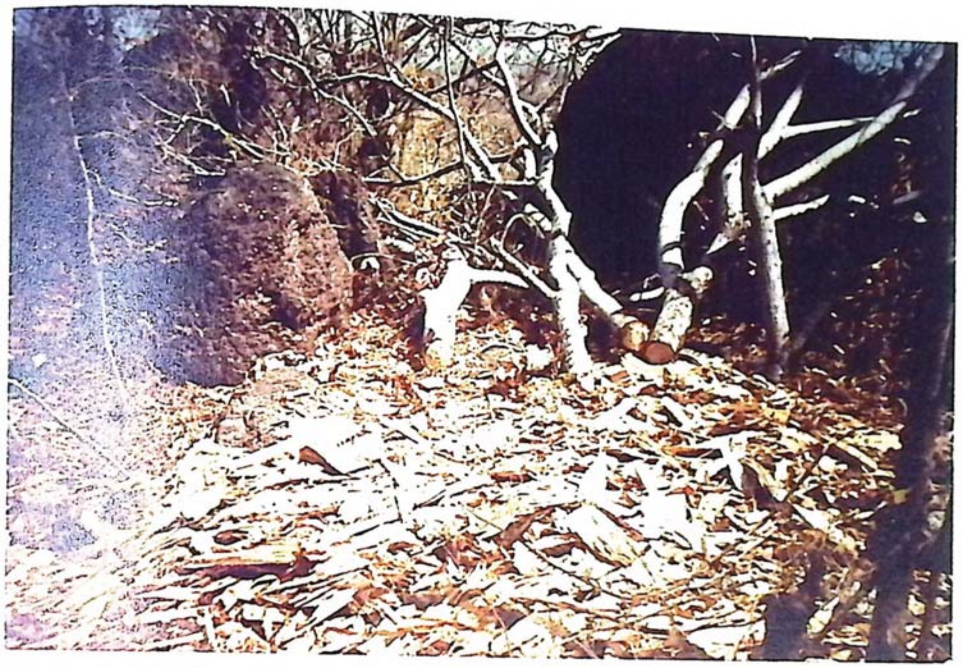
Plate - 1

1. **Disturbance due to sheep grazing in the vicinity of active den sites near Ghusariya village.**

2. **Livestock grazing in Mix forest, an ideal habitat of sloth bear near Bharridand stop dam.**

Plate - 2

3. Disturbance due to tree cutting on a hillock near Lityasarai village.



4. Cutting of Pakri tree on a den site near Barbasan.

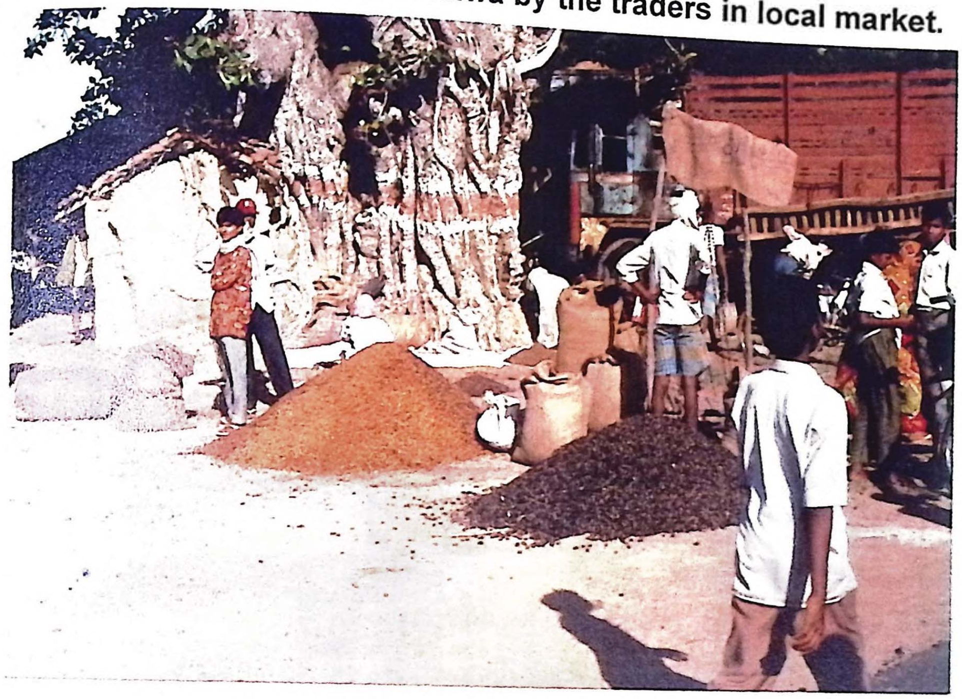
Plate - 3

5. Heap of lopped branches in bear habitat near Ratga village.

6. Fuel wood lots taken to market for selling.

Plate - 4

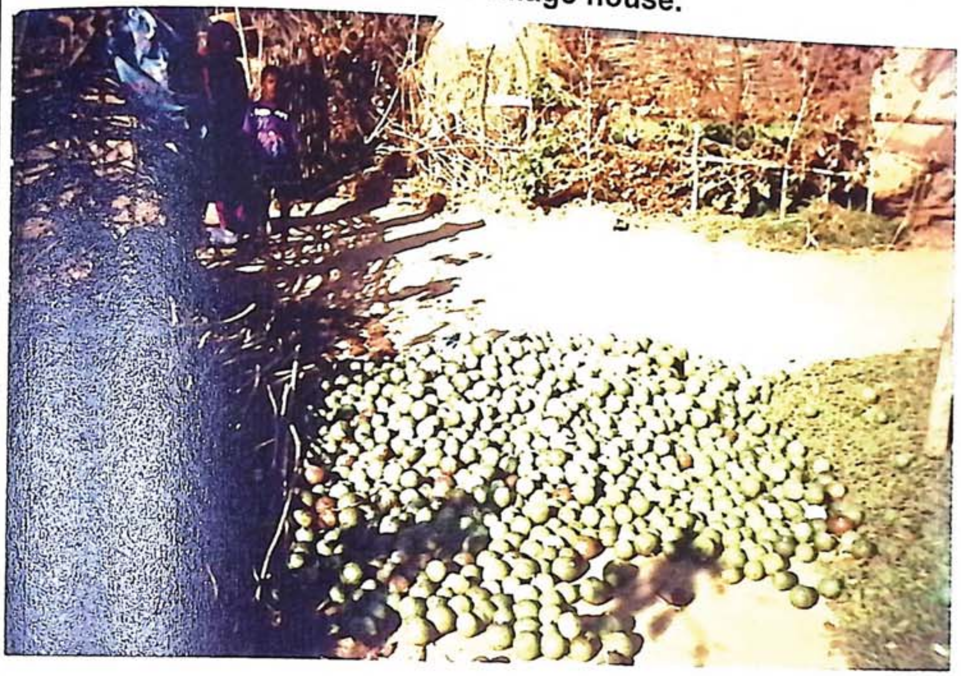
7. Selling of mahua and bhelwa by the traders in local market.



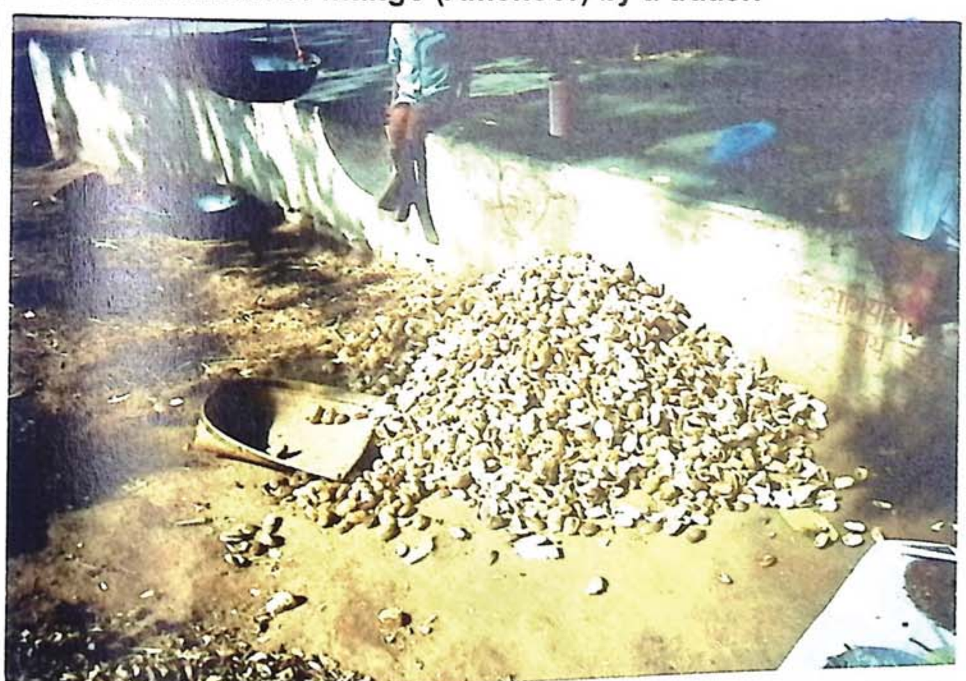
8. Drying up of mahua seeds in a village house.

Plate - 5

9. Collection of bel fruits in a village house.



10. Procurement of mango (Amchoor) by a trader.



Chapter VI. Distribution and Population abundance of sloth bears

6.1.0. Introduction

Estimation of sloth bear (*Melursus ursinus*) population and distribution becomes more important in an area when a species is highly threatened due to continuous habitat degradation and loss of habitat with the increasing human population. In North Bilaspur forest division, man-bear conflicts are on the rise and situation has become alarming. If the man-bear conflicts are not resolved now, the circumstances may pose serious threats to sloth bear survival. Reliable estimation of sloth bear population and knowledge about its distribution pattern are very essential for the field managers to develop mitigatory strategy to combat man-bear conflicts on the long term basis.

There are many methods that have been used in the world to estimate the bear population e.g. capture and recapture of animals (Amstrup, 1981), home range technique (Schwartz and Franzmann, 1983), marking and non-marking of animals (Eberhardt and Knight, 1996) and monitoring of female population and distinct family groups (Knight *et al.*, 1996 and Servheen, 1983). Many studies have been conducted for the estimation of grizzly bear, black bear and brown bear populations using capture and recapture and marking and non-marking techniques (Servheen, 1983; Akenson *et al.,* 2001 and Garshelis *et al.,* 1999). Only one study for the estimation of sloth bear population was done in Royal Chitwan National Park (Garshelis *et al.*, 1999). Estimation of animals along the line transects has been used successfully for many ungulates and bird species (Burnham *et al.,* 1980). This is the first study in India to assess the sloth bear abundance and its distribution based on transects (direct bear sighting and indirect evidences) and bear counts at den sites in Pendra and Marwhai ranges of the North Bilaspur forest division.

6.2.0. Methods

If the purpose of a census is comparison than the data ought to be precise enough to detect differences (Rodgers *et al.,* 1991). In many cases a simple index of density using dung counts may be the most efficient way to show changes. For example counting pellets or scats in a series of quadrates in two areas can be a way to show the differences in animal use of those two areas. Dung/scat is reliable indicator of animal presence (provided one can identified the species) and has frequently been used for estimating animal abundance (Rodgers *et al.,* 1991). In certain situation, dung counts can lead the actual population estimates, but there are many assumptions to be met. However scat counts can easily be used as an index of population abundance. Two types of sample units are considered for sample counts of animals using actual sightings; counting within blocks, and counting along transect lines to know the presence of animal(s) or/and location of the den sites. Line transect is the robust method to estimate population of a species, in which animals are counted along the straight line and their number, distance and angular or perpendicular distance from the observer is recorded (Anderson *et al.,* 1979; Buckland *et al.,* 1993 and Burnham *et al.,* 1980).

In North Bilaspur forest division situation, line transects, indirect evidences, distribution of den sites and bear count in the vicinity of den sites methods were used for estimating population abundance and distribution of sloth bear. The details are as follows.

6.2.1. Distribution of bear population

Through intensive surveys and transect study in NBFD, bear den sites were located and identified as active sites and temporary ones. Besides collecting den sites information along the transects, villagers were contacted to find location of den sites in their areas during the field work. Den with single or multiple openings in a small hillock was considered as one den site. Distinct tunnels in a large hillock with multiple openings were considered as separate den sites. All the den sites were marked on the toposheets and then transferred into GIS domain to map the distribution of bear den sites across the study area. Local name of each den site and its nature (actively or temporarily used) was recorded. A Kruskal-Wallis test was used to determine whether there was any difference ($P<0.05$) between the used and available habitats (Zar, 1984).

6.2.2. Bear abundance based on transects

To estimate the bear population abundance, 78 linear transects were laid in all the representative areas covering various habitat types and landuse categories in the North Bilaspur forest division. All the transects were walked four times over a period of one year in different seasons, and observations were recorded in pre-designed formats. These transects were covered in 312 walks (78 transects x 4 times). While walking on the transects, direct bear sightings were recorded, and indirect evidences of bear presence such as scats and digging of termite mound or ants nest were collected from every 10 m circular plot at the interval of 250 m (Plate 1, 2 & 3). Bear abundance was calculated and analysed in terms of bear encounter rate and density indices based on abundance of scats and diggings per hectare.

6.2.3. Bear abundance based on bear count

When the transects were walked initially, it was realized that sighting of bears along the transects was difficult during day time due to high level of disturbance from people and livestock. Hence an alternative method was used to estimate the bear population in the area. Six bear den sites, namely, Pundi dongri (Tauli), Jhandi dongri (Masurikhar), Amli dongri (Chuabahra), Lamra dongri (Ghusariya), Ladara dongri (Jhirna Pauri) and Niranjan kharil (Jhirna Pauri) were selected in different areas of Pendra and Marwahi ranges. These 6 den sites were considered as the representative of various active den sites in the study area.

Further, it was also assumed that bears did not change their den sites frequently and rarely used temporary den sites. These den sites were intensively surveyed and systematic counting of bears was carried out at dusk time during the summer season. The peak summer months i.e. May and June, were found to be the best time for counting bears. Verification of occurrence of bears was also done during winter and monsoon months. At each den site, bears was counted in between 1600-2000 h, when presumably all the bears were out from their dens. The counting continued for 6-8 consecutive days at each den site. On the basis of body size of bears and their grouping behaviour, individuals were identified sex-wise and counted without any duplication. This was found to be the most suitable method for the estimation of bear population when transect method did not work precisely and low sample size (n=3) of collared bears was not useful for population estimation.

6.3.0. Results

The Distribution pattern and abundance of sloth bear population based on the transects, direct bear count in the vicinity of den sites and estimating density indices from indirect evidences such as scat abundance and digging of termite mounds in the NBFD are presented as under:

6.3.1. Distribution of sloth bears

In NBFD, altogether 109 bear den sites were identified across the study area; 44 and 65 den sites were located in Pendra and Marwahi ranges respectively (Figure 1, Appendix 1). The locations of various den sites in relation to the forest compartment, revenue land and nearest village are given in Appendix 2. Among them 56 den sites were found to be actively used by bears and rest 53 were used occasionally. In Pendra range, there were 18 active dens, whereas in Marwahi range, 38 dens were actively used by bears. It was observed that most of the den sites were located in the forest areas, but few dens were found in the revenue land also. Related to the number of active and temporary dens, distribution of bears has been determined. Bears occupied almost 73% area in NBFD, and there were no bears in the vicinity of Basantpur, Pendra, Semra, Gaurela and Murmur towns in Pendra range and Kudri, Kotmi, Kurkai and Patgawa towns in Marwahi range, which covered 27% of the total area (Chapter V-Table 1). The distribution of sloth bears based on occurrence of active and temporary dens has been shown in the Map 1.

6.3.2. Bear abundance based on transects

Along the transects in 312 walks, only 4 bears (2 males, 1 female and 1 cub) were seen in 3 sightings in the study area. Average bear encounter rate during each walk was very low i.e. 0.0096. In the fragmented and disturbed habitat conditions, bears were rarely active during the day time and so there was remote possibility of their sighting.

The data on indirect evidences showed the use of diverse range of habitat types and landuse categories by sloth bear. Out of 78 transects, indirect evidences were recorded along the 76 transects. The average density of diggings per hectare was highest in Sal forest (35.98), followed by diggings in Land near to water bodies (18.4), Sal mix forest (17.37), Mix forest (17.13), Scrub land (9.89), Plantation (9.86), Open land (7.64) and Crop field (7.22) (Table 1). Whereas, the scat density per hectare was observed highest in Open land (3.4), followed by Mix forest (3.63), Sal forest (3.15), Land near to water bodies (2.12), Crop field (1.7), Scrub land (1.33) and Sal mix (0.58). Average density of diggings and scats in various habitat types was 16.69/ha and 2.29/ha respectively, whereas average number of diggings and scats per transect was 20.40 and 9.88 respectively. The number of diggings and scats in different habitat types was found to be proportional to the abundance of the bears in that area. The results indicated that the bear abundance was comparatively high in Sal forest, Sal mix forest, Mix forest and Land near to water bodies than other habitat categories. Whereas the bear abundance was high in Open land, Mix forest, Sal forest and Land near to water bodies. It was also observed that forest patches close to the bear den sites had more diggings.

To compare whether the used and unused habitats with different variables significantly different or not, non-parametric Kruskal-Wallis test was applied. The habitat available at digging sites was found significantly different (χ^2 = 5.25, df= 7, P=0.022) from the sites where bear signs were not present. Occurrence of diggings varied from plot to plot (0 to 22). Frequencies of occurrence of digging (group size of diggings) in the plots were significantly different to each other (χ^2 = 308.88, df= 15, P=0. 000).

6.3.3. Bear abundance based on bear count

At Pundi dongri, Jhandi dongri, Amli dongri, Lamra dongri, Ladara dongri and Niranjan kharil den sites, 5, 5, 6, 9, 5 and 5 bears respectively were counted (Table 3). In total, there were 10 males, 9 females, 6 cubs and 10 unidentified bears in the vicinity of these den sites. On average 5.83 bears were estimated at each den site.

With the assumptions that bears did not change their den sites frequently and the population of each den represented the number of bears in other similar den sites as well, the bear population of 6 den sites was extrapolated at 95% confidence limit with number of active (56) den sites. Based on this, the bear population was estimated to be 326 ± 90 bears in the study area (Table 4). With extrapolation of bear population, there were approximately 93 ± 29 males, 100 ± 53 females, 84 ± 45 cubs, and 140 ± 78 unidentified individuals in the North Bilaspur forest division. As the Marwahi range showed more active den sites, the bear population appeared to be high in this range in comparision to number of bears in Pendra range. Further since the North Bilaspur forest division encompassed 1395.72 km^2 areas, the bear population could be projected as one bear in 4.28 km^2.

6.4.0. Discussion

In changing environment, population estimation of animal species is essentially required not only to know the trend but also to effectively manage decling or increasing problematic species populations. Since human-bear conflicts are on the rise and has now reached to alarming level in the NBFD, hence it requires estimation of population abundance of bears and their distribution so that future course of action to deal with the conflicts can be developed.

Bear population distribution and size is extremely difficult to find out. On the basis of location of dens, direct sighting of bears and indirect evidences, distribution pattern and population abundance of sloth bear can be studied. In Pendra and Marwahi ranges of NBFD, bear dens, actively and temporarily used, were located in the bouldary hillocks throughout the study area. The number of active dens was more in the forests of Marwahi area than Pendra range. Although Pendra range along the Amarkantak chain of hillocks showed contiguous forests but number of den sites was low. In both Pendra and Marwahi ranges, most of the den sites and available habitats of sloth bears were interspersed with human settlement and agricultural areas. Further, the dens sites were close to each other in Marwahi range, whereas the dens were distantly apart from each other and scattered. This actually indicated the bear distribution pattern in the NBFD. Related to the number of active and temporary dens, distribution of bears has been determined. The distribution of sloth bears based on occurrence of dens has been shown in the Map 1. Bears occupied almost 73% area of NBFD, and there were no bears in the vicinity of Basantpur, Pendra, Semra, Gaurela and Murmur towns in Pendra range, and Kudri, Kotmi, Kurkai and Patgawa towns of Marwahi range, which covered 27% of the total area.

Since census of sloth bear is very important for management point of view, hence an alternative method i.e. Identification of all bear den sites and density indices based on bear evidences such as scats and digging of termite mounds was used to estimate population abundance. Bears usually rest in dens during day time. They rarely come out of dens and move in search of food at the time when people remain active and cattle are around in the day time. So direct sighting of 4 bears along the transects did not reflect the meaningful abundance of sloth bear. The bear encounter rate was unrealistic as far as actual population density was concerned. There was a conception that the bears could be estimated on the basis of line transects while the study began. Line transects were walked during day time, mostly in morning and evening time, and it was realised that there was high degree of biotic disturbance every where. Presence of people and cattle in the vicinity of den sites and forest patches literally forced the animal to stay inside the dens during day time. Many den sites fell along the transects but bear movement was not observed despite the presence of indirect evidences along the belt.

Density index of indirect evidences was correlated with the number density of bear diggings and scats in different habitat types and landuse categories. Density of scats was high in Open land, Mix forest and Sal forest and diggings was high in Sal forest, Land Near to water bodies, Sal mix and Mix forest. Forest patches near to den sites had more digging signs and scats.

In NBFD, scat density of 2.29/ha or 22.9/km^2 shows very high bear abundance. Whereas in Mudumalai wilidlife sanctuary, bear abundance was very low based on scat density of 1.11/km^2 (Desai *et al.,* 1997). In Amarkantak belt, there are contiguous forests with few den sites. Accordingly, the bear signs were not many. Density of sloth bear in Chitwan National Park was 0.1bear/km^2 (Laurie and Seidensticker, 1975) and 0.27bear/km^2 (Garshelis *et al.,* 1999), Mudumalai 0.17bear/km^2 (Desai *et al.,* 1997), and Ruhena Wilpattu National Park 0.05 (Santiapillai, and Santiapillai, 1990). In North Bilaspur forest division, density of 0.23 bear/km^2 is comparatively high.

Based on the Kruskal-Wallis test, the habitats used by bears were significantly different from the unused habitat as indicated by presence or absence or frequency of occurrence of bear signs. The number of diggings and scats in different habitat types was proportional to the abundance of bears in NBFD. On the basis of indirect evidences, bear abundance was found to be comparatively high in Open land, Sal forest, Sal mix forest, Mix forest and Land near to water bodies than other habitat categories. Such estimates of sloth bear abundance in protected areas based on indirect evidences have been generated, and difficulty of finding correlation of signs or sightings with estimates of abundance is known (Wesley, 1977 and Saharia, 1980). Eisenberg and Lockhart (1972) conducted a reconnaissance of Wilpattu National Park in Sri Lanka. Sloth bears were encountered 24 times in 583 km^2 search area. Assuming no sloth bears were seen twice, Jafferson (1975) converted these data to a density of 4 bears/100 km^2.

Walking along the transects, sighting of bears and indirect evidences did not reflect the meaningful abundance of sloth bear in NBFD. Hence an alternative approach of counting bears at 6 specific den sites representing the whole range of habitats was used. Through scanning of these sites and counting of bears coming out of dens and returning ones, approximate population abundance of bears can be estimated in the area. An average of 5.83 bears were found at each den site. Identification of sex of subadult and cubs was very difficult, but adult male and female bears were counted easily.

In NBFD, the bear population is estimated to be 326 ± 90 bears in 1395.72 km^2. The population abundance is found to be 0.23 bear/km^2 or one bear in 4.28 km^2. There were approximately 93 ± 29 males, 100 ± 53 females, 84 ± 54 cubs and 140 ± 78 unidentified individuals. As in Marwahi range, active den sites of similar nature were more in comparision to Pendra range, the bear population could be high in Marwahi areas.

Presently in NBFD, though the forests are highly disturbed and degraded they support substantial number of sloth bear that can be compared with bear population in protected areas of Nepal (Joshi *et al.*, 1995) and Sri Lanka (Santiapillai and Santiapillai, 1990). Using the sighting data, a crude density of 5 bears/100 km^2 was estimated in Wilpattu National Park (Eisenberg and Lockhard, 1972). Iswariah (1984) estimated density of 12 sloth bears/100 km^2 outside protected area in Ramnagaram Taluk, Karnataka. In Chitwan Natonal Park, variation of density from 25-72 bears/km^2 found to be correlated with season and habitat conditions (Garshelis *et al.*, 1999).

Figure 1. Number of active and temporary bears den sites in Pendra and Marwahi ranges.

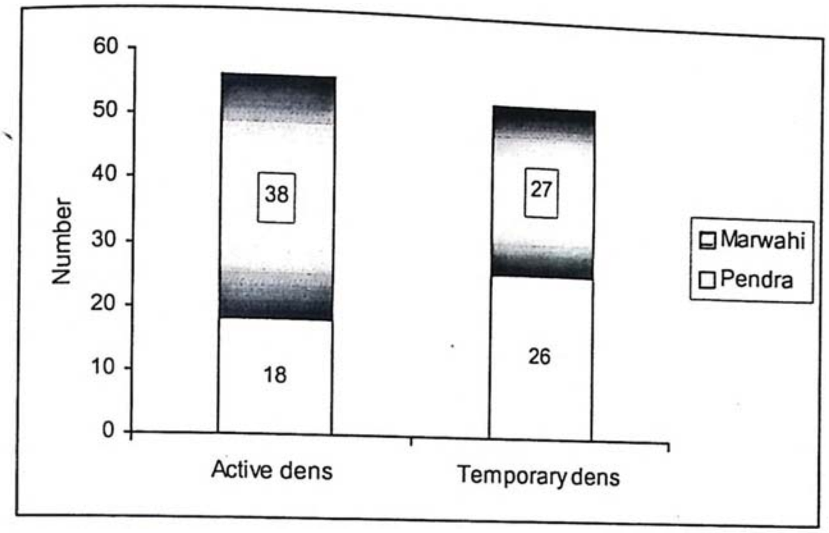


Table 1. Abundance of bear digging signs and scats in different habitat types in NBFD.

Habitat type	No. of plots	No. of plots with digging & scats	No. of diggings/ha	No. of scats/ha
Mix forest	114	55	17.13	3.63
Sal forest	54	38	35.98	3.15
Sal mix	55	28	17.37	0.58
Crop field	25	7	7.22	1.70
Scrub land	88	28	9.89	1.33
Open land (Blank)	25	7	7.64	3.4
Water bodies	15	9	18.4	2.12
Plantation	14	8	9.86	0
Total	390	180		

Table 2. Number and sex class of bears observed at selected den sites.

S. No.	Den sites and their location	Males	Females	Cubs	Unidentified	Total count
1	Pundi dongri, Tauli	2	1	2		5
2	Jhandi dongri, Masurikhar	1	3	1		5
3	Amli dongri, Chuabahra	1	2		3	6
4	Lamra dongri, Ghusariya	2	2	2	3	9
5	Ladara dongri, Jhirna Pauri	2	1	1	1	5
6	Niranjan Kharil, Jhirna Pauri	2			3	5
Total		10	9	6	10	35

Table 3. Projection of bear population in NBFD based on bear count at den sites.

	Population		Test of significance		Population estimate
	Mean	Standard error (SE)	T-value (p>0.05)	Confidence limit (L)	(No. ± SE)
All bears	5.83	0.65	2.45	1.60	326 ± 90
Male	1.67	0.21	2.45	0.52	93 ± 29
Female	1.80	0.37	2.57	0.96	100 ± 53
Cubs	1.50	0.29	2.78	0.80	84 ± 45
Unidentified	2.5	0.5	2.78	1.39	140 ± 78

Appendix 1. List of active and temporary den sites in NBFD.

Code No.	Name of den sites	A/T	Code No.	Name of den site	A/T
1	Bhal Marhia	T	56	Khanta dongri.a	A
2	Chandli dongri	T	57	Khanta dongri.b	T
3	Bharhi dongri	A	58	Khanta dongri.c	T
4	Bamngarh dongri	T	59	Akhta dongri	T
5	Baghathore dongri	T	60	Khirwa Pahar	T
6	Laridhaba dongri	T	61	Golpitta dongri.a	A
7	Pakariya dongri.a	T	62	Golpitta dongri.b	T
8	Pakariya dongri.b	T	63	Piperya dongri.c	T
9	Pakariya dongri.c	T	64	Piperya dongri.d	T
10	Pakariya dongri.d	T	65	Hathipat dongri.a	T
11	Pakariya dongri.e	T	66	Kuchdhowa dongri.a	T
12	Pakariya dongri.f	T	67	Bhalu wali dongri	A
13	Pakariya dongri.g	A	68	Parkhuri dongri.a	T
14	Thar Pathra dongri	A	69	Majhuraha dongri	T
15	Bagh Marhia dongri	T	70	Jhandi dongri.	A
16	Thuha dongri	A	71	Chandeli dongri	A
17	Kariha dongri	T	72	Surungtola dongri	T
18	Bagh marhia dongri	T	73	Dhanpur dongri.a	A
19	Chitwahi dongri	T	74	Dhanpur dongri.b	T
20	Lachi dongri	A	75	Dhobhar dongri	T
21	Khorra baba dongri	T	76	Latkeni dongri	A
22	Amli dongri	A	77	Tendu Choti dongri	A
23	Rekhi dongri	A	78	Tendu Badi dongri	A
24	Khurpa dongri	T	79	Baijarah dongri	A
25	Khurpa dongri	T	80	Sahes dongri	T
26	Bhurbusi dongri	T	81	Papiyara dongri	T
27	Raksha dongri	T	82	Chana dongri	A
28	Amli dongri	A	83	Dhadhol mara	A
29	Demha dongri	T	84	Karhanhia dongri	A
30	Baniga dongri	A	85	Baghmara dongri	A
31	Baghdavri dongri	T	86	Davakol dongri	A
32	Ghundi dongri	A	87	Mahra bahra dongri	A
33	Jaldi dongri	A	88	Litya Sarai dongri	A
34	Panika dongri	A	89	Mendra murhi dongri	A
35	Jogi dongri	A	90	Bhasbhiri dongri	A
36	Talwa dongri	A	91	Gazal dongri	A

37	Chitwahi dongri	T	92	Dwari dongri	T
38	Gidhlai dongri	A	93	Chipti Pahar	T
39	Chitwahi dongri	A	94	Janta pani dongri	A
40	Dhirwa baba dongri	T	95	Jhandi dongri	A
41	Khilsarii dongri	T	96	Sidh baba dongri	T
42	Bhaluwali dongri	A	97	Marakot dongri	A
43	Ladara dongri.a	A	98	Papiyara dongri	A
44	Niranjan Kharil.b	A	99	Papiyara dongri	T
45	Bhareli dongri.c	T	100	Barghorka dongri	A
46	Kharil dongri.d	T	101	Chitwahi dongri	T
47	Kural dongri	A	102	Kolbira dongri	T
48	Lamra dongri	A	103	Aura dongri	A
49	Ghusariya dongri.a	T	104	Chandul dongri	T
50	Ghusariya dongri.b	A	105	Kolbira dongri	A
51	Ghusariya dongri.c	T	106	Jhandi dongri	A
52	Madwahi dongri	A	107	Kolbira dongri	A
53	Pundi dongri	A	108	Kolbira dongri	T
54	Jhandi dongri	A	109	Chitwahi dongri	T
55	Bhuthi dongri	A			

A= Active den site   T= Temporary den site (Used occasionally)

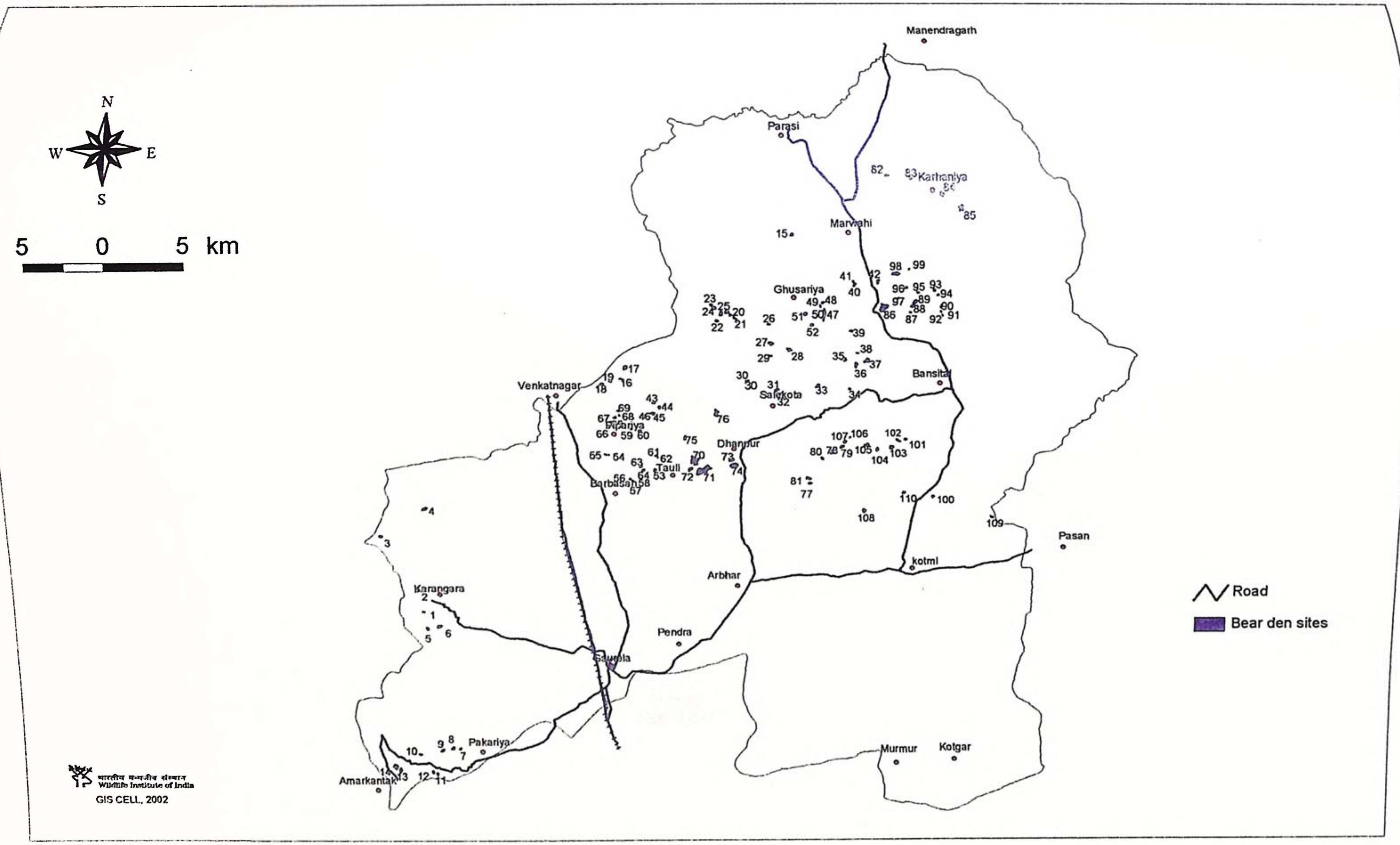
Appendix 2. Location of bear den sites.

Forest compartment No.	Den ID	Den location (Nearest village)
UN	75	Dhobhar
UN	76	Latkeni
UN	77, 81	Silpahri
UN	108	Kolbira
RL	110	Patharra
RL	34	Ratga
UN	30	Karsiwa
RL	42	Pandripani
RL	40,41	Kumhari
RL	82	Chanadongri
RL	83	Rajarani
1074	109	Damdam
1241	7,8,9	Pakariya

1242	10	Pakariya
1243	11,12,13, 14	Pakariya
1249	1,2,5,6	Karangara
1255	3	Saleghore
1259	4	Chirlioti
1264	84,85	Karhaniya, Katra
1266	98, 99	Marakot
1268	86, 87,88,89,97	LityaSarai
1269	93, 94, 95, 96	Marakot, Chilhan
1270	90,91,92	Litya Sarai
1279	100	Matiadand
1328	73, 74	Dhanpur
1329	70, 71,72	Mashurikhar
1330	61, 62	Tauli
1331	56, 57, 53	Tauli
1332	55, 54	Barbasan
1333	63, 64	Pipariya
1335	59,60,65,66,67, 68,	Parkhuri
1338	69	Parkhuri
1340	16, 17, 18, 19	Dharmohli
1351	20,21,22,23,24,25	Khurpa, Dharhar
1352	26	Charcheri
1353	27, 28, 29	Chuabahra
1358	43, 44,45,46	Jhirnapanri
1361	31, 32	Salekota
1362	33	Ratga
1368	78, 79, 80	Silpahri
1369	104, 105, 106, 107, 101, 102, 103	Bhagarra
1371	37, 38, 39	Sachratola
1372	35, 36	Ratga
1375	47	Ghusariya
1376	48, 49, 50, 51, 52	Ghusariya
1382	15	Bahutadol,

UN= Unknown, RL= Revenue land

Map 1: Distribution of bear den sites in North Bilaspur forest division.



Map 1 showing distribution of different bear den sites.

Code No.	Name of den site	Code No.	Name of den site
1	Bhal Marhia	56	Khanta dongri.a
2	Chandli dongri	57	Khanta dongri.b
3	Bharhi dongri	58	Khanta dongri.c
4	Bamngarh dongri	59	Akhta dongri
5	Baghathore dongri	60	Khirwa Pahar
6	Laridhaba dongri	61	Golpitta dongri.a
7	Pakariya dongri.a	62	Golpitta dongri.b
8	Pakariya dongri.b	63	Piperya dongri.c
9	Pakariya dongri.c	64	Piperya dongri.d
10	Pakariya dongri.d	65	Hathipat dongri.a
11	Pakariya dongri.e	66	Kuchdhowa dongri.a
12	Pakariya dongri.f	67	Bhalu wali dongri
13	Pakariya dongri.g	68	Parkhuri dongri.a
14	Thar Pathra dongri	69	Majhuraha dongri
15	Bagh Marhia dongri	70	Jhandi dongri.
16	Thuha dongri	71	Chandeli dongri
17	Kariha dongri	72	Surungtola dongri
18	Bagh marhia dongri	73	Dhanpur dongri.a
19	Chitwahi dongri	74	Dhanpur dongri.b
20	Lachi dongri	75	Dhobhar dongri
21	Khorra baba dongri	76	Latkeni dongri
22	Amli dongri	77	Tendu Choti dongri
23	Rekhi dongri	78	Tendu Badi dongri
24	Khurpa dongri	79	Baijarah dongri
25	Khurpa dongri	80	Sahes dongri
26	Bhurbusi dongri	81	Papiyara dongri
27	Raksha dongri	82	Chana dongri
28	Amli dongri	83	Dhadhol mara
29	Demha dongri	84	Karhanhia dongri
30	Baniga dongri	85	Baghmara dongri
31	Baghdavri dongri	86	Davakol dongri
32	Ghundi dongri	87	Mahra bahra dongri
33	Jaldi dongri	88	Litya Sarai dongri
34	Panika dongri	89	Mendra murhi dongri
35	Jogi dongri	90	Bhasbhiri dongri
36	Talwa dongri	91	Gazal dongri

37	Chitwahi dongri	92	Dwari dongri
38	Gidhlai dongri	93	Chipti Pahar
39	Chitwahi dongri	94	Janta pani dongri
40	Dhirwa baba dongri	95	Jhandi dongri
41	Khilsarii dongri	96	Sidh baba dongri
42	Bhaluwali dongri	97	Marakot dongri
43	Ladara dongri.a	98	Papiyara dongri
44	Niranjan Kharil.b	99	Papiyara dongri
45	Bhareli dongri.c	100	Barghorka dongri
46	Kharil dongri.d	101	Chitwahi dongri
47	Kural dongri	102	Kolbira dongri
48	Lamra dongri	103	Aura dongri
49	Ghusariya dongri.a	104	Chandul dongri
50	Ghusariya dongri.b	105	Kolbira dongri
51	Ghusariya dongri.c	106	Jhandi dongri
52	Madwahi dongri	107	Kolbira dongri
53	Pundi dongri	108	Kolbira dongri
54	Jhandi dongri	109	Chitwahi dongri
55	Bhuthi dongri		

Plate - 1

1. **Sloth bear searching for ground termites nest.**

2. **Sloth bear feeding on red ants on a broken branch.**

Plate - 2

3. Bears scats in Mix forest near Marakot village.

4. Claws marks of bear on a saleha tree on the edge of Mix forest near Chuabahra village.

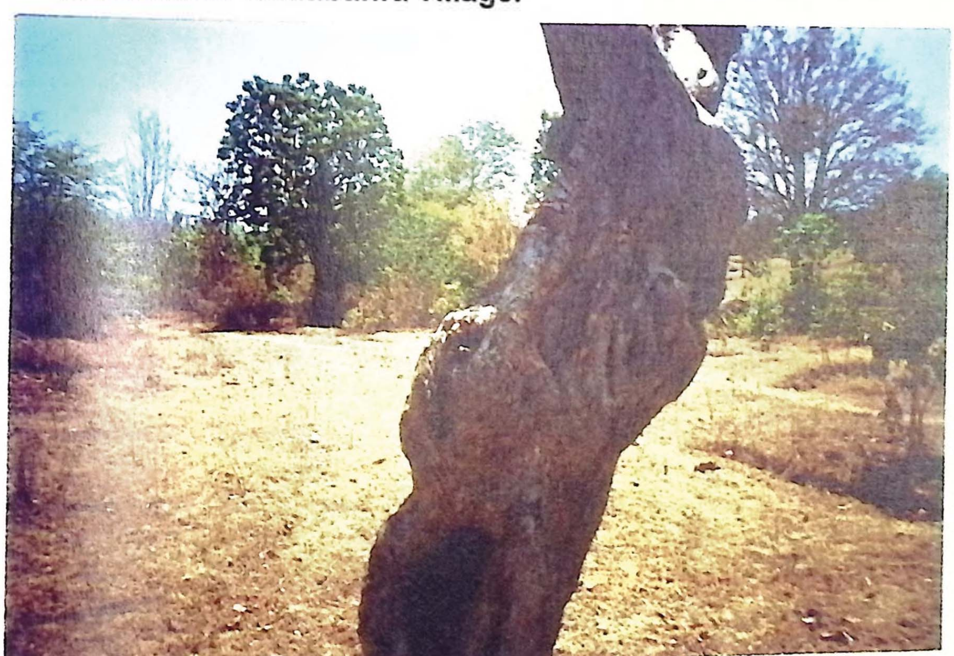
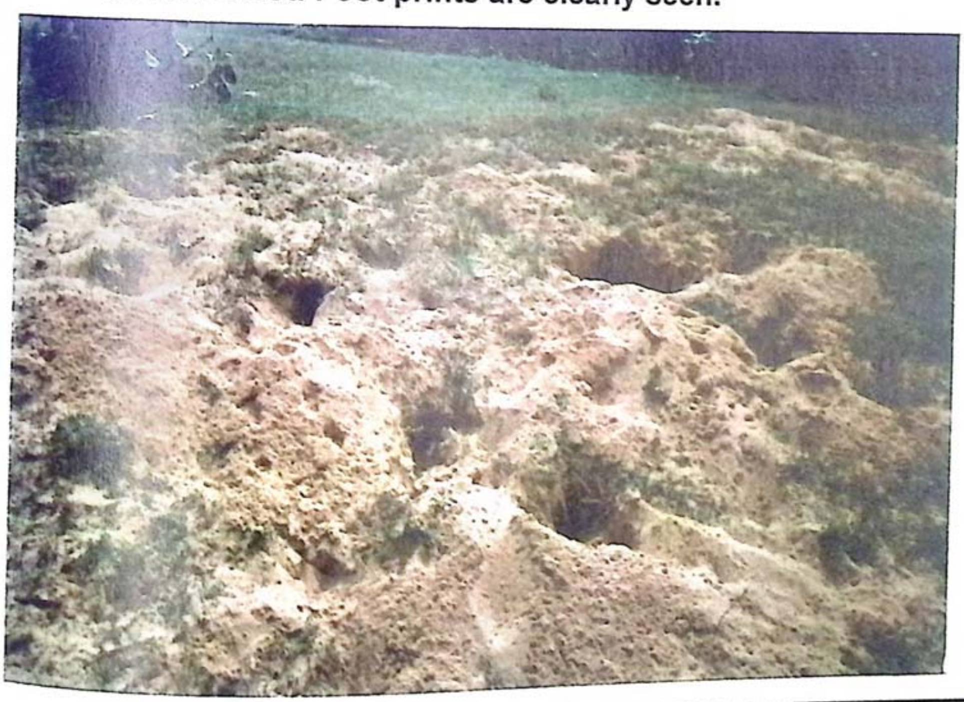


Plate - 3

5. Digging of soil by bear to feed on termites. Claw marks are clearly seen.

6. Multiple diggings by bears on the bank of a nullah in search of termite nest. Foot prints are clearly seen.



Chapter VII. Habitat use and Ranging pattern of sloth bear using Radio-telemetry

7.1.0. Introduction

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). Despite the specific myrmecophagus habits, sloth bear is omnivorous but highly prefers the vegetarian diet especially fruits (Gopal, 1991). Studies on movement pattern and home range of sloth bear showed that the home range size was mainly dependent on the food supply (Joshi *et al.,* 1995; Desai *et al.,* 1997 and Yoganand, 1998 and 2001). Depletion of natural habitat and expansion of human habitation and agriculture establishment have greatly impacted the movement and habitat utilization of sloth bear (Chauhan *et al.,* 1999). Out of 12 landuse types, 8 foraging habitats were identified within the range of sloth bear in Pendra and Marwahi ranges of NBFD. Relationship between denning and movement pattern showed the little variation with latitude and area of black bear (Ferguson *et al.,* 2001). Black bear and grizzly bear are known to dig dens and using natural excavations or depressions for living. But information on denning of sloth bear is scarce.

No systematic information is available on the denning, movement pattern and home range, and territoriality of sloth bear thriving in man-altered disturbed and fragmented forest areas. How the increasing biotic pressure is affecting sloth bear habitat and its population in these areas is also not known? The study therefore envisages to assess the habitat use pattern and ranging pattern of sloth bear in North Bilaspur forest division, where the available sloth bear habitats are highly disturbed and fragmented.

7.2.0. Methods

To study the habitat use and ranging pattern of sloth bear, the following methods using radio-telemetry have been used in Pendra and Marwahi ranges of NBFD.

7.2.1. In the study area, vegetation showed high degree of heterogeneity because of patchiness and fragmentation of forests, encroachment and high biotic pressure. After the reconnaissance survey, 78 linear transects were laid in various habitat types viz. Mix forest, Sal forest, Sal mix forest, Crop field, Scrub land, Open land, Land near to water bodies and Plantation in the two ranges as described in Chapter IV. Along each transect of 1 km length, five sampling plots of 10 m radius with 250 m interval were laid. Indirect evidences such as digging, scats and claw marks were recorded from within 390 plots on 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, termite mound, nearest water source, distance from the nearest den, cattle dung, distance from the habitation and disturbance from the road etc. was recorded from within these sample plots and transects. Tree canopy and stand heights of trees were measured using Densiometer and Range measuring system respectively. The data of each sampling plot was pooled as per habitat type for analysis. Bear sighting along the transects on the either sides and habitat type of bear location were recorded for estimation of bear abundance.

7.2.2. From the vegetation data of different sample plots, assessment of fruiting tree species and their abundance in each habitat type was calculated. The fruiting trees 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 some of these species with ≤ 30 cm GBH were considered as shrub. Density of fruiting trees growing in the vicinity of villages was also estimated using plot less sampling method i.e. nearest ten tree method (Kent and Coker, 1992). Identification of fruiting trees of bear diet was ascertained on the basis of analysis of scats, collected from the two ranges.

7.2.3. To study the ranging pattern, radio-collared bears were tracked twice in a month through homing in location from the emerging of bears from the dens and till their return following the method of White and Garrot (1990). Each bear location was taken at the interval of 30 minutes and activities of bears were recorded. The radio-location data was converted to Universal Transverse

Mercator (UTM) coordinates and used for estimating the home ranges. Hundred percent Minimum convex polygon (MCP) obtained by ten cumulative sequential samples versus number of locations were plotted to determine appropriate sample size of radio locations for home range estimation as followed by White and Garrot (1990) and Harris *et al.* (1990). Ninety five percent Minimum convex polygon was used for estimating home ranges (Mohr, 1947; Southwood, 1966 and White and Garrot, 1990) using computer software CALHOME (Kie, 1994). Home ranges and areas of the utilization were computed in ARCVIEW software (1996).

7.2.4. Indian Remote Sensing Satellite imagery (IRS- IB/LISS II B, 1996) was used for analysis of availability and use of different habitats. Habitats were delineated based on unsupervised classification, followed by supervised classification and ground truthing. Area of different habitats together within the 100% MCP of each bear was considered as available habitats. Radio-locations were plotted in the classified imagery and their percent frequency in each habitat category was computed and considered as used habitats. Compositional analysis (Aebischer *et al.*, 1993) was used to determine habitat preference for collared bears. For compositional analysis, log ratios for all habitat pairs used rows as the numerator and columns as the denominator. For the similarity of signs of the ratios were used for interpretation. As rows of signs indicated the habitat that was utilized more than others (signs indicated the reverse). Aebischer *et al.* (1993) transformed the total available and utilized (MCP home range) habitat composition to log ratios y_0 and y using the proportion of scrub as the denominator and then calculated the difference $d=y-y_0$. The code numbers used for various habitat categories viz. Mixed sal (30-60%), Mixed sal (<30%), Scrub land, Dry river course, Rocky out crops, Mixed forest (> 60%), Mixed forest (30-60%), Mixed forest (<30%) and Habitation and agriculture for interpretation of habitat use by collared bears were 4, 5, 6, 7, 19, 20, 24, 25, 26 and 30 respectively. Frequencies of radio-collared of bear 1, bear 2 and bear 5 were 151.51, 151.53 and 151.60 MHz respectively.

To assess the habitat use by sloth bear in NBFD, 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). Radio-locations and equivalent random locations were plotted against 100% MCP area for each radio-collared bear. And then linear regression was drawn at 95% confidence level to assess the habitat use by the collared bears and find whether the bears preferred or avoided particular habitat or used habitat as per the availability. Multi-dimensional scaling, regression analysis, and non-parametric analysis were performed in SPSS Software (Norussis, 1994).

7.3.0. Results

In North Bilaspur forest division, human habitation and agricultural land occupied about 60% of total area, and remaining 40% area had 380 km^2 forests, Rocky out crop, Waste land, Revenue land, Scrub land, Water bodies and Plantation etc. Habitat use by sloth bear in North Bilaspur forest division was assessed based on direct sighting of bears, indirect evidences and ranging pattern of radio-collared bears.

7.3.1. Fruiting trees vs habitat use

Since the habitat use by bear will largely depend on the availability of food resources and shelter, number of fruiting tree and shrub species were counted in various habitat types. Fruiting tree species counted in these habitat classes were amaltas (*Cassia fistula*) sitaphal (*Anona squamosa*), gular (*Ficus racemosa*), bargad (*F. bengalensis*) pakri (*F. virens*), peepal (*F. religiosa*), bel (*Aegle marmelos*), char (*Buchanania lanzan*), jamun (*Syzygiym cummini*), kusum (*Schleichera oleosa*), mahua (*Madhuca indica*), tendu (*Diospyros melanoxylon*) and mango (*Mangifera indica*) (Table 1). Among all habitat types, average fruiting tree density was estimated 37.55 per hectare. The fruiting tree species and density per hectare was highest in Sal mix forest (8 species, 72.96/ha), followed by Sal (6 species, 60.16/ha), Mix forest (12 species, 55.03/ha), Land near to water bodies (6 species, 36.09/ha), Scrub land (11 species, 26.42/ha) and Crop field (2 species, 7.64/ha). The density was lowest in Plantation (1 species, 4.55/ha). These densities of preferred fruiting trees in different habitat types were very low as compared to the overall tree density i.e.

202.39 per hectare in the study area (Cited in the Chapter IV). As many as 30 food items were found in 1086 scats. Gular, pakri, bargad, peepal, ber, bel, jamun and mahua were the main food items of the bear diet based on the scat analysis. As many as 4 species of fruiting plants were observed in a plot. One hundred fourty seven plots (37.7%) were without any fruiting species. Generally one or two fruiting species were found in the plots with bear evidences (Table 2). The average shrub density was estimated 727.31 per hectare among various habitat types (Table 3). Fruiting shrub species found in these habitat types were amaltas (*Cassia fistula*), sitaphal (*Anona squamosa*), gular (*Ficus racemosa*), bargad (*F. bengalensis*), pakri (*F. virens*), peepal (*F. religiosa*), bel (*Aegle marmelos*), char (*Buchanania lanzan*), jamun (*Syzygiym cummini*), kusum (*Schleichera oleosa*), mahua (*Madhuca indica*), tendu (*Diospyros melanoxylon*), mango (*Mangifera indica*), makar tendu (*Diospyros malabarica*), jangli ber (*Ziziphus nummularia*), makoiya (*Z. oenoplia*), kasai (*Briedelia squamosa*), reul (*Mimusops elengi*) and bihi (*Psidium guajawa*). Maximum shrub density was found in Sal mix (1278.52/ha), followed by Sal (948.34/ha), Mix forest (885.02/ha), Open land (810.19/ha), Scrub land (735.38/ha), Land near to water bodies (560.51/ha), Plantation (473.16/ha) and Crop field (127.39/ha). Out of all fruiting shrub species found in different habitat types, only two species viz. jangli ber and makoiya were important species of bear diet. Both the plants were exclusively distributed in forests; makoiya was mainly found in the Mix forest and Scrub land, whereas jangli ber *was* found growing in Plantation, followed by Sal mix, Land near to water bodies, Sal mix forest and

Mix forest. The Sal mix forest, Sal and Mix forest with high fruiting tree and shrub density showed increased use of these habitats based on indirect evidences (diggings and scats) of bears. Average fruiting tree density in the vicinity of villages was about 5 per hectare.

Availability of fruiting trees and other food items: amaltas, sitaphal, gular, pakri, gusti, bel, char, jamun, kusum, Mahua, tendu, makar tendu, jangli ber, makoiya, kasai, reul, bihi, honey and bees (*Apis dorsata* and *A. indica),* termites *(Cyclotermes obesus),* black ant *(Camponotus* sp.*), beetles,* red ant *(Solenopsis* sp.*),* maize *(Zea mays)* and sweet potato (*Ipomea batatas*) in the forests and village sites is shown in Table 4. There were some fruiting species and food items found both in the forests and villages, whereas few species were specific to either forests or villages as well. In forests and villages, 17 fruiting trees and food items were commonly distributed, whereas 7 and 6 feeding items were specifically available in forests and villages respectively.

7.3.2. Habitat use by sloth bears

The data on habitat use by sloth bear collected from the 390 sample plots along the transects showed maximum number of plots in the Mix forest habitat category (114), followed by Scrub land (88), Sal mix (55), Sal (54), Crop field (25), Open land (25), Land near to water bodies (15) and Plantation (14). Hence the proportional availability was highest in Mix Forest (0.297), followed by Scrub land (0.226), Sal mix (0.141), Sal (0.138), Crop field (0.64), Open land (0.64), Land near to water bodies (0.38) and Plantation (0.36). As such there was no preference or avoidance by bear for any habitat.

Number of diggings per hectare was observed highest in Sal forest (35.98), followed by Land near to water bodies (18.8), Sal mix forest (17.37), Mix forest (17.13), Scrub land (9.89), Plantation (9.86), Open land (7.64) and Crop field (3.4) (Table 5). Out of 78 transects, bear evidences were found along 76 transects. In Mix forest, Sal forest and Open land, average 3.63, 3.15 and 3.4 scats per hectare respectively were recorded. Average number of diggings and scats in various habitat types were 16.69/ha and 2.29/ha respectively, whereas average number of diggings and scats per transect was 20.40 and 9.88 respectively.

The Goodness of fit comparison showed that expected utilization in each habitat category differed significantly from the occurrence of habitat categories within the study area (χ^2=15.71, df=7 p=0.05). The null hypothesis was therefore rejected, implying that observed bear evidences were not distributed proportionally to the occurrence of habitat categories. Open land and Crop field habitat categories were used less than expected, whereas other habitat categories were utilized more than expected. 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, they visited forest areas more.

7.3.3. Use of terrain

Various terrain types such as flat, undulating, gentle slope and steep slope were found to be differentially used by bears based on the indirect evidences. The proportional availability of undulating terrain was highest (0.556) as compared to gentle slope (0.279), flat (0.136) and steep slope (0.028) (Table 6). Expected use of terrain was highest for undulating (100.154) followed by gentle slope (50.308), flat (24.46) and steep slope (5.07). Following hypothesis was tested using the Chi square test: 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 (χ^2=1.27, df=3, p=0.5) 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 (Table 6). There was neither any preference nor avoidance by bears for any type of terrain. Bear used certain category of terrain for specific purpose. Most of the bear den sites were situated in the hillocks. Occasionally, bears were found to den along the rivers and drainages during summer season. Spaces in between the boulders of rocks were found to provide good shelter for bears. In Pendra and Marwahi ranges, most of the area was found to be either undulating or flat interspersing with the chain of hillocks. For denning, bear used gentle to steep slope, whereas the undulating or flat terrain was used as feeding ground.

7.3.4. Use of water bodies

In Pendra and Marwahi ranges, most of the areas have underground rocks. Digging of such soil was difficult for harbouring water. Only the Son river flows through the study area, but it dries up in summer season. People have traditional method of harvesting rain water by digging ponds and constructing check dams. They use the collected water throughout the year. There were number of small ponds in the vicinity of different villages and few check dams constructed in the large catchment area. Water availability for bears was in plentiful throughout the study area. About 77% of the den sites had the water accessibility within the limit of 500 m (Table 7). At many places, river sand beds wère dug by bears for drinking water.

7.3.5. Location and use of den sites

We identified 109 den sites in Pendra and Marwahi ranges. Bears regularly used more than 51.38% den sites, whereas rest were used occasionally (Table 8). More than 96.33% den sites used were located within the limit of 1250 m from the human habitation. Bears were mostly occupying den sites located within 1 km range from human habitation.

Generally, number and size of dens is correlated with the size of hillock. One small hillock could be identified as unit of den, and large hillock was found to have more than one den in between boulders. There were number of compartments in between boulders and outlets (openings) to provide shelter to many bears and other animals. For example, a den site on outskirts of Tauli village in Marwahi range was shared by leopard, hyena, jackal and sloth bears, and there was no competition and territoriality collapse. Most of the den sites were located in the large hillocks, and few were in small hillocks.

7.3.6. Digging of termite mounds

Termite (*Cyclotermes obesus*) acts as one of the favourite and regular food item of sloth bear. Density of termite mounds was estimated per hectare in different habitat types. There were two types of termite nests; one was underground nest and it was very difficult to make out from outside, whereas second type was prominent mound varying from small to large size. Along the nullas and river bank, we found large number of diggings of termite mounds. There were numerous underground termite nests along the water bodies, but because of their small colony size, bears preferred the open termite mounds more. Once dug by bear, termites were not eliminated completely; termites recovered very quickly and built their nests again. Number of diggings per hectare was observed highest in Sal forest (35.98), followed by Land near to water bodies (18.8), Sal mix forest (17.37), Mix forest (17.13), Scrub land (9.89), Plantation (9.86), Open land (7.64) and Crop field (3.4). Some transects were laid especially along the nullah and rivers with the assumption that bears might be using these areas along the water bodies, and it was found true. Although highest density of termite mounds were found in Land near to water bodies (33.97/ha) and Plantation (27.3/ha), but proportionally the habitats covered small areas (Figure 1). Other habitat categories: Sal mix forest, Mix forest and Sal forest had 21.42, 19.83 and 17.69 termite mounds per hectare respectively. Average density of termite mounds in various habitat types was 16.35 per hectare.

7.3.7. Two dimensional scaling of habitat variables

Two dimensional scaling (Norussis, 1994) of habitat variables available in the bear habitats showed that bear evidences were more in the areas located at considerable distance from villages and den sites, which had high vegetation cover (canopy, tree species richness, fruiting tree species richness, tree height, shrub cover and herb cover), and availability of food. Interestingly, the habitats used by bears had more signs of biotic pressure i.e. cut trees, fell trees and cattle grazing. It showed that bears preferred to use thick vegetation cover with more fruiting trees and termite mounds (Table 9 and Figure 2).

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

We assessed two hypotheses; first was that all the habitat variables were evenly distributed in used and unused areas by bear i.e. null hypothesis (H_0), and second was that habitat variables were not evenly distributed in the areas where bear signs were present and absent i.e. Alternative hypothesis (H_A). Chi-square values were significant for forest types, tree species richness, fruiting tree species richness, lopped trees, fell trees, tree height, tree canopy, shrub cover, distance from habitation, cattle dung, distance from den and termite mounds. This proved that these variables were not same in areas where bear signs were present or absent. This rejects the Null hypothesis (H_0) and accepts the Alternative hypothesis (H_A). Whereas for the terrain, herb cover and distance from water source, Chi-square value was not significant. This showed that these habitat variables were almost same in the areas where bear signs were present or absent (Table 10). Availability of water and herb cover did not discriminate the bear presence or absence. Therefore null hypothesis has been accepted.

7.3.9. Logistic regression model for habitat utilization by bear

Can probability of habitat utilization or avoidance by bears be made on the basis of habitat variables present on the used plot or unused plot? It was checked using logistic regression model; this model classified the data sets of utilized and avoided plots up to 66.92% correct (Table 11). This showed that upto 67 percent utilization of habitats by animal could be predicted on the basis of habitat variables present in the used and unused plots.

7.3.10. Habitat use by radio-collared bears

Three bears were radio-collared and the habitat use by them was studied using the compositional analysis. For the compositional analysis, 100% MCP area was used to determine habitat preference by all the three bears. The extent of area used by bear 1 (male) and bear 5 (male) was almost the same i.e. 30.22 km^2 and 31.02 km^2 respectively, whereas bear 2 (female) used only 11.34 km^2 (Map 1). The male bears covered larger areas, utilizing different habitat types. The MCP area at 100% was plotted against the total radio-locations and their matrix was prepared.

Bear 1 highly preferred the Mix sal (< 30%), followed by Dry river course and then Habitation and agriculture. The order of preference for different habitat types was observed as Mix sal (< 30%) > Dry river course > Habitation and agriculture > Mix forest (< 30%) > Scrub land > Mix forest (30-60%) > Mix forest (> 60%) > Mix sal (30-60%) > Rocky outcrop (Figure 3). One-way Anova showed that utilization of each habitat category was significantly different to each other (F=11.11, df=9, P=0.001). The regression analysis at 95% confidence level between radio-locations versus random locations against MCP revealed that bear 1 (male) utilized different habitats as per their proportional availability (Figure 4).

Rocky outcrops was maximally utilized by bear 2, followed by Habitation and agriculture and Scrub land. The order of preference was observed as Rocky outcrop > Habitation and agriculture > Scrub land > Mix forest (> 60%) > Mix forest (< 30%) (Figure 5). One-way Anova test showed that utilization of each habitat category was significantly different to each other (F=7.2, df=5, P=0.001). Regression analysis at 95% confidence level between radio-locations versus random locations against MCP revealed that bear 2 (female) preferred Rocky outcrop and Habitation and agriculture more than the proportional availability (Figure 6).

Bear 5 also preferred Rocky outcrops maximum. The order of preference of habitat use was observed as Rocky outcrops > Dry river course > Mix forest (< 30%) > Habitation and agriculture > Scrub land > Mix forest (30-60%) > Mix sal (30-60%) > Mix sal (> 60%) (Figure 7).

One-way Anova test showed that utilization of each habitat category was significantly different to each other (F=11.11, df=9, P=0.001). Regression analysis at 95% confidence level between radio-locations versus random locations against MCP revealed that bear 5 avoided Mix sal (> 60%), Mix sal (30-60%), Mix forest (> 60%), and Mix forest (30-60%). Rocky outcrops, Scrub land and Habitation and agriculture were used more than the proportional availability (Figure 8).

7.3.11. Ranging pattern of sloth bears

In Pendra and Marwahi ranges, the radio-collared bears and other bears inhabiting den sites in different areas were found to use available habitats without showing any territorially. Movement of radio-collared male and female bears was monitored in distant areas having live den and occupied by other bears. The radio-collared bear 1, bear 2 and bear 5 covered large home ranges at 100% MCP i.e. 30.22 km^2, 11.34 km^2 and 31.02 km^2 (Table 12 and Map 1). Whereas the home range of bear 1, bear 2 and bear 5 at 95% confidence level was 22.33 km^2, 7.8 km^2 and 20.01 km^2 respectively.

Since *CALHOME (Kie, 1994)* software could use radio-locations differently for analysis, the home ranges were smaller at 95% confidence level in comparison to 100% MCP home ranges estimated in ArcView 3.1 software extension (ArcView, 1996). The seasonal variation in home ranges and habitat use of radio-collared bears are shown in Table 13. The home range of bear 1 covered 18.82 km^2, 13.87 km^2 and 18.47 km^2 in winter, monsoon and summer season respectively, which were smaller than the annual home range i.e. 22.33 km^2 (Map 2). The area covered by this bear during winter and summer was almost the same. The male bear 5 had the home range of 11.79 km^2, 17.23 km^2 and 6.5 km^2 in winter, monsoon and summer seasons respectively, which were much smaller than the annual home range of 20.01 km^2 (Map 3). Larger area was covered by the bear during monsoon than the winter and summer. The female bear 2 showed the seasonal home range 7.94 km^2, 3.84 km^2 and 5.27 km^2 in winter, monsoon and summer seasons respectively (Map 4). The bear covered larger area during winter in comparison to monsoon and summer. The female covered very small area during monsoon i.e. 3.84 km^2.

During winter and summer months, bears were mainly observed feeding on fruits, and in monsoon season, bears mainly feed on termites and black ants. In search of food, bears covered larger areas during nights without any disturbance and threats. Irrespective of seasons, the bears largely used Habitation and agriculture, Rocky outcrops, Dry river course, Scrub land, Sal, Sal mix and Mix forest habitat categories. All the collared bears were found ranging more in the Scrub land, followed by Habitation and agriculture during winter, monsoon and summer months. The male bear 1 covered almost the same area during winter (18.82 km^2) and summer (18.47 km^2). The area covered by this bear during monsoon was 13. 87 $km^{2.}$ The predominant use of Scrub land and Habitation and agriculture by the bear was 12.4 km^2 and 3.64 km^2 respectively during winter, 12.63 km^2 and 3.28 km^2 respectively during summer and 8.34 km^2 respectively and 3.39 km^2 during monsoon. There was not much variation in the use of rest of the habitats viz. Mix sal, Mix forest, Dry river course, Rocky outcrops, Water bodies and Riparian area. The male bear 5 predominantly used Scrub land, Habitation and agriculture and Mix forest (30-60%) upto 4.45 $km^{2,}$ 2.78 km^2 and 2.0 km^2 respectively during winter, and 6.74 km^2, 4.29 km^2 and 2.28 km^2 respectively during monsoon, and 2.97 km^2, 1.89 km^2 and 0.18 km^2 respectively during summer. The female bear covered maximum area. The female bear predominantly used Scrub land and Habitation and agriculture upto 4.16 km^2 and 1.84 km^2 respectively during winter, 2.31 km^2 and 1.1 km^2 respectively during monsoon and 2.50 km^2 and 1.15 km^2 respectively during summer. The male bears changed their den sites a few times, but female permanently occupied its den and never moved away. Movement pattern of these bears was correlated with the availability of food and shelter in NBFD.

7.4.0. Discussion

In the Pendra and Marwahi ranges of NBFD, the forests are highly disturbed, fragmented and interspersed with human habitation and agricultural areas (Plate 1 & 2). Due to continuous encroachment on forest land and increasing biotic interference for collection fuelwood and non-timber forest produce, livestock grazing and land mining, sloth bear population has been ecologically dislocated. All these factors together might have adversely impacted the habitat use and ranging pattern of sloth bears in these areas. The proportional habitat availability to sloth bears in NBFD was highest in Mix forest, followed by Scrub land, Sal mix, Sal forest, Crop field, Open land, Land near to water bodies and Plantation. But as such the expected utilization of the habitat categories differed significantly from their occurrence in the study area. The relation between utilization and availability of brown bear habitat features using six variables was compared by testing the hypothesis i.e. bears use habitats in proportion to their availability. Brown bears preferred forested habitats and used beech (*Fagus sylvatica*) and durmast (*Quercus petraea*) oak forests in greater proportion than their availability (Clevenger *et al.*, 1992). The habitats 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, wet seeps, wet meadows, and alpine slab rock (Servehen, 1983). 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). The indirect evidences in different available habitats revealed that sloth bears were generalistic as far the habitat use was concerned. There was no preference or avoidance of any habitat type, although more evidences were found in Sal forest habitat followed by Land near to water bodies, Sal mix and Mix forest. Bear signs in the Land near to water bodies habitat were more because of occurrence of large number of underground termite nests and softness of the soil, which provided the preferred food item to bears. As indirect bear evidences were recorded only in 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, they spent considerable time in forest areas. 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).

High density of fruiting tree species in Sal mix forest, Sal forest and Mix forest might be attracting more and more bears in these habitats, and due to which there were high abundance of digging signs and scats in these habitat types. Fruiting trees had many claws marks of sloth bear in Pendra and Marwahi ranges. Signs of black bear presence were common nearby the large trees in the Coastal Plain of North in Carolina (Landers *et al.,* 1979). The fruits of two shrub species makoiya and jangli ber perhaps acted as preferred component of bear diet. Both the plants were exclusively distributed in forests; makoiya *(Ziziphus oenoplia*) was mainly found in the Mix forest and Scrub land, whereas jangli ber (*Ziziphus nummularia*) *was* found growing in Plantation, followed by Sal mix, Land near to water bodies, Sal mix forest and Mix forest. Availability of fruiting trees and other food items: amaltas, sitaphal, gular, pakri, gusti, bel, char, jamun, kusum, mahua, tendu, makar tendu, jangli ber, makoiya, kasai, reul, bihi, honey and bees (*Apis dorsata* and *A. indica),* termite *(Cyclotermes obesus),* black ant *(Camponotus* sp.*), beetles,* red ant *(Solenopsis* sp.*),* maize *(Zea mays)* and sweet potato (*Ipomea batatas*) in the forests and village sites appear to influence the use of these habitats areas by bears. Certain areas with bear signs were without any fruiting trees. Presence of bear signs could also be correlated with bears feeding on termites or their movement across these areas. Many feeding items were available both in forests as well as in the vicinity of villages, whereas a few food items were exclusively found either in forests or villages. Frequent use of human habitation might be due to availability of more feeding items and in around in villages.

Perhaps due to this reason, there were more and more encounters of humans with bear in the vicinity of villages. The availability of fruiting trees in the forests were found predominantly of young classes, and fruit supply was comparatively less. Bears were found to move frequently in villages in search of fruiting trees (Plate 3-Photo 6). During winter and monsoon, bears were increasingly attracted to the villages and crop fields due to availability of ber (*Ziziphus mauritiana*), maize (*Zea mays*) and ground nut (*Arachis hypogea*). Reynold and Beecham (1980) also recorded the movement 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 fruiting time. In Dachigam National Park, black bears were extensively utilizing the forest habitats and were mainly dependent on fruits of *Prunus avium, Morus alba, Quercus robur, and Juglans regia* (Manjrekar, 1989). Most of the areas in Pendra and Marwahi ranges were undulating or flat interspersed with chains of hillocks (Plate 3-Photo 5). Since bear habitats were largely impacted from increasing biotic pressure, bears did not prefer any particular terrain as far as the habitat utilization was concerned.

All the available terrain types: flat, undulating, gentle slope and steep slope were used by sloth bears in proportion to their availability. Bear used certain categories of terrain for specific purpose. Most of the bear den sites were situated in the hillocks. Occasionally bears were found to den along the rivers and drainage during summer season. Spaces in between the boulders of rocks were found to provide good shelter for bears. In general, bear used gentle to steep slope for denning, whereas the undulating or flat terrain was used as feeding ground.

Availability of water was in plentiful throughout the study area. There were number of ponds and check dams in the two ranges, which made the easy availability of water to the bears. Most of the live bear den sites were within the limit of 500 m from the water source. Analysis of variance using Kruskal-Wallis non-parametric test for habitat use indicated that presence of water and herb cover did not discriminate the presence or absence of bears in the study area. Two-dimensional scaling of habitat variables also showed that bears could sustain the biotic pressure on their utilized habitats; bears did not have any option rather than to utilize the available habitats.

In the coastal areas of North Carolina, black bears used bays, swamps and tree cavities for denning (Landers *et al.,* 1979). In Mudumalai wilidlife sanctuary, sloth bear dens were located in dry stream beds (nullas) and rocky outcrops (Desai *et al.,* 1997). Many den sites were dug along the nullas by sloth bears. In Pendra and Marwahi ranges, sloth bears mainly used bouldery rocky outcrops for denning. Although bears were found halting in crevices along stream beds or nullas or other habitats, but they were never found digging dens. The vegetation cover did not appear to influence the use of den sites by bears in Mudumalai wildlife sanctuary. Similarly in NBFD, sloth bears were found to use boulderly hillocks, which were generally with or without vegetation cover. Most of the den sites had moderate to thick vegetation surrounding them. Distribution of bear den in relation to villages showed that most of the den sites were located very close to the human habitation within the limit of 1000 m. As preferred feeding items including agricultural and horticultural crops were available in the vicinity of human habitation, occurrence of live den sites was more in the close proximity of villages. Bears used small boulders to large hillocks for denning, and shared some of the hillocks with leopard, hyena and jackal without any competition.

Density of termite mounds and their diggings in any area might be an indicator of bear presence. In Chitwan National Park, density of termite mounds in the upland sal forest was found to be more as compared to the alluvial flood plains (Joshi *et al.,* 1995). In Pendra and Marwahi ranges, maximum density of termite mounds was found in Land near to water bodies, followed by Plantation, Sal mix, Mix forest and Sal forest. Land near to water bodies with high density of termite mounds was preferred by bears as evident from high density of bear signs in this habitat type. Number of diggings per hectare was observed highest in Sal forest, followed by Land near to water bodies, Sal mix forest, Mix forest, Scrub land, Plantation, Open land and Crop field. Extensive digging of termite mounds in Land near to water bodies, Sal, Sal mix forest and Mix forest habitats was correlated with more utilization of these habitats. Two-dimensional scaling of habitat variables also revealed that bear signs were more in the habitat types, which had many fruiting trees and high abundance of termite mounds.

Habitat data based on indirect bear evidences showed that logistic regression can be used to predict probability of occurrence of bears in the area.

Logistic regression model had classified the habitat variables of used and unused areas upto 67% correct. This indicated on the basis of certain habitat variables, presence or absence of bears could be predicted. Analysis of variance using Kruskal-Wallis non- parametric test for habitat use showed that habitat variables present in used and unused areas of bears were not the same. Heterogeneity of the vegetation was another characteristic in North Bilaspur forest division. Forest cover was patchy and fragmented; so bears were found to cross from one patch to another or one village to another in search of food. Habitat utilization of the radio-collared sloth bears showed that bears maximally used the Habitation and agriculture, Scrub land and Dry river course habitats, followed by Sal and Mix forest. One male and female preferred Rocky outcrops to maximum level. Habitat use based on compositional analysis clearly showed that Mix sal (< 30%) got the maximum rank for the utilization by bear 1, followed by Dry river course and Habitation and agriculture habitat categories. Regression plotted between random and radio-locations revealed that there was as such no preference or avoidance of any habitat, and use of different habitats was generalized. Whereas Rocky outcrops got the maximum rank for the utilization by bear 2, followed by Habitation and agriculture, Scrub land and Mix forest (> 60%). Regression plotted between random and radio-locations revealed that Rocky outcrops and Habitation and agriculture were most preferred habitats by the female. Habitat use based on compositional analysis for bear 5 also showed that Rocky outcrops got the maximum rank, followed by Dry river course, Mix forest (< 30%) and Habitation and agriculture. However, regression plotted between random and radio-locations revealed that Rocky outcrop, Scrub land and Habitation and agriculture habitat categories were preferred by bear 5. Habitation and agriculture habitat was the continuous source of providing feeding items, whereas Rocky outcrops was used as denning area (shelter) by the bears. Hence bears largely used these two habitat types. Similarly, Dry river course with soft soil colonized large number of termite mounds, which was extensively used by sloth bears for feeding on termites.

In Pendra and Marwahi ranges, bear population was not evenly distributed, and certain areas or pockets were not occupied by bears. Uneven distribution and non-occupancy of some areas by bears may be attributed to the availability of unsuitable habitats, no denning areas, and isolation of forest patches or plantations. Bears occupied the areas, which had good den sites and shelter and availability of feeding items in the surroundings.

In Pendra and Marwahi ranges, the radio-collared bears and other bears inhabiting den sites in different areas were found to use available habitats without showing any territorially (Plate 4). Similarly in North-eastern Minnesota, black bear did not show any territorial behaviour (Rogers, 1977). Overlapping of habitat use by radio-collared bears and bears from other den sites and resource sharing in common areas might be due to occurrence of these bears in the disturbed and fragmented forest areas in the study area.

In NBFD, home range of the male bear 1 and 5 was 22.33 km^2 and 20.01 km^2 respectively at 95% confidence limit and 30.22 km^2 and 31.02 km^2 respectively at 100% MCP. Whereas the female showed comparatively smaller home range i.e. 7.8 km^2 at 95% confidence limit and 11.34 km^2 at 100% MCP. The annual home range of male and female bears in Chitwan National Park was to be found 14.4 km^2 and 9.4 km^2 respectively (Joshi *et al.,* 1995). In Mudumalai wildlife sanctuary, home range of two subadult males moved together and a female with two cubs was reported 5.54 km^2 and 19.1 km^2 respectively (Desai *et al.*, 1997). In comparison to myrmecophagous sloth bear, home range of the other ursids was found to be much larger.

In West Central Idaho, home range of female black bear was 16-130 km^2 and male bear was 109-115 km^2 (Amstrup and Beecham, 1976). Range of movement of black bear in North-central Kenai Peninsula, Alaska and grizzly bear in Mission mountains, Montana were correlated with the bear age and sex (Schwartz *et al.*,1983 and, Servheen, 1983). Females covered smaller area than the male bears. Black bear female with cub/yearling and female without offspring covered 4.4-42.8 km^2 and 13- 31.5 km^2 areas respectively, whereas adult male and subadult male covered 40.6-340.8 km^2 and 10.9-20.9 km^2 areas respectively. Home range of 42 km^2 for adult black bear males and 15 km^2 for adult females was observed in the Great Smoky Mountains National Park (Garshelis *et al.,* 1981). In Tangjiahe Natural Reserves, China, home range of an adult male and a subadult male of black bear was 36.5 km^2 and 14.4 km^2 respectively (Reid *et al.*, 1991). Munday and Flook (1973) reported that the area covered by one grizzly bear was between 18.1 km^2 and 28.5 km^2 in the Glacier National Park.

In NBFD, sloth bear did not show much difference in the seasonal pattern of habitat use. During winter and summer season, the male bear 1 covered almost the same area. Monsoon restricted the use of the area by male bear to 13.97 km^2, which was considerably less than areas covered during winter and summer. It was mainly due to drastic reduction of the use of Scrub land by the male bear during monsoon. Except the use of Scrub land and Habitation and agriculture, these was no significant seasonal shifts in the use of different available habitats viz. Mixed sal, Mixed forest, Dry river course, Rocky outcrops, Water bodies and Riparian habitats. In case of male bear 5, summer restricted the use of the area to 6.5 km^2, which was comparatively less than the areas covered during winter and monsoon. It could be due to reduction of the use of Scrub land and Habitation and agriculture during winter and monsoon. Except the Scrub land and Mix forest, there was no seasonal variation in the use of different available habitats. However, the collared female used the area of 3.84 km^2 during monsoon, which was less than the areas covered during winter and summer. It could also be due to drastic reduction of the use of Scrub land and Habitation and agriculture during winter and summer. There were no significant seasonal shifts in the use of different available habitats. The factors influencing the seasonal shifts may be temperature, light conditions, human activity, cattle grazing and more importantly the availability of food items. The habitat use pattern by sloth bear would have been more clear if radio-collaring of more bears was possible. The data obtained from three radio-collared bears was not adequate for the study.

Irrespective of seasons, all the bears largely used Scrub land and Habitation and agriculture habitat categories. The use of these habitats by bears was directly correlated with the availability of food items in NBFD. Food resource availability varied with seasons. Seasonal resource availability during summer was mahua, bel, mango, char, jamun, reul, termites and ants; winter was ber, gular, peepal, pakri, amaltas, bargad termites and ants and monsoon was termites, ants, maize and ground nut (Plate 5).

In Tangjiahe Natural Reserves, China, black bear made distinct range shifts in early autumn to obtain mast food at lower elevations (Reid *et al.*, 1991). Spacing in grizzly bears was also found to be related to distribution of food resources (Servheen, 1983). Similar observations were made by Joshi *et al.* (1995) for sloth bear in Royal Chitwan National Park, where bears showed shift from alluvium habitat to upland sal forest for their food requirement.

In NBFD, the human settlement and agriculture fields occupied about 60% of the total area, and rest of the area showed very little (about 380 km^2) forested areas with all type of forest cover, Rocky outcrops, Wasteland, Revenue land, Scrub land, Water bodies and Plantation.

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Table 1. Fruiting tree density per hectare in different habitat in NBFD.

S. No.	Tree species	Mix forest	Sal forest	Sal mix	Crop field	Scrub land	Land near to water bodies	Plantation
1	*Cassia fistula*	1.96	0.59	1.16	0	2.17	2.12	0
2	*Anona squamosa*	2.23	0	0	0	0.36	0	0
3	*Ficus bengalensis*	0.28	0	0	0	0	0	0
4	*Aegle marmelos*	0.84	0	0	0	1.09	0	0
5	*Buchanania lanzan*	12.85	24.77	24.32	1.27	3.62	2.12	2.27
6	*Ficus racemosa*	0.28	0	0	0	0	8.49	0
7	*Syzygium cummini*	1.4	2.36	0.58	0	1.09	6.37	0
8	*Schleichera oleosa*	3.07	0	2.32	0	1.81	0	0
9	*Madhuca indica*	12.01	14.74	26.06	6.37	2.17	6.37	0
10	*Ficus virens*	0.28	1.18	0	0	2.9	0	0
11	*Ficus religiosa*	0.28	0	0.58	0	0.36	0	0
12	*Diospyros melanoxylon*	19.56	16.51	17.37	0	9.77	10.62	0
13	*Mangifera indica*	0	0	0.58	0	1.09	0	2.27
Total		55.03	60.16	72.96	7.64	26.42	36.09	4.55

*Average fruiting tree density 37.55 per hectare

Table 2. Frequency of occurrence of fruiting trees in plots used by bear in NBFD.

No. of fruiting trees	No. of plots sampled	Plots with or without fruit trees (%)	No. of plots used by bears	Proportional utilization of plots (%)
0	147	37.7	57	38.78
1	157	40.3	76	48.41
2	69	17.7	38	55.07
3	15	3.8	7	46.67
4	2	.5	2	100
Total	390	100	180	

Table 3. Fruiting shrub density per hectare in different habitat types in NBFD.

S. No.	Species	Mix forest	Sal forest	Sal mix	Crop field	Scrub land	Open land	Land near to water bodies	Plantation
1	*Anona squamosa*	27.94	0.00	32.43	0.00	20.27	15.29	0.00	18.20
2	*Cassia fistula*	7.82	2.36	0.00	0.00	5.79	0.00	0.00	0.00
3	*Aegle marmelos*	5.59	0.00	2.32	0.00	11.58	0.00	0.00	9.10
4	*Ziziphus nummularia*	15.64	23.59	67.17	5.10	10.13	0.00	42.46	109.19
5	*Buchanania lanzan*	12.29	96.72	46.32	0.00	4.34	0.00	42.46	0.00
6	*Syzygium cummini*	4.47	11.80	4.63	0.00	2.90	0.00	16.99	18.20
7	*Briedelia squamosa*	22.35	11.80	64.85	0.00	4.34	0.00	8.49	9.10
8.	*Diospyros malabarica*	2.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	*Ziziphus* oenoplia	1.12	0.00	0.00	0.00	1.45	0.00	0.00	0.00
10	*Ficus virens*	1.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	*Mimusops elengi*	1.12	0.00	25.48	0.00	0.00	0.00	0.00	0.00
12	*Diospyros melanoxylon*	783.33	802.08	1033.0	122.29	668.79	794.90	424.63	309.37
13	*Schleichera oleosa*	0.00	0.00	2.32	0.00	5.79	0.00	0.00	0.00
14	*Psidium guajava*	0.00	0.00	0.00	0.00	0.00	0.00	8.49	0.00
15	*Ficus racemosa*	0.00	0.00	0.00	0.00	0.00	0.00	16.99	0.00
Total		885.02	948.34	1278.52	127.39	735.38	810.19	560.51	473.16

Average fruiting shrub density 727.31 per hectare

Table 4. Availability of food items in forests and vicinity of villages.

S. NO.	Fruit trees and food items	Available in forests	Mainly available in villages
1	*Ficus bengalensis*	*Ficus virens*	*Psidium guajava*
2	*Ficus racemosa*	*Cassia fistula*	*Mangifera indica*
3	*Ficus religeosa*	*Mimosops elengi*	*Arachis hypogea*
4	*Ficus glomerata*	*Schleichera oleosa*	*Zea maize*
5	*Syzygium cummini*	*Ziziphus oenoplia*	*Ziziphus mauritiana*
6	*Aegle marmelos*	*Solenopsis sp.*	*Ipomea batatas* (S.potato)
7	*Anona squamosa*	*Ziziphus nummularia*	
8	*Briedelia squamosa*		
9	*Buchanania lanzan*		
10	*Diospyros mealnoxylon*		
11	*Briedelia squamosa*		
12	*Apis indica*		
13	*Apis dorsata*		
14	*Cyclotermes obesus*		
15	*Camponotus sp.*		
16	Beetles		
17	Honey		

Table 5. Habitat use by sloth bear in NBFD.

Habitat type	No. of sample plots (n=390)	No. of plots with bear signs	Proportional availability	Expected uses	Lower confidence limit	Upper confidence limit	Diggings /ha	Scats /ha
Mix forest	114	55	0.292	52.615	0.212	0.399	17.13	3.63
Sal forest	54	38	0.138	24.93	0.128	0.294	35.98	3.15
Sal mix	55	28	0.141	25.38	0.082	0.229	17.37	0.58
Crop field	25	7	0.064	11.538	0.000	0.078	7.22	1.70
Scrub land	88	28	0.226	40.615	0.082	0.229	9.89	1.33
Open land	25	7	0.064	11.538	0.000	0.078	7.64	3.4
Land near to water bodies	15	9	0.038	6.92	0.006	0.094	18.4	2.12
Plantation	14	8	0.036	6.462	0.003	0.086	9.86	0

Table 6. Use of terrain by sloth bear in NBFD.

Terrain type	No. of plots with terrain type	Proportional availability of terrain	No. of plots showing terrain use	Expected use of terrain	Lower confidence limit	Upper confidence limit
Flat	53	0.136	27	24.46	0.083	0.217
Undulating	217	0.556	95	100.154	0.435	0.621
Gentle slope	109	0.279	51	50.308	0.199	0.367
Steep slope	11	0.028	7	5.077	0.003	0.075
Total	390		180			

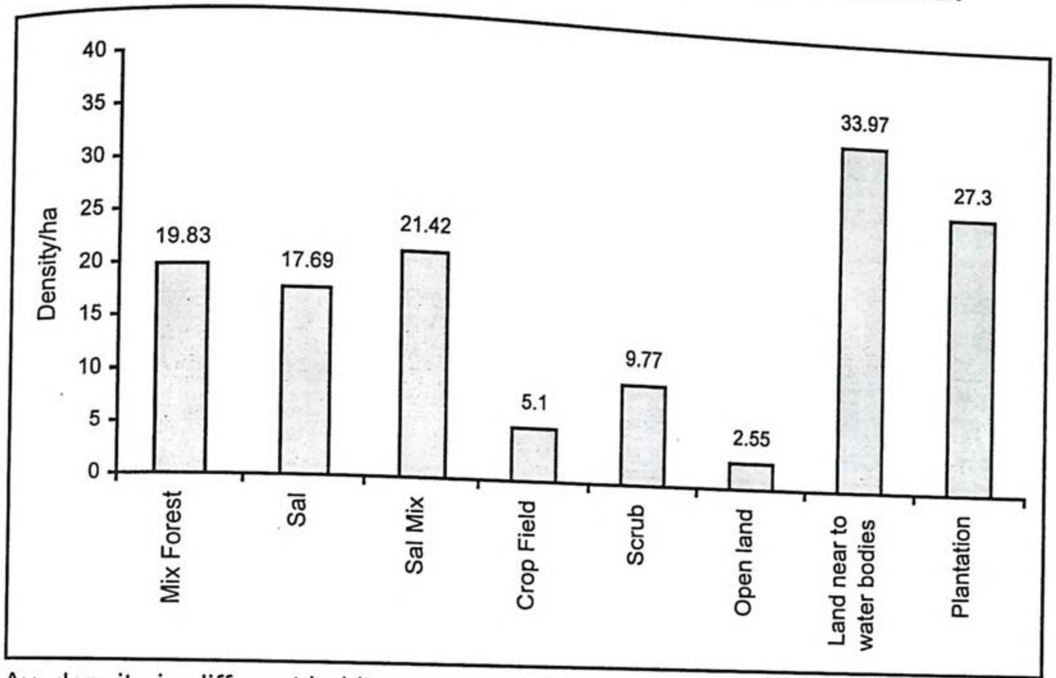
Table 7. Den distance from water bodies in NBFD.

S. No.	Den distances from the Water source (m)	No. of dens
1	0-250	62
2	250-500	22
3	500-750	6
4	750-1000	4
5	1000-1250	11
6	1250-1500	0
7	1500-1750	4

Table 8. Location of den sites in relation to villages and their use by bear.

Distance from habitation (m)	No. of active dens	No. of temporary dens	Total no. of dens
0-250	12	15	27
250-500	18	9	27
500-750	6	5	11
750-1000	3	5	8
1000-1250	13	10	23
1250-1500	1	2	3
1500-1750	1	5	6
1750-2000	0	0	0
2000-2250	2	2	4
Total	56 (51.38%)	53 (48.62%)	109

Figure 1. Density of termite mounds in different habitats in NBFD.



Av. density in different habitats: 16.35 per hectare

Figure 2. Two dimensional scaling of habitat variables in used and unused plots.

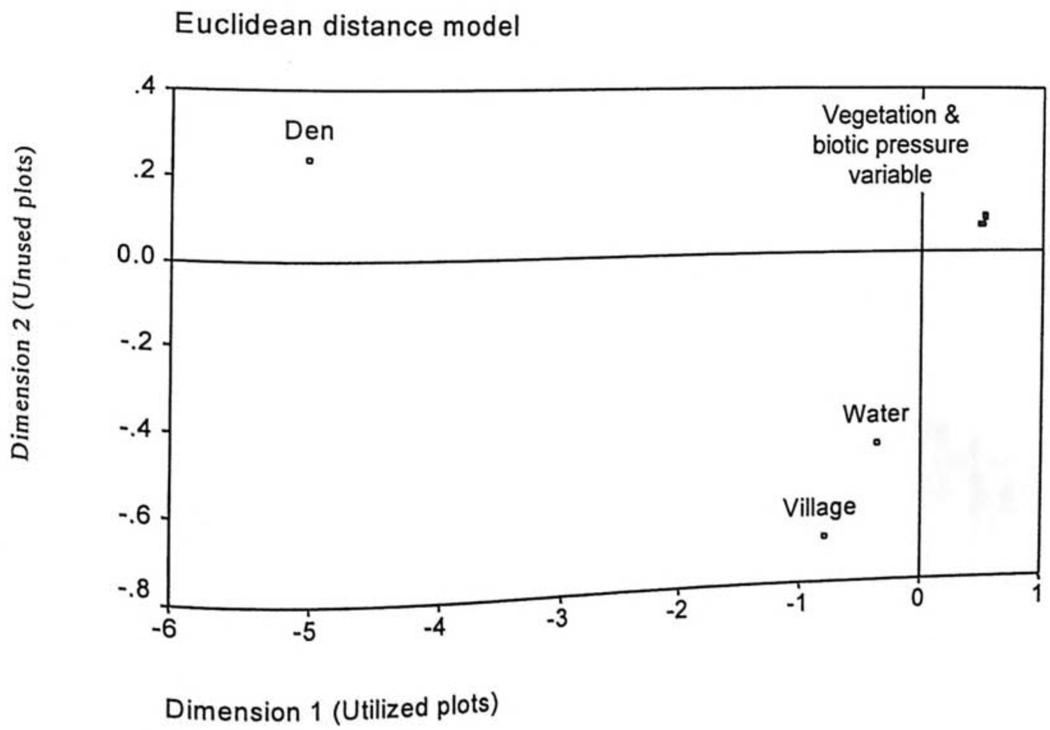


Table 9. Two dimensional scaling of habitat variables in used and unused plots.

Stimulus No.	Variable	Dimension 1 (Used)	Dimension 2 (Unused)
1	Tree canopy	.5440	.0654
2	Terrain	0.5244	.0839
3	Tree species richness	0.5247	.0834
4	Fruiting tree species richness	0.5235	.0842
5	Fell trees	0.5239	.0835
6	Lopped tree	0.5238	.0823
7	Tree height	0.5237	.0813
8	Shrub cover	0.4995	.0625
9	Herb cover	0.4962	.0641
10	Village distance	-0.7929	-.6896
11	Disturbance from road	0.5231	.0841
12	Cattle dung	0.522	.0833
13	Water	-0.3680	.4679
14	Den	-5.022	.2378
15	Termite mound	0.4946	.0618

Table 10. Analysis of variance using Kruskal-Wallis non-parametric test for habitat use by sloth bears.

Habitat Variable	Canopy	Terrain	Forest type	Tree richness	F. tree richness	Fell trees	Lopped trees	Tree height
Chi-square	17.156	.040	5.251	17.238	5.945	3.962	12.553	26.021
Df	1	1	1	1	1	1	1	1
Asymp. sig.	.000	.841	.022	.000	.015	.047	.000	.000

Habitat Variable	Distance from habitation	Disturbance from road	Cattle dung	Water	Den	Digging /ha	Shrub cover	Herb cover
Chi-square	10.700	8.258	32.712	.822	8.336	272.195	9.853	2.491
Df	1	1	1	1	1	1	1	1
Asymp. sig.	.001	.004	.000	.365	.004	.000	.002	.114

Table 11. Logistic regression model for probability of habitat utilization by sloth bear.

Classification table for bear absence and presence
The Cut Value is .50

Observed		Predicted .00 (0)	Predicted 1.00 (1)	Percent Correct	
.00	0	145	65	69.05%	(absent)
1.00	1	64	116	64.44%	(present)
			Overall	66.92%	

*0 = Bear absence

Figure 3. Habitat use by bear 1 based on compositional analysis

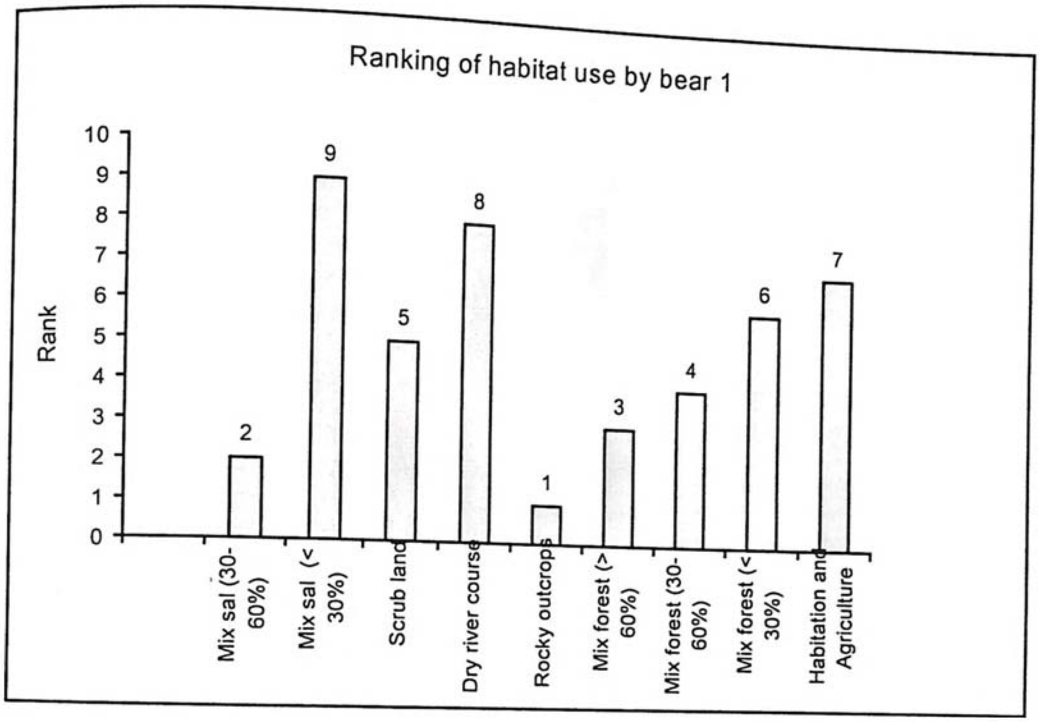


Figure 4. Regression analysis for habitat use by bear 1

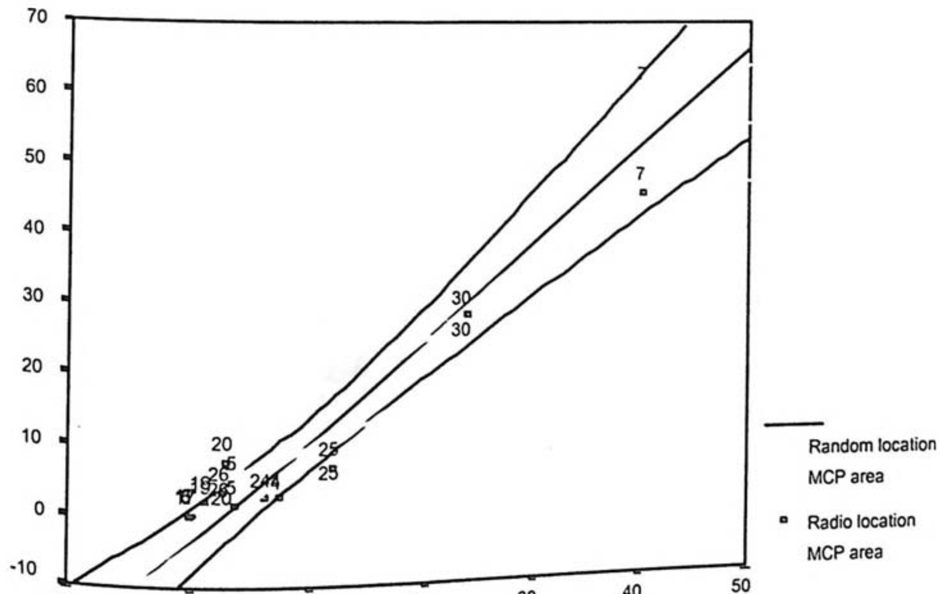


Figure 5. Habitat use by bear 2 based on compositional analysis.

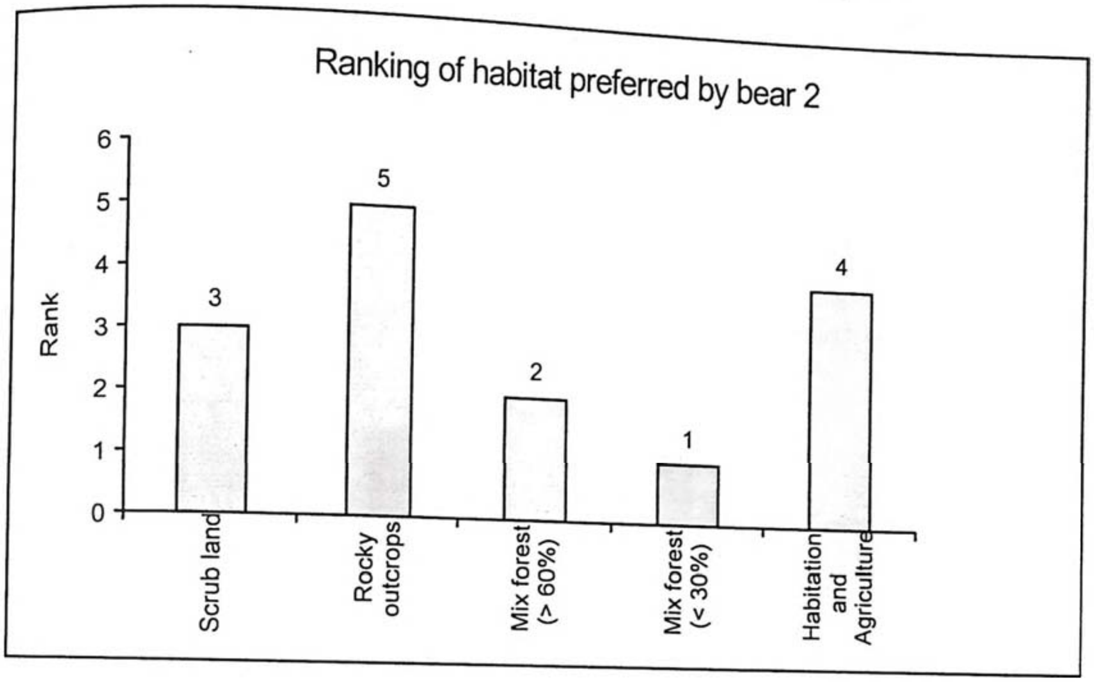


Figure 6. Regression analysis for habitat use by bear 2 (female).

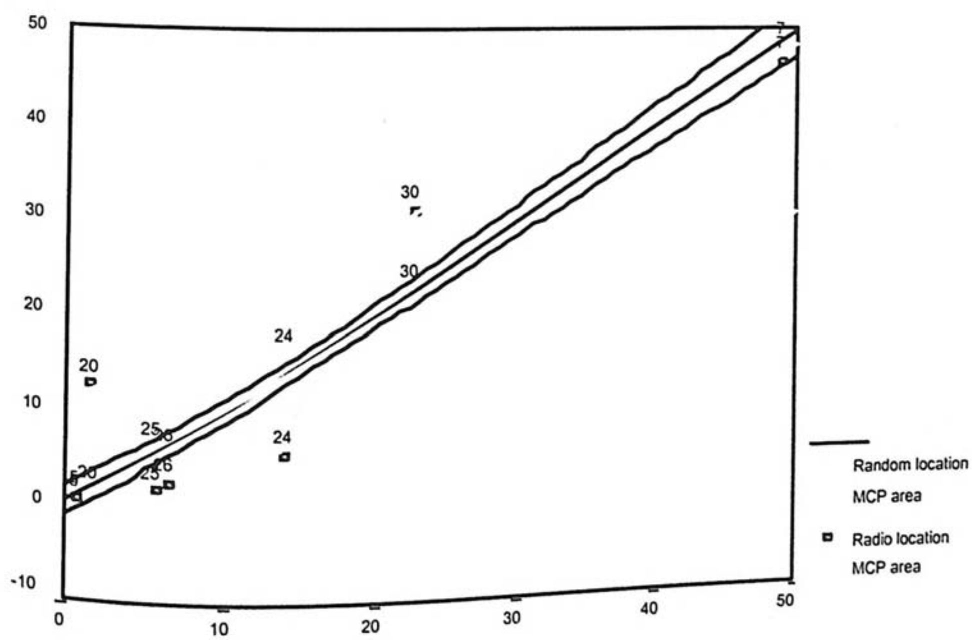


Figure 7. Habitat use by bear 5 based on compositional analysis.

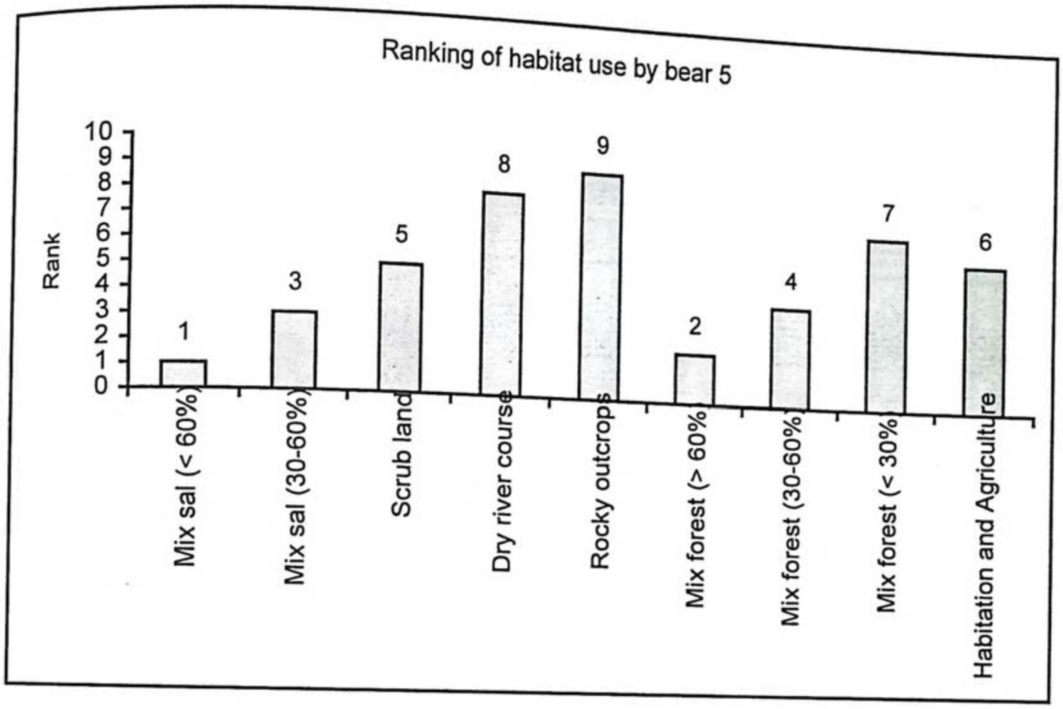


Figure 8. Regression analysis for habitat use by bear 5

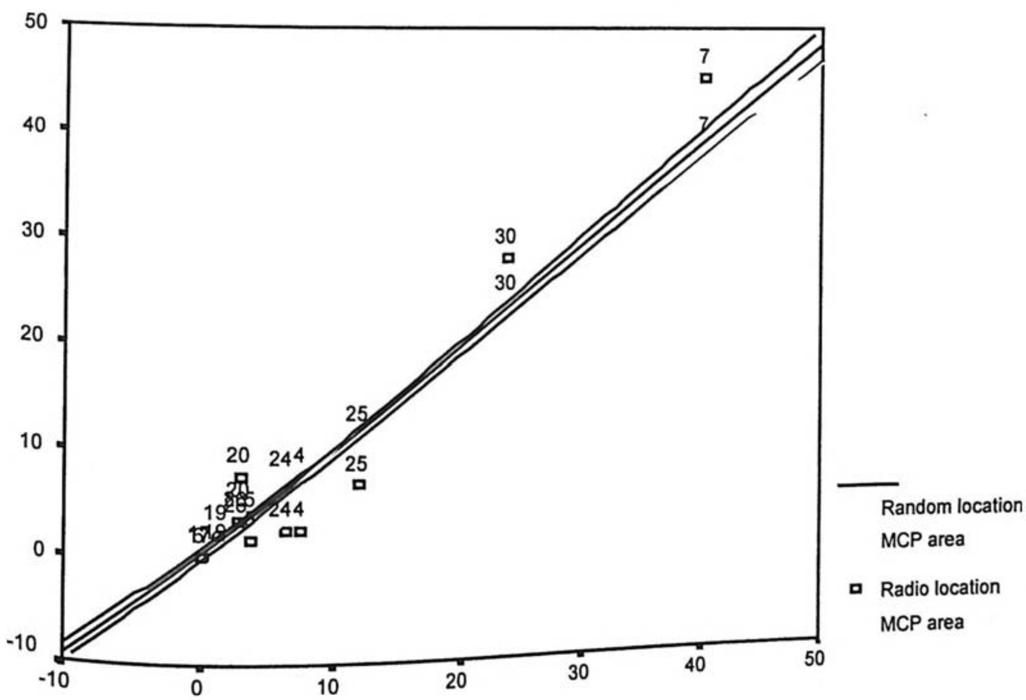


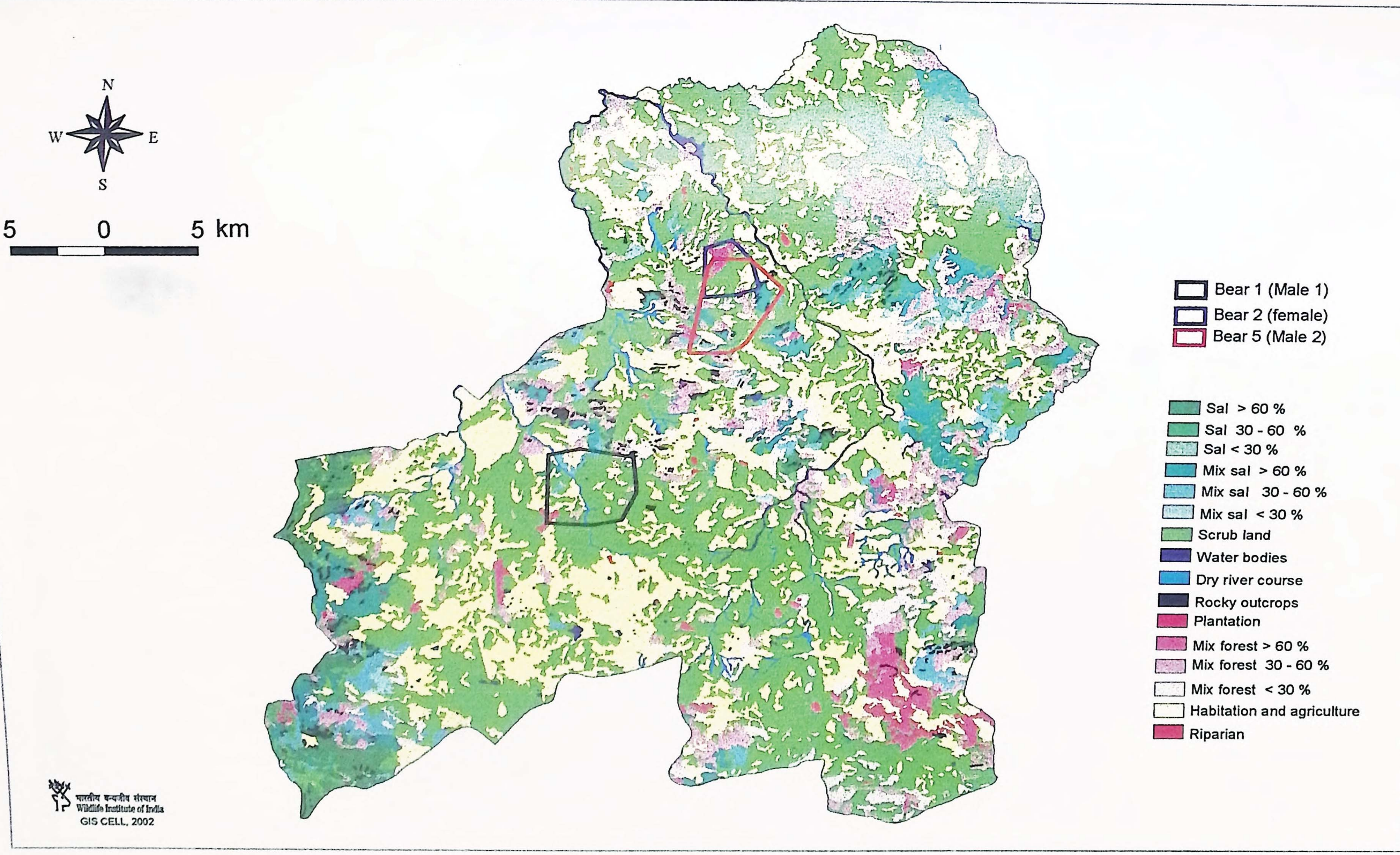
Table 12. Home range of sloth bear in NBFD.

	Bear 1	Bear 2 (female)	Bear 5
95 % MCP home range (Km^2)	22.33	7.8	20.01
100 % MCP home range (Km^2)	30.22	11.34	31.02

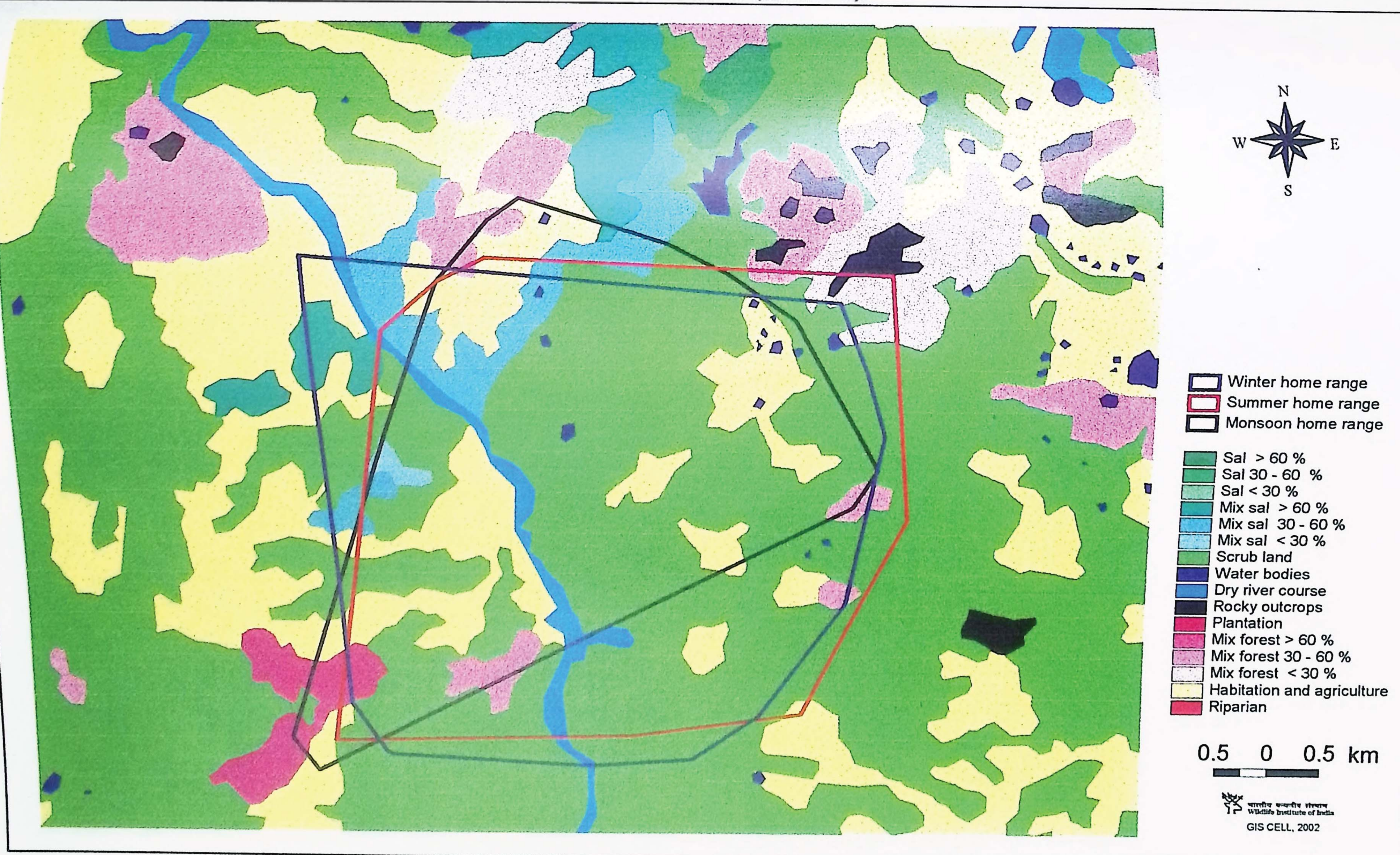
Table 13. Seasonal variation in the habitat use by male and female sloth bears in NBFD

Code	Habitat category	Habitat use area (km^2)								
		Winter			Monsoon			Summer		
		Male 1 (km^2)	Male 2 (km^2)	Female (km^2)	Male 1 (km^2)	Male 2 (km^2)	Female (km^2)	Male 1 (km^2)	Male2 (km^2)	Female (km^2)
4	Mixed sal > 60 %	0.31	0.55		0.02	1.19		0.02	0.34	
5	Mixed sal 30-60 %	0.99	0.42	0.01	0.87	0.85	0.01	0.77	0.13	0.02
6	Mixed sal < 30 %	0.11			0.01			0.11		
7	Scrub land	12.4	4.55	4.16	8.34	6.74	2.31	12.63	2.97	2.50
17	Water bodies	0.09	0.04		0.07	0.03		0.09		
19	Dry river course	0.68	0.35		0.36	0.27		0.58		
20	Rocky out crops		0.46	0.1		0.44	0.048	0.02	0.22	0.01
24	Mixed forest >60 %	0.13	0.01	0.76	0.34	0.44		0.16	0.6	1.36
25	Mixed forest between 30-60 %	0.45	2.00	0.46	0.38	2.28	0.16	0.54	0.17	0.11
26	Mixed forest <30 %	0.03	0.63	0.61		0.7	0.21	0.27	0.18	0.11
30	Habitation and agriculture	3.64	2.78	1.84	3.39	4.29	1.1	3.28	1.89	1.15
34	Riparian									
	Total area covered (km^2)	18.82	11.79	7.94	13.87	17.23	3.84	18.47	6.5	5.27

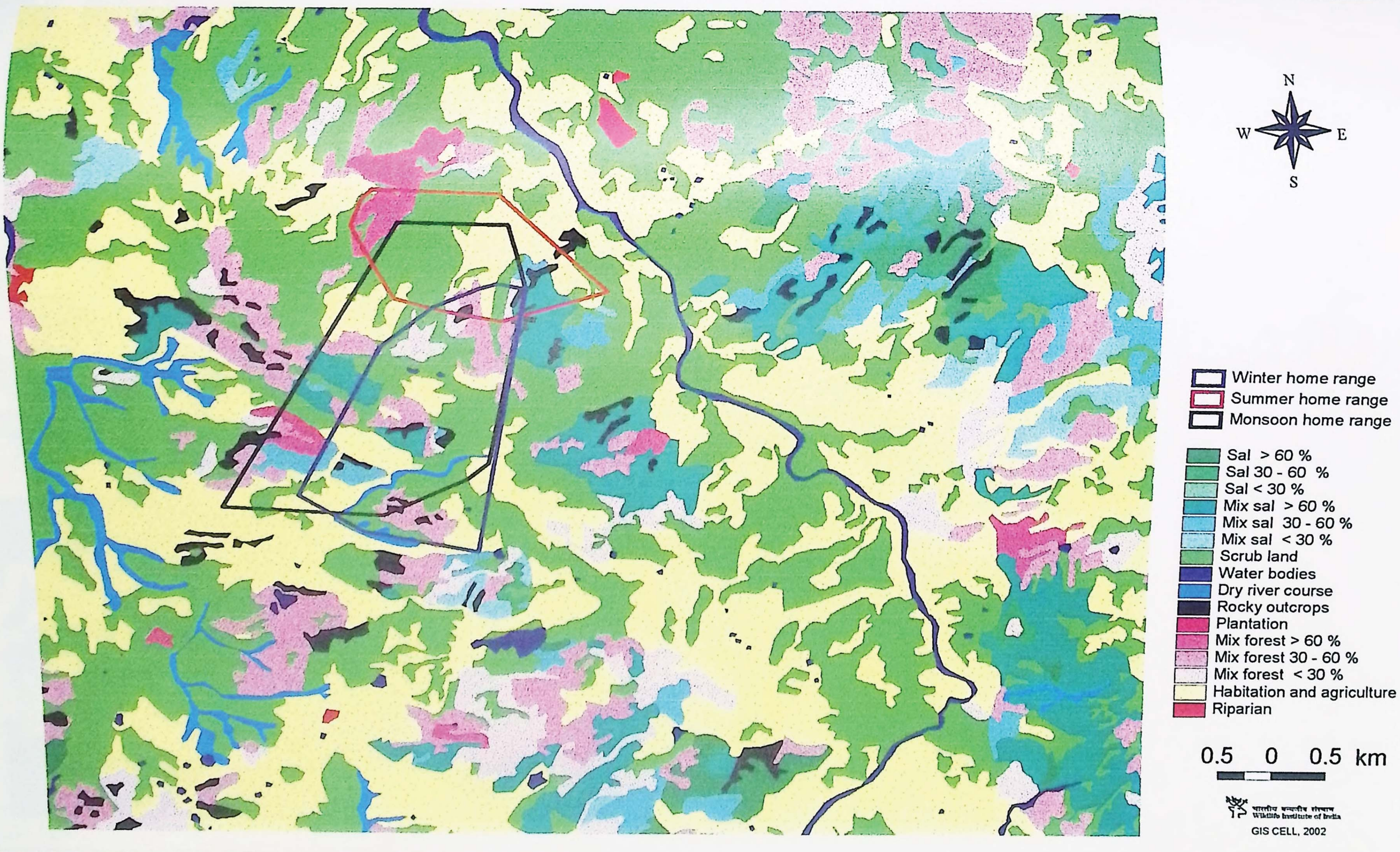
Map 1: Annual home ranges of three sloth bears in North Bilaspur forest division.



Map 2: Seasonal shifts in home ranges of sloth bear 1 (Male 1).



Map 3: Seasonal shifts in home ranges of sloth bear 5 (Male 2).



Map 4: Seasonal shifts in home ranges of sloth bear 2 (Female).

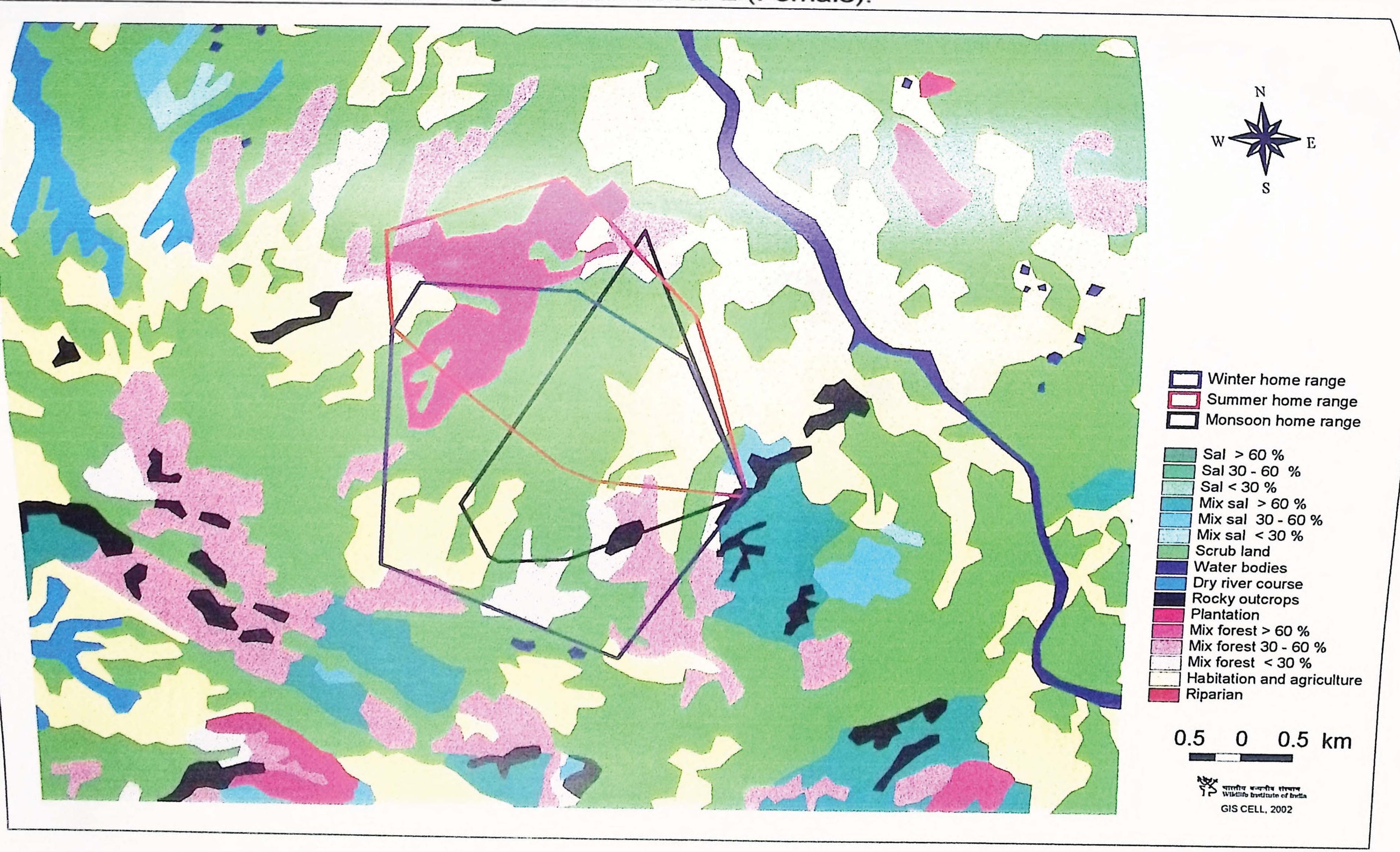


Plate - 1

1. **Agriculture expansion on forest land and denning areas near Karangara village.**

2. **Use of Sal mix forest by sloth bear.**

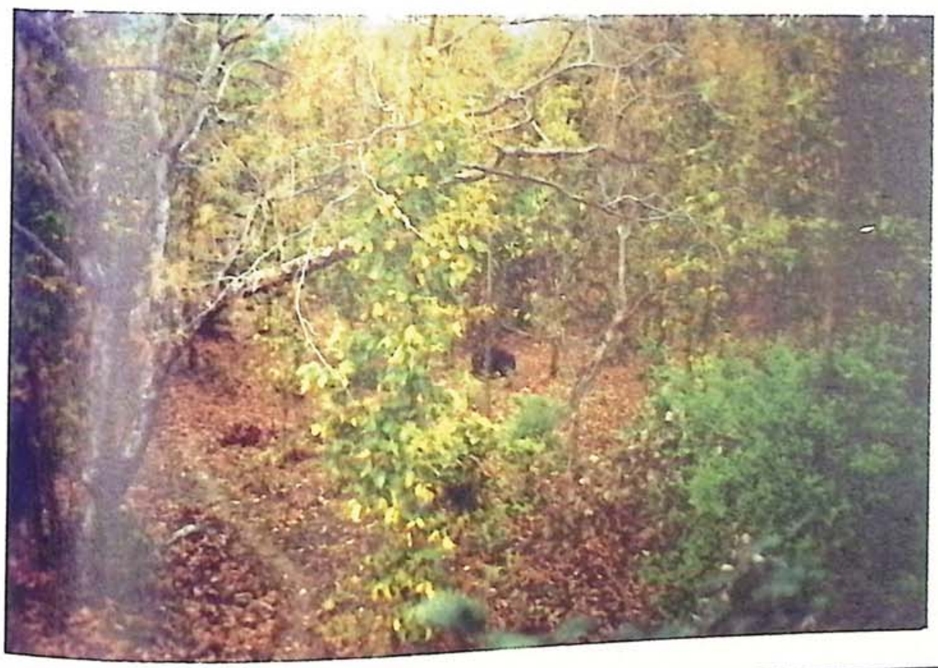


Plate - 2

3. Movement of bears in Scrub land habitat.

4. Open land contiguous with Sal forest in bear areas of NBFD.

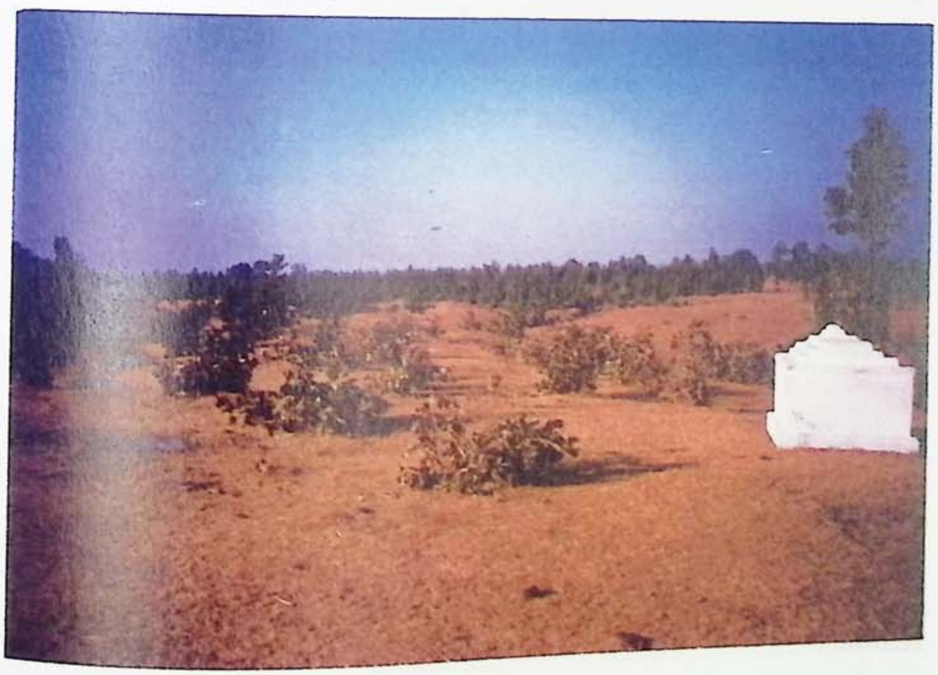
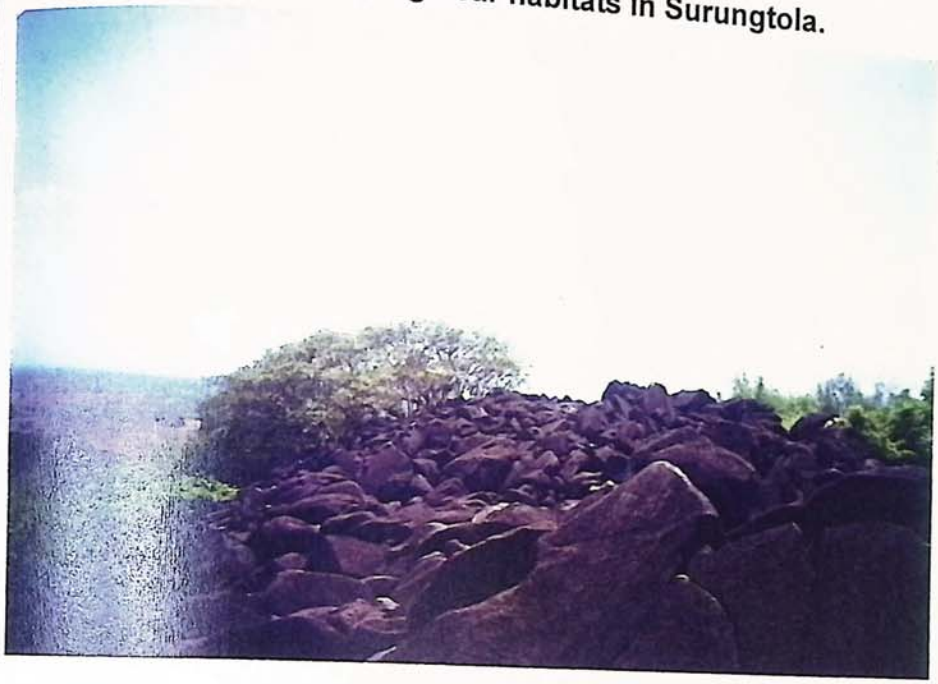


Plate - 3

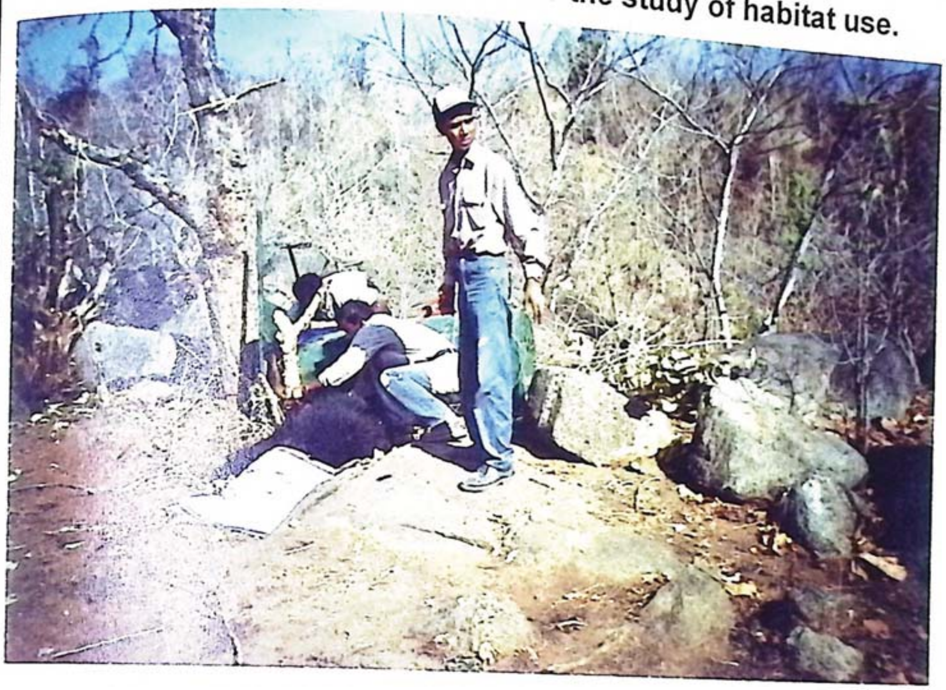
5. Den sites and low lying bear habitats in Surungtola.



6. Burning of dried leaves for ground clearance to enable mahua collection.

Plate - 4

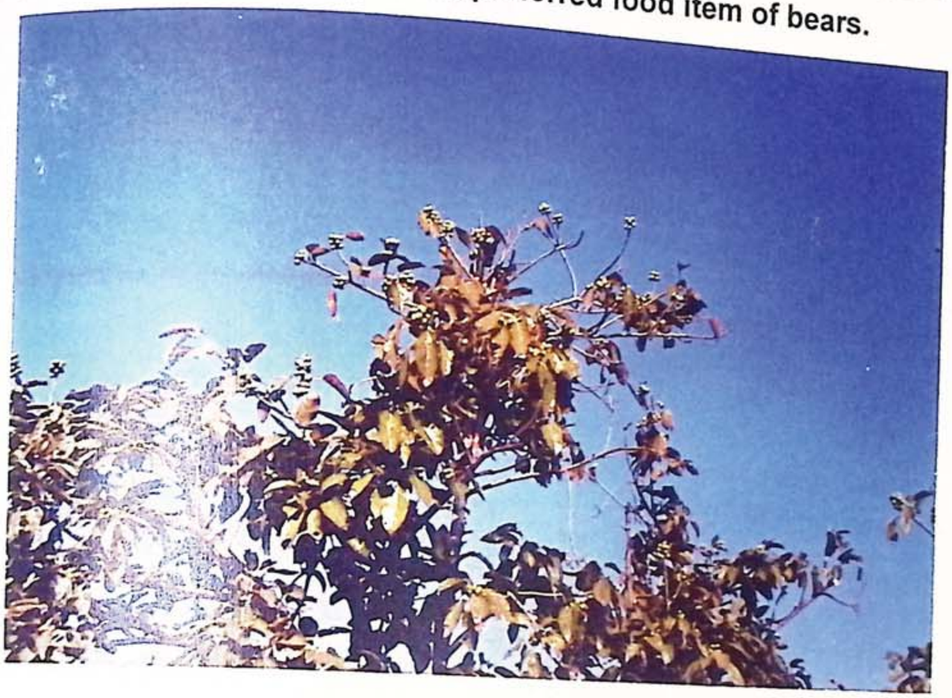
7. Radio collaring of sloth bear for the study of habitat use.



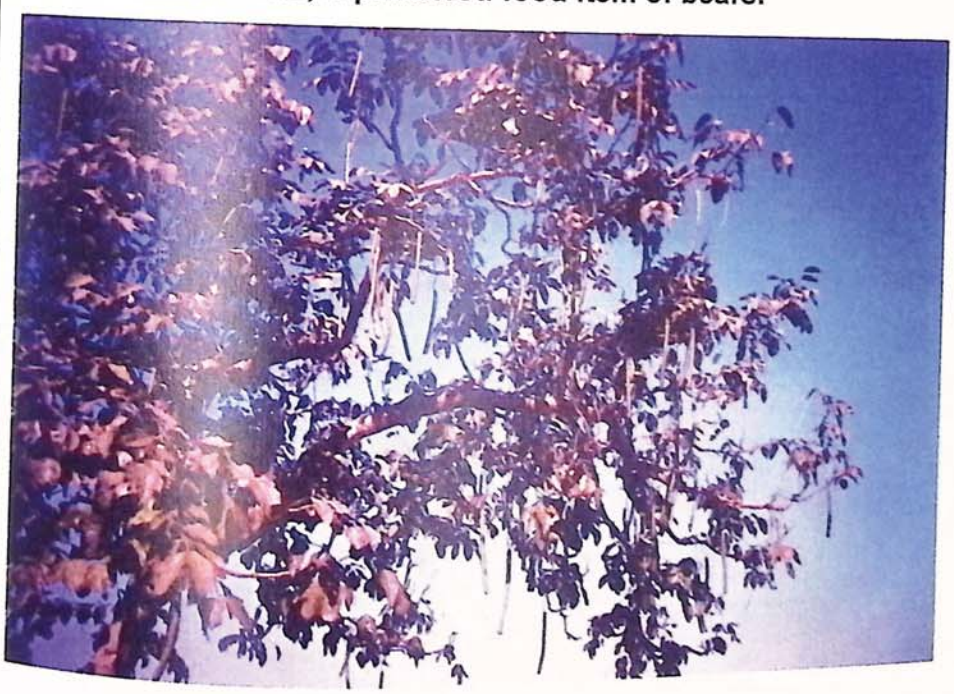
8. Collaring of a sloth bear for the study of habitat use in Surungtola.

Plate - 5

9. Pakri tree bearing fruits, preferred food item of bears.



10. Amaltas fruits, a preferred food item of bears.



Chapter VIII. Conclusions and Recommendations

1. The Satellite imageries and GIS maps and Compartment map revealed that most of the forest cover is Pendra and Marwahi ranges of NBFD was patchy, fragmented and interspersed with the human habitation and agricultural fields. Due to this reason, TWINSPAN did not classify the vegetation community distinguishably. Hence the broad vegetation types were determined on the basis of tree species, fell in the sampling plots.
2. The Land cover and landuse patterns simply showed diverse habitats, which could sustain sloth bear population in the two ranges. More heterogeneity, richness and diversity of vegetation might be good indicators of availability of many food items in any habitat. In Pendra and Marwahi ranges, out of 8 broad heterogeneous habitat types, Mix forest and scrub land was found with high species richness with preferred fruting species for bears. The vegetation was comprised of 27 families, 65 genera and 81 species. These habitats may be suitable for sloth bear population and needs to be protected.
3. The relationships among tree communities showed maximum similarity at minimum distance between in Sal and Sal mix forests and then minimum distance was between Mix forest and Sal forest, followed by Mix forest and Scrub land, Mix forest and Land near to water bodies, Mix forest and plantation and Mix forest and Crop field. And maximum similarity for shrub vegetation was between Sal and Sal mix, followed by Mix forest and Scrub land, Mix forest and Sal, Crop field and Plantation, Crop field and Land near to water bodies, Crop field and Open land and Mix forest and Crop field.

4. Sloth bear frequently raid villages in search of fruit trees of importance of their food value. Though the fruit tree density was less in villages than the forests, the availability of fruits was much more as compared to forests. This was due to the fact that trees in villages were mature and protected, whereas in the forests, the trees were young and unprotected, and fruit biomass was comparatively less. Fruiting Tree density per hectare was estimated highest at Sal mix forest followed by Sal, Mixed forest, Land near to water bodies, Scrub land, Crop field and Plantation and was lowest at cultivated land. Among fruiting shrub species, only two species i.e. *Ziziphus oenoplia* and *Ziziphus nummularia* were significant for bears as the fruits were highly preferred. All these fruiting species classified under of 14 families, 16 genera and 19 species.
5. Besides food values of fruiting species, high density of trees in Sal forest, Sal mix and Mix forest in NBFD was important from point of providing shelter to sloth bear.
6. Importance Value Index (IVI) generally shows the dominance of a species upon others in the community. In fact, high value of IVI of a fruiting tree species of bear diet in different habitats will indicate the good status of food availability. Species with high IVI were *Diospyros melanoxylon, Madhuca indica* and *Buchanania lanzan* in Mix forest, Sal forest and sal mix forest; *Madhuca indica* and *Buchanania lanzan* in Crop field; *Diospyros melanoxylon, Madhuca indica, Mangifera indica* and *Ficus virens* in Scrub land; *Ficus racemosa, Diospyros melanoxylon* and *Buchanania lanzan* in Land near to water bodies, and *Mangifera indica* in Plantation habitat.

7. In NBFD, forests are interspersed with human habitation and agriculture land, and almost the whole area was impacted from biotic pressure to varying degree. The townships, villages and agricultural land occupied 27.31% of the total area. And except 2.5% biotic pressure free area, the remaining 70.19% area was greatly impacted from biotic pressure and invariably used by sloth bear.
8. All together 42 NTFP items were found to be collected by villagers in the study area. Though people collect the forest produce throughout the year, but the collection was high during the tendu patta and mahua flowering and fruiting period from March to June. There were 32 items of were of plant origin, 3 from insects and 7 from mashroom. All the plant forest produce were comprised of 21 families, 28 genera and 32 species.
9. Out of 30 food items of bears, 17 items were commonly distributed in forests as well as village areas, additional whereas 7 items were exclusively available in forests and 6 items were found only in the vicinity of villages.
10. Biotic pressure in the form of cutting/felling of trees on sloth bear habitat was highest in Sal mix forest, followed by Sal forest, Mix forest, Plantation, Scrub land, Land near to water bodies and Crop field. Lopping of trees was maximum in Sal mix, followed by Mix forest, Sal, Plantation, Land near to water bodies, Scrub land, and Crop field. Whereas cattle grazing pressure was highest in Open land, followed by Plantation, Scrub land, Land near to water bodies, Mix forest, Crop field, Sal mix and Sal forests. Sheep grazers from Gujarat caused tremendous pressure on bear areas during summer season.

11. In Pendra and Marwahi areas, Ghusariya, Ratga, Karseewa, Karhanya and Silpahri hill ranges were contiguous. Scattered hillocks and boulders are found all over. There were 109 dens in these hills/hillocks, and most of them were occupied by sloth bears. This indicated high bear population in the two ranges. Since there were more active dens in Marwahi area than Pendra, occurrence of bear was higher in Marwahi range.

12. The potential bear sites, the Jhandi dongri of Surungtola and Jhandi of Barbasan in Pendra and Marakot in Marwahi with many live dens and high bear population were highly impacted from illegal mining. This was the direct severe threat to the survival of bears in these areas.

13. During summer season, man made forest fires were quite frequent in the study area. Being deciduous vegetation, huge amount of dry leaf litter used to be accumulated on the ground and this dry cover was most vulnerable to catch fire. Most fire prone areas were Silpahri, Ratga, Ghusariya, Lityasarai, Karhanhia, Chullapani and Rumga in Marwahi range, and Pakariya, Padwania and Amarkantak forests in Pendra range. These fires were adversely affecting the bear habitats by burning/suppressing growth of *Ziziphus mauritiana*, *Z. oenoplia*, and *Z. nummularia*.

14. During the transect study, only 4 bears were sighted in these areas. The bear encounter rate was very low during day time, which could be attributed to disturbance factor in fragmented habitats. Bear preferred to stay inside dens during the day time.

15. Based on the survey of 6 den sites, bear occurrence varied from 5 to 9, the average number of bear was 5.83 per den site in North Bilaspur forest division with an area of 1395.7 km^2. An estimated bear population was 326

based on extrapolation of the number of bears in selected den sites. Thus the density of bear was 1 bear per 4.28 km^2.

16. Average density of digging and scats in Sal forest, Land near to water bodies, Sal Mix forest, Mix forest, Scrub land, Plantation, Open land and Crop field was 16.69/ha and 2.29/ha respectively, which indicated high bear population in these habitat types. Two dimensional scaling of habitat variables showed that bear evidences were more in areas with high vegetation cover and food availability.

17. Habitat characteristics at bear use areas and digging sites were significantly different from the sites where bear signs were not present. Frequencies of occurrence of diggings by bear along the transects in different habitats were significantly different to each other.

18. The habitat utilization for digging of termites mounds and ant nests showed that all the eight habitat categories were not very significantly different, and the habitat use was in proportion to density of termite mounds. Habitat variables were not equally distributed in the areas where bear signs were present or absent. Availability of water and ground cover did not discriminate the bear presence or absence. Up to 66% utilization of habitat by bear could be predicted on the basis of habitat variables present on used and unused areas. Prefer analysis of availability and utilization revealed that there was no preference and avoidance of any habitat type. Thus the use of available habitats by bears was generalized. Goodness fit of comparison showed that the expected utilization of various terrain categories was not significantly different from the observed utilization.

19. Bear preferred the areas with big bouldary hillocks with adequate cover, irrespective of any habitat type. Based on radio-telemetry study, use of habitation and agriculture was maximum, where they were getting sufficient fruits, ants and termites. Besides this, bears were frequently found in Mix forest, Scrub land and Dry river course.

20. Out of 109 total den sites, 77% dens were located within the limit of 500 m from the water sources. 88% dens were located within the limit of 1250 m from the human habitation. More than 50% den sites were regularly used by bears whereas rest used occasionally.

21. The home range of male bear 1 and bear 5 at 100% MCP was 30.22 km^2 and 31.02 km^2 respectively, whereas it was 11.34 km^2 for the female bear. The home ranges at 95% confidence level for bear 1, bear 5 and the female were 22.33, 20.01 and 7.8 km^2 respectively.

Recommendations

1. In NBFD, the existing bear inhabited areas with mix of preferred habitats need to be protected on priority from human interference.
2. Large and contiguous forest patches with high bear population, namely, Pakariya, Karangara in Amarkantak belt of Pendra range, and Ghusariya, Ratga, Lityasarai, Chilhan, Chuabahra, Silpahri and Chullapani of Marwahi range need special attention for protection of the bear habitats.
3. In Pendra and Marwahi ranges, cattle grazing should be completely banned in bear denning sites. There has to be some regulation imposed on cattle grazing in forest areas distantly away from den sites; villagers can take their cattle in these forests strictly only during day time avoiding morning and evening hours. While planning strategy for conflict mitigation and conservation of bear, emphasis should be laid on proper sustainable resource management in forest areas in the two ranges.
4. Cattle grazing and camping by nomadic shepherd and local Dahiyan in forests of Amarkantak in Pendra and Marwahi ranges adversely affect the bear habitats. To check this, entry of these shepherds into bear areas should be banned and reinforced effectively.
5. Likewise Illicit cutting and lopping of trees must be completely banned in bear denning sites in NBFD. Three is need to delineate some isolated forest patches away from potential bear areas where local people can be allowed for regulated extraction of fuel wood and lopping activity, leaving fruiting trees of bear interest (food value). Keeping in view dependency of local people on forests and increasing demand for fuelwood and non-

timber forest produce, afforestation activities need to be started on large scale.

6. Most important denning areas and preferred bear habitats: Lityasarai, Marakot and Karangara areas have been increasingly encroached upon by villagers for cultivation. There is immediate need to check encroachment on these forests and denning areas. The encroached forest land should be taken back, demarcated and then planted with fruit trees of sloth bear interest, and protected for habitat restoration. Encroachment on the other bear habitats listed in the Chapter V also need to be verified by the forest department.
7. During May-June, large scale collection tendu leaves is done on annual basis. Bundles of tendu leaves are tied up with bark of *Ficus bengalensis;* which is very important tree species providing preferred food in form of fruits to sloth bear. To facilitate bark removal, tree branches are also cut by the collectors. This might severely affect the growth and fruiting of the trees and thus the food availability for sloth bears in these areas. Considering this, the bark removal from the *Ficus* sp. should be completely stopped.
8. The local people venture into forests anytime of the day to collect non-timber forest produce. Collection of NTFP from bear denning areas should also be completely banned. NTFP other than preferred fruiting trees by bear such as *Madhuca indica* flowers and fruits, *Aegle marmelos*, *Buchanania lanzan* and *Ziziphus mauritiana* and *Ziziphus nummularia* can be allowed for collection strictly between 1000-1500 h in forests distantly

away from den sites. People can continue to collect these food items from revenue land including villages and cultivated areas.

9. The villagers increasingly collect mahua flowers from forests and revenue land for preparation of liquor. The left over mahua residue smells strongly, that attract bears in the villages. Likewise, bears also get attracted to *Ziziphus mauritiana* fruits collected in houses. To avoid this, the mahua residue should be either disposed far off from villages or buried in ground and preferred food items need to be properly stored concealed.

10. Stone mining activities in important bear habitats and denning hillocks e.g. Surungtola, Barbasan, Marakot, Lityasarai etc. must be totally prohibitive from immediate effect.

11. Annually in summer season, Amarkantak and Ratga forests are severely impacted by frequent man-made fires. As a result, *Ziziphus nummularia* (jhar ber) and *Ziziphus oenoplia* (makoiya), the preferred food items of sloth bears get completely burnt. Effective management by keeping strict vigil, using preventive measures and adoptive punishment procedure must be practiced.

12. To enrich forests supporting high bear population and rejuvenate surrounding degraded forest areas of Chuabahra, Ghusariya, Ratga, Madwahi, Bahutadol, Lityasarai, Chilhan, and Usad, planting of highly preferred food plants viz. *Mangifera indica*, *Psidium guajawa*, *Ziziphus mauritiana*, *Z. nummularia*, *Z. oenoplia*, *Buchanania lanzan*, *Diospyros melanoxylon*, *Ficus racemosa*. *F. bengalensis*, *F. virens*, *F. glomerata*, *F. religeosa* and *Aegle marmelos* must be undertaken on priority.

13. Bears increasingly invade Habitation and agriculture fields, and cause extensive damage to agricultural crops, especially groundnut and maize. Venturing of man into bear habitats and competition for resource sharing lead to more and more man-bear conflict in NBFD. To reduce crop damage/mitigate problems; crops should be protected when mature, crackers, liting of fire and loud shouting can be used to keep away animal form the fields. Changing in cropping pattern, insurance of crops and possibility of fencing around the crop fields or villages may be helpful for poor villagers to some extent and their resentment for conflicts can be reduced. Similarly to avoid human casualties, people should move in groups in morning and evening hours, do not chase and disturb bear when see, and give escape path for bears to avoid confrontation.

14. There are many isolated den sites in Pendra range viz. Barbasan, Tauli, Surungtola, and Marwahi range viz. Katra, Karhaniya, which are surrounded by human habitation and agriculture fields. Bears emerge from these dens and invade village areas, crop fields and scattered patchy forests for their food requirement. Apparently these bears seem to have no future. In conservation effort, there is urgent need to conduct experimental trial to capture few bears from these isolated pockets and translocate them to some suitable areas elsewhere.

15. To conduct a feasibility study, translocation of some bears into pre-identified sites in Achanakmar sanctuary can be tried. For planning translocation experiment, information on status and distribution of sloth bear in Achanakmar sanctuary is necessary. This will help mitigation of

man-bear conflicts effectively and conservation of this threatened species.

16. Among the local tribal people, the need of education and awareness programmes about conservation of sloth bear population, forest ecosystem and coexistence with bears is greatly felt. Villagers must know the natural history of bears, bear habitats, feeding habits, behaviour and reasons of man bear conflicts and possible solutions.

17. There is also need to develop educational packages for the local people and carry out extension work in affected areas. This would include information on conservation issues, coexistence with bears and safety measures. People moving around in villages, crop fields and forest areas, if encounter bear(s), must follow precautionary measures and learn to avoid bear attacks. The important measures include:

    1. While walking in bear areas, people should keep quite or suppress their voice as much as possible.
    2. If you see bear(s), leave the area or make a wide detour or wait until the bear moves away. Always leave an escape route for the bear.
    3. Whenever bear is encountered, one should not run. Sudden reaction or running away may provoke the animal to attack. Walk back slowly facing the bear and talking in a low voice. Even if the bear approaches you to get a better look or stand on hind legs and nod its muzzle, continue withdrawing slowly and talking in a soft voice.
    4. People should watch for the aggressive behaviour of bear by listening to its howling, puffing sounds or stress call. One should be

careful, sometimes standing bear with its head up and eyes locked may lead to an attack.

5. Many bear attacks are due to sudden confrontation or when mother with cub or bear feeding are approached. People should be vigilant and take all precautions while moving in forest areas.
6. When attacked by sloth bear, use all possible ways to escape the animal. Either climb on tree, produce loud yelling sound or use any object, stick or axe available on the spot.

Now the following studies are urgently required to develop strategies for mitigation of man-bear conflicts and conservation of sloth bear in NBFD. To resolve man-bear conflicts:

1. To assess status and distribution of sloth bear in NBFD and adjacent mining areas bordering Shahdol and West Sarguja districts and Achanakmar WLS.
2. To study ranging and activities pattern of sloth bear in NBFD and adjacent mining areas bordering Shahdol and West Sarguja districts and Achanakmar WLS.
3. A feasibility study: capture of sloth bear from isolated forest patches/den sites in NBFD, and this translocation to preidentified sites in Achanakmar WLS, followed by monitoring of bears at the capture sites and released bears.
4. To develop education and awareness programs and carry out extension activities in the affected villages in NBFD and evaluate their impact on people response, resource use and intensity of man-bear conflicts.

5. Delineate a few forest patches/denning areas and provide protection. Carry out plantation of preferred fruiting trees in selected areas and their monitoring impacts on vegetation, bear habitats use and movement pattern in NBFD.

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Distribution and Abundance by Indirect Evidences

Date : ....

Format - 1

Range/Locality : ....

Transect No. : .... Time : Start............. End.............

Compart. No.	Belt No.	Evidences	Age class A C U	Scat O F	Vegetation		Remarks
					Type	Density	

Evidecnes : Scat - S; Foot print - FP; Claw mark - CM; Food remnant - FR; Turn logs - TL; Termite mounds - TM; Honey comb removed - HCR; Digging - D; Feeding sign - FS.

Age Class : Adult - A; Cub - C; Unidentified - U.

Scat : Old - O; Fresh - F.

Veget. type : Grassland - GL; Scrubland - SL; Mixed forest - MF; Sal forest; Rocky outcrop - RK

V. Density : Degraded land (0-10%) - OF; Dense forest (>40%) - DF.

Date :.............
Range/Locality:............
Transect No. : ....

Time : Start............ End...............

ompa rt. No.	Activities	Time (h)	Distance along transect (m)	Sighting angle ( )	Angular singhting distance (m)	Perpendicular sighting distance (m)	Age class		Vegetation		Remarks
							A	C	Type	Density	

Activities : Feeding - F; Sleeping - S; Moving - M; Suckling - SK; Resting - R.
Veget. type: Grassland - GL; Scrubland - SL; Mixed forest - MF; Sal forest - SF; Rocky outcrop - RK.
V. Density : Degraded land (0-10 %) - DL; Open forest (10-40 %) - OF; Dense forest (>40 %) - DF.
Remarks : Species and part eaten.

Location on map

Distribution by Den Counting (Direct and local interview)

Format - 3

Date:.................
Range/Locality:.........................

Sr. No.	Comp. No.	Vegetation		Topography						Den occupancy		Time		Remarks
		Type	Density	Soil type	Eleva-tion	Slope	Aspect	Tree sp.	GBH	Habi-tuated	Aban-doned	O	I	

Veget. type : Grassland - GL; Scrubland - SL; Mixed forest - MF; Sal forest - SF; Rocky outcrop - RK.
V. Density : Degraded land (0-10 %) - DL; Open forest (10-40 %) - OF; Dense forest (> 40 %) - DF.
Soil Type : Soft - S; Sandy - Sn; Gravel - G; Rockey - R; Compact - C.
Aspect : North - N; South - S; East - E; West - W.
Remarks : Distance from water source; Distance from human habitation; Den occupants; adult or cub. Bear sighting time.

Format- 4

Date : ....
Range/Locality : ....

Frequency	Compartment No. (Loca-tion No.)	Time		Activities	Habitat Characteristics			Remarks
		From	To		Foraging (F)	Denning (D)	Escape (E)	

Activities : Feeding - F; Sleeping - S; Moving - M; Suckling - SK; Resting - R.

Habitat comp : Foraging (habitat)..(season wise)
Denning (habitat)..(season wise)
Escape (habitat)..(season wise)

Location on map.

Date:.............

Range/Locality:...............

Freq. No.	Comp. No. (Location No.)	Vegetation Type	Terrain	Soil Type	Tree			Shrub		Herb		Biotic Pressure	
					Species	Canopy Cover %	Density	Species	% cover	Species	% Cover	Type	Extent

Vegetation : Sal Forest-SF; Sal Mixed-SM; Deciduous-D; Moist Mixed Deciduous-MMD; Scrub Land-SL; Degraded Scrub Land-DSL;

Terrain: Flat-F; Gentle Slope-GS; Steep Slope-SS;

Biotic Pressure : *Type* : Fire-F; Lopping-L; Grazing-G; *Extent* : Fire->50%=1 (High); 10-20%=2 (Medium); Nil=3 (Low); Lopping-No. of tees lopped; Grazing - (a) No. of cattle dung count (b) Hoof marks - High (H), Medium (M) & Low (L).

Tree Density (P.C.Q.)

Date: Format-6

Compartment No. ....

Location no.	Sample point	T_1	d_1	T_2	d_2	T_3	d_3	T_4	d_4	$D_{(Av.)}$

T = Name of nearest tree from sample point in each quadrat

d = Distance of that tree from sample point in each quadrat

Location Point Vegetation Composition : Trees

Format - 7

Date: ....
Range/Localty: ....
Compartment No.: ....

Altitude:..
Forest type: ....
Fire Incidence: ....

Circular Plot: r = 10 m

Frequency & location no.	Tree species	Phenology	GBH	No. of trees felled	No. of trees lopped	Stand height (m)	Canopy cover (%)

Location Point Vegetation Composition : Shrub

Format - 8

Date: ....
Range/Locality: ....
Compartment No.: ....

Circular Plot : r = 5 m

Frequency & Location No.	Shrub Species	Shrub Height (m)	Dominant Shrubs	Shrub cover (%)	Weed (%)

Location Point Vegetation Composition : Herb

Date: ....
Range/Locality: ....
Compartment No.:.................

Format – 9

Circular Plot : r = 1 m

Frequency & Location No.	Herb/grass species	Herb/grass Height (cm)	Herb/grass cover (%)

Distribution, Wildlife Evidence & Regeneration

Date:..

Transect No.:.........................

Sample Point No.:.................

Format - 1(

Circular Plot : r = 10 m

Disturbance	Distance from nearest habitation (m)					
	Disturbance from nearest road					
Cattle grazing	Dung					
	Hoof marks					
Wildlife evidence	Faecal matter					
	Pugmarks					
	Digging					
	Others					
Nearest water source (m)						
Regeneration						

Disturbance from nearest road : A = Nil (Path Track);
B = Less (Cart Track);
C = Medium; and
D = High (Highway)

Hoof marks : H = High
M = Medium
L = Low

Regeneration (Dominant tree species) : 0 = Nil;
+ = Fair;
++ = Good; and
+++ = Very Good

Biotic Pressures

Format - 11

Transect No:.......

A belt of 10 m each side along the transect

Biotic Pressures	Yes/No	Near sample Point No.	Remarks
Lopping			
Cutting			
MFP collection			
Grass cutting			
Fuel wood collection			
Direct sighting: - cattle			
- human			
- other wild fauna			
Dead animal			

Vegetation Composition : Trees

Format - 12

Date: ....
Range/Locality : ....
Transect No.:................

Compartment No.........................
Sample Point No...................

Altitude:....................................
Fire Incid.:..................................
Topography: ....

Circular Plot : r = 10 m

Tree species	Phenology	GBH	No. of trees felled	No. of trees lopped	Stand height (m)	Canopy cover (%)	Forest Type

Topography : Hill/Hillock - H; Plateau - P; Valley - V; Ravine - Ra.

Soil : Rocky - R; Sandy-Sn; Gravel - G; Loamy - L; Clay - C.

Vegetation Composition : Shrub

Format - 1

Date:......................

Transect No.:...............

Sample Point:.................

Circular Plot : r = 5 m

Shrub species	Shrub height (m)	Dominant shrubs	Shrub cover (%)	Weed (%)

Vegetation Composition : Herb

Format - 14

Date: ....

Transect No.:..............

Sample Point No.: ....

Circular Plot : r = 1 m

Herb/grass species	Herb/grass height (cm)	Herb/grass cover (%)

MFP Collection Information

Format-1

(Village interview

MFP	Eaten by bear (Y/N)	Month		Frequency	Time
		From	To		

MFP Collection Information

Format-15

(Village interview)

MFP	Eaten by bear (Y/N)	Month		Frequency	Time
		From	To		

Crop Damage Information

Format-16
(Village - Interview)

Crop/ Plantation	Phenology		Activity			
	Part	Stage of growth	Feeding	Trampling	Resting	Digging

Crop Damage Assessment

Format-17

Crop:..................

Growth Phase: ....

Sample point no.	Part Eaten	Activity	% Damage

Activity : Feeding - F; Trampling -T; Resting - R; Digging -D