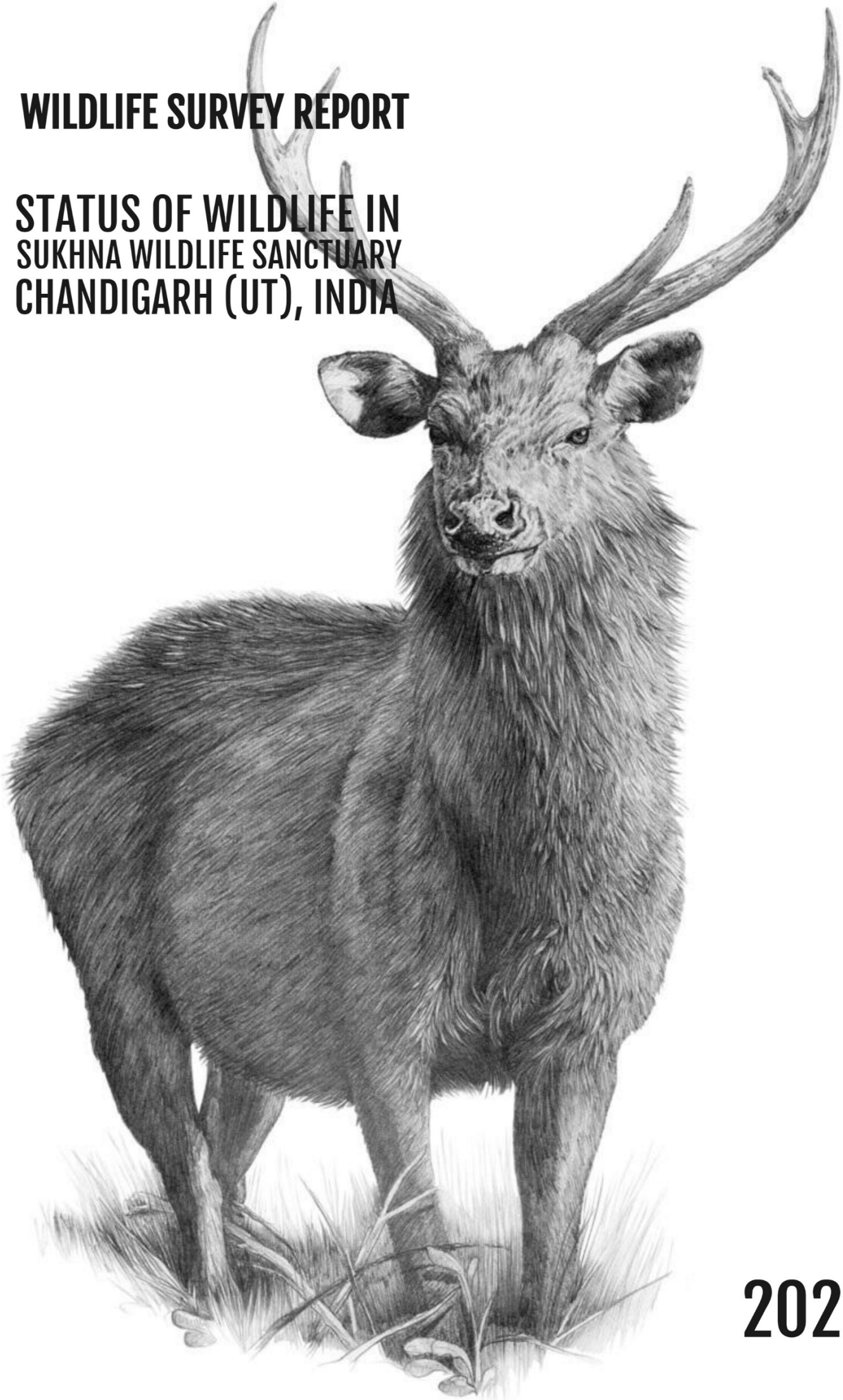
WILDLIFE SURVEY REPORT

STATUS OF WILDLIFE IN
SUKHNA WILDLIFE SANCTUARY
CHANDIGARH (UT), INDIA



2021

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TR. No. 2021/22

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2021

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Published by:
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Technical Report No.: TR NO/2021/22

Word Processing and Layout: WII Team
Map Illustrations: WII Team
Typesetting and Printing: WII Team
Cover: WII Team

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Citation: *Habib. B., Noor, A., Sharma, A., Yadav, N., and Goyal N. (2021): Status of Wildlife in Sukhna Wildlife Sanctuary, Chandigarh – 2021. Technical Report. Wildlife Institute of India, Dehradun 248001, India. Technical Report No. 2021/22. Pp.56.*

Acknowledgements

This report would not have been possible without the support of various persons who actively participated in the wildlife survey which was conducted in Sukhna Wildlife Sanctuary, Chandigarh for 5 days from 5th to 9th May, 2021. The dedication and enthusiasm of the field staff of Department of Forests & Wildlife, Chandigarh (UT) Administration needs a special mention without which this work would not be made possible. We thank Sri. Debendra Dalai, IFS, Chief Conservator of Forests and Chief Wildlife Warden (CCF & CWLW, DFW-CH), and Dr. Abdul Qayum, Deputy Chief Conservator of Forests (DCF, DFW-CH), Chandigarh Administration for their continuous support and facilitation. Time to time help provided by Sri. Devender Chauhan, RFO, Sukhna WLS is also acknowledged and thanked.

We wish to express our profound gratitude to Dr. Dhananjai Mohan, Director, WII. We are equally thankful to the Dean-Faculty of Wildlife Science, WII, Research Coordinator, and the Registrar, WII, for their continuous support in various ways.

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Abbreviations

WLS	Wildlife Sanctuary
UT	Union Territory
DFW-CH	Department of Forests and Wildlife, Chandigarh
PA	Protected Area
WII	Wildlife Institute of India
CWLW	Chief Wildlife Warden
CCF	Chief Conservator of Forests
DCF	Deputy Conservator of Forests
TR	Tiger Reserve

Executive Summary

Sukhna Wildlife Sanctuary (Sukhna WLS) is part of the Union Territory of Chandigarh and falls in the Great Indian Northern Plains near the foothills of the Shiwalik Hills. In process of continuing their effort of having scientific database and information on their wildlife populations and wildlife conservation, the Department of Forest and Wildlife, Union Territory of Chandigarh (DFW-CH), approached Wildlife Institute of India (WII), Dehradun (wide letter Nos. For/2021/50, dated: 06/04/21 and For/2020/0074, dated: 24/02/2020) to assist in capacity building of the field personnel in conducting wildlife surveys in Sukhna Wildlife Sanctuary, the only Protected Area (PA) of the UT. Subsequently, WII prepared an outline for the wildlife surveys for which initial training of the field personnel was considered as a prerequisite to further the survey program. Following this, WII conducted a capacity building and training workshop to train the frontline staff so that they collect scientifically robust data and get acquainted with the methods to be employed during the execution of project activities.

A day-long training workshop was then held at the Chandigarh Botanical Garden, on 22nd April 2021 in the presence of 17 attendees. The DFW-CH personnel were trained in employing different field techniques such as line transect sampling, sign surveys, point counts, and use of necessary equipment (e.g. GPS units, binoculars, range finders, etc.) required during the surveys. In-field exposure to the techniques and equipment was made before starting the main survey to validate the sampling techniques. Shri Debendra Dalai, Chief Conservator of Forests and Chief Wildlife Warden (CCF&CWLW, DFW-CH), and Dr. Abdul Qayum, Deputy Chief Conservator of Forests (DCF, DFW-CH) also presided over the training workshop. Subsequently, the primary data collection process for Sukhna WLS was conducted by the DFW-CH in a five-day programme beginning 5th May to 9th May 2021.

A total of 10 line transects (2 km each) inside Sukhna WLS and an additional four transects outside Sukhna WLS were sampled with an overall effort of 88 km of transect walk (80 km walk effort was made inside Sukhna WLS and 8 km walk effort in forest patches outside the Sukhna WLS). This effort yielded a total of 223 direct observations (195 inside and 28 outside Sukhna WLS) consisting of 13 wildlife species that included four ungulates, two primates, two carnivore species, one rodent, and reptile species each, two bird species, and also free-ranging stray dogs Due to low sample size of observations, the density of species other than Sambar could not be estimated with robustness. The density and other parameters of other species were not calculated because of the very low sample sizes as n>40 were considered adequate for data analysis in Distance software. Thus, data from all 14 transects of Sukhna WLS (transects which were inside as well as those monitored outside the sanctuary) were pooled for density and other parameters estimation for Sambar. Observations of other species such as Nilgai, Wild boar and Hanuman langur were pooled to estimate global detection probability which then was used to estimate the density estimates for these species, assuming they have uniform detectability in the environment. Therefore, further conservation and management strategies should consider these findings with caution.

Sambar had the highest density (number of individuals/km^2) of 18.08±4.22, followed by Nilgai (2.01±0.57), and Wild boar (1.17±0.33) in Sukhna WLS during the survey.

The mean group size of Wild boar was the highest with 4.28±0.89 (median = 4; range = 1–12) followed by Chital (3.5±0.5; median = 4; range = 2–5), and Nilgai (3.20±0.55; median = 2; range = 1–10). Sambar had the mean group size of 2.57±0.22 (median = 2; range = 1–16). Hanuman langur's grouping tendency averaged at 2.54±0.72 (median = 1; range = 1–8) while the Indian peafowl had mean group size of 2.42±0.29 (median = 2; range = 1–5). The detection probability varied from lowest of 0.41 to 0.56 for Sambar and pooled prey species, respectively.

The population estimates obtained through extrapolation of the density estimates on the area of the sanctuary puts Sambar as the dominant species with an estimated population of *ca*. 290–763 individuals. The population estimate of Sambar obtained during the current survey is more robust than the estimate obtained during the previous surveys owing to several reasons including more amount of effort and area coverage undertaken this time (80 km compared to 16 km previously), more number of observations (N=138) than previously (N=21) and lower CVs associated with the estimates. Indian peafowl's population could not be estimated due to low number observations (N=14) although an estimate of population could be made during the previous survey. Population estimates of other species such as Nilgai could not be estimated due to low number of observations.

A total of 10 trails or routes of variable length (average=5.05 km; 4–5.5 km) and totalling an effort of 50.5 km (with 34:54 man hours) were walked in 10 beats across Sukhna WLS during the wildlife survey period. A total of 286 observations of indirect signs such as droppings, scats, footprints/pugmarks, scratch marks, pellets, etc. were made based on which 13 species could be identified. Interestingly, presence of barking deer was ascertained by indirect evidence only and in case of carnivores, leopard pugmarks were also recorded which could not be confirmed based on direct observations.

A total of 30 points for counting birds were sampled across the 10 transects (three point count stations at each transect with inter-station distance of 400 m) during the survey. The same points were used for broad characterisation of habitat and vegetation. A total effort of 60 point samplings were conducted yielding a total of 67 species of birds belonging to 32 families and 15 orders were identified in the point transects. Of these observed species, ca. 28% of the species had more than 10 observations. Indian peafowl was the most abundant (N=59) species recorded, followed by red-wattled lapwing (N=30) and the red junglefowl (N=26). Among the species recorded with less frequency 20 species were recorded only once.

Conclusions and Recommendations

1. Despite being small in area, Sukhna WLS supports good biological diversity and has the potential to be considered as one of the important wildlife and biodiversity conservation area. Therefore, steps should be undertaken to have plans for regular monitoring and research programs targeting not only the sanctuary but also its surrounding forested areas.

2. Sambar is the most abundant ungulate species in the Sukhna WLS with the highest density similar to Rajaji TR. The estimated population of Sambar in the sanctuary stands at *ca*. 290–763.

3. For the first time, adjacent areas lying outside the Sukhna WLS were also surveyed during the current survey. Although, Nilgai observations were dominated large congregations of Sambar were observed in these forest areas which are adjacent to Sukhna forest areas. It is established based on the observations that species move out of the sanctuary therefore, understanding the quality of these habitat patches and connectivity between these areas is necessary.

4. The presence of feral cattle and free-ranging stray dogs inside Sukhna WLS also got confirmed. Their presence can be a potential source of many problems to wildlife such as competition for resources, the potential of disease transfer to wildlife, etc. This problem needs to be dealt with timely and appropriate management interventions. This aspect needs to be studied thoroughly in a long-term research project.

5. Long-term monitoring employing advanced research methods such as camera trapping should be conducted through a research project of at least 2 years is recommended so that sound, reliable and robust data is collected and ecological parameters can be assessed.

6. Independent long-term bird surveys for resident breeding, as well as wintering birds, are recommended so that sound, reliable and robust data can be collected on ecological parameters of the species.

7. Given the high abundance of Sambar and the presence of other important wildlife in the sanctuary, it is also recommended that a detailed study on habitat characterization and vegetation community structure should be undertaken to understand wildlife–habitat relationships in the sanctuary.

8. Awareness programs need to be conducted regularly so that local people get involved proactively in the biodiversity conservation process.

1 Introduction

India is home to a large variety of wildlife species. The various ecosystems ranging from the Himalayas in the north to the evergreen rain forests in the south, the arid sand deserts of the west to the marshy mangroves of the east. The country is one of the most bio-diverse regions of the world and contains three of the world's 36 biodiversity hotspots – the Western Ghats, the Eastern Himalayas, and the Indo-Burma hotspot (Myers et al. 2000). All these biodiversity areas and ecosystems support a wide range of wildlife that has an important role in maintaining the balance of nature and the natural environment. Conservation managers devote a considerable amount of time and resources in preserving the wildlife. Monitoring the wildlife species for their distribution, abundance, and density is one of the critical tasks in wildlife management to evaluate the effects of management decisions and also for their conservation. It is a process, the end product of which is not only the numbers of a species but also an indication that there has been a change in the number of a species, with an understanding of the factors that have been responsible for this change. At the same time, the data generated during the surveys should meet the needed scientific rigor for analysis and appropriate inferences as accurate and consistent data collection allows for tracking population trends and assessing the efficiency of their interventions.

1.1 Union Territory of Chandigarh

The Union Territory (UT) of Chandigarh, one of the first planned cities in post-independence India is the joint Capital of the states of Punjab and Haryana. It is the fifth-largest Union Territory covering an area of 114 km^2, which is 0.003% of the geographical area of the country. Physiographically, the UT falls in the Great Indian Northern Plains near the foothills of the Shiwalik Hills (ISFR 2019). The average annual rainfall varies from 400 mm to 600 mm and the average annual temperature ranges between 1 °C to 45 °C. The UT has a population of 1.06 million amounting to 0.09% of India's population (Census 2011). The rural and urban population constitutes 2.75% and 97.25 %, respectively. The population density of UT is 9258 persons/km^2. The livestock population of Chandigarh UT is 24197 (Livestock Census 2012).

1.1.1 Forest and Vegetation Types

There are two forest types as per the Champion and Seth (1968) classification i.e. 5B/C2 Northern Mixed Dry Deciduous Forest (48.33 % of forest cover), 5B/DS1 Dry Deciduous Scrub (0.09% of forest cover). The major area of the UT is under plantation (51.58% of forest cover). The Dominant tree species of Chandigarh include *Dalbergia sissoo* (Shisham), *Leucaena leucocephala* (Safed babool), *Acacia catechu* (Khair), *Melia azadirachta* (Bakain), *Populus* spp., *Terminalia arjuna* (Arjuna), *Cassia fistula* (Amaltas), and *Acacia arabica* (Keekar).

1.1.2 Forest Cover

The Forest Cover in the UT is ~22.03 km^2 which is 19.32% of the UT's geographical area (ISFR 2019). There has been an increase of 0.41% from the previously reported 21.56 km^2 in 2017 (ISFR 2017). In terms of forest canopy density classes,

the state has 1.36 km^2 under Very Dense Forest (VDF), 14.24 km^2 under Moderately Dense Forest (MDF), and 6.43 km^2 under Open Forest (OF). The Protected Area (PA) Network of the UT comprises the two Wildlife Sanctuaries, Sukhna Wildlife Sanctuary, and the City Bird Sanctuary.

1.2 Sukhna Wildlife Sanctuary

Sukhna Wildlife Sanctuary (hereafter Sukhna WLS) is part of the Union Territory of Chandigarh and is located in the north-east of the city Chandigarh. The sanctuary with an area of 25.98 km^2 lies between 30˚17' N to 30˚11' N Latitudes and 76˚16' E to 76˚29' E Longitudes. It is a catchment of the famous Sukhna Lake, which flanks the city's north-eastern edge. It lies in the outermost Shivalik range and consists typically of conglomerates and loose strata which have been gullied by weathering into the semblance of hills and nullahs geologically. Thus, there is an altitudinal variation of 346 m to 620 m from mean sea level. Since, Sukhna WLS falls in these Shivalik Hills, which are ecologically sensitive and geologically unstable, it is highly prone to soil erosion during rains and represents a fragile eco-system. According to Champion and Seth (1968), Sukhna WLS represents 5B/C1 Northern Tropical Dry Mixed Deciduous Forests and 5/DS1 Dry Deciduous Scrub spread over the Shivalik Hills and the adjoining alluvial plains, yet it is rich in terms of diversity of its flora and fauna (Anonymous 2018).

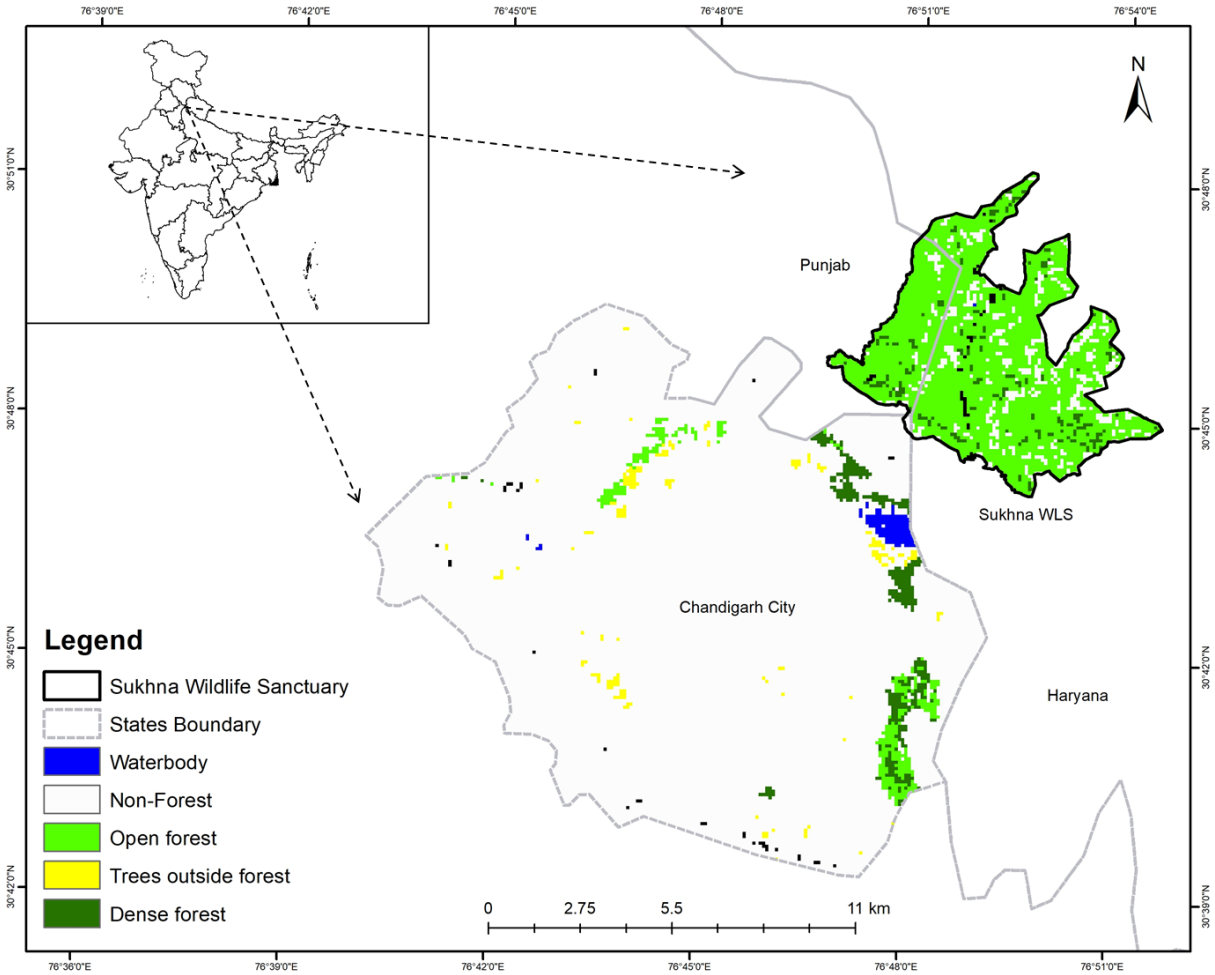


Figure 1: Location of Sukhna Wildlife Sanctuary, Chandigarh

1.2.1 Biodiversity Values of Sukhna WLS

The mammalian fauna found in Sukhna WLS includes Sambar (*Rusa unicolor*), Chital (*Axis axis*), Nilgai (*Boselaphus tragocamelus*), Indian pangolin (*Manis crassicaudata*), wild boar (*Sus scrofa*), barking deer or Indian muntjac (*Muntiacus muntjac*), golden jackal (*Canis aureus*), small Indian civet (*Viverricula indica*), jungle cat (*Felis chaus*), Indian crested porcupine (*Hystrix indica*), Hanuman langur (*Semnopitheaus entellus*), rhesus macaque (*Macaca mulatta*), Indian hare (*Lepus nigricollis*), Indian grey mongoose (*Urva edwardsii*), etc. In case of avifaunal elements, more than 150 species of birds have been recorded including water birds. Prominent among them are Indian peafowl (*Pavo cristatus*), red junglefowl (*Gallus gallus*), Grey francolin (*Ortygornis pondicerianus*), Great hornbill (*Buceros bicornis*), and several other species belonging to families like Passeriformes, Columbiformes, Piciformes, etc. Several species of reptiles have also been reported from the sanctuary which includes species like Indian cobra (*Naja naja*), Indian rat snake (*Ptyas mucosa*), Common krait (*Bungarus caeruleus*), Russell's viper (*Daboia russelii*), Indian python (*Python molurus*), and Common Indian Monitor Lizard (*Varanus bengalensis*). Also, there is a wide variety of Butterflies, Moth, Honey-bee, and other micro-organisms that are in abundance.

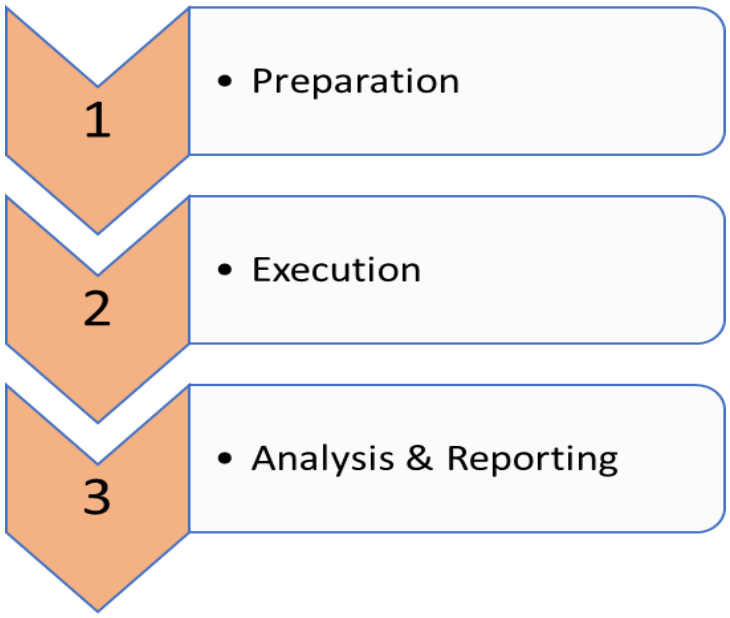
In case of flora, the Sukhna WLS boasts to have more than 40 tree species, ~18 shrub species, ~10 species of climbers, ~28 types of herbs, and ~16 species of grasses besides some other species. Notable species found in the area include *Acacia catechu* (Khair), *Bombax ceiba* (Semul), *Acacia arabica* (Kikar), *Azadirachta indica* (Neem), *Dalbergia sissoo* (Shisham), *Butea monosperma* (Dhak), *Cordia myxa* (Lasura), *Diospyros montana* (Kendu), *Zizyphus jujube* (Ber), *Murraya koengii* (Kari patta), *Vitex negundo* (Nirgundi), *Carissa spinarum* (Karaunda), *Adhatoda vasica* (Vasaka), *Abrus precatorius* (Rati), etc. Bamboo also exists in some patches. The area in riverbeds is covered by grasses such as *Saccharum munja*, *Eulaliopsis binata*, and elsewhere including ridges by *Apluda mutica*, *Heteropogon contortus*, *Cymbopogon parkeri*, etc. (Anonymous 2018).

2. The Wildlife Survey

2.1 Background

In pursuit of having a scientific database and information on their wildlife populations, the Department of Forest and Wildlife, Union Territory of Chandigarh (henceforth DFW-CH), requested the Wildlife Institute of India (WII), Dehradun (wide letter Nos. For/2021/50, dated: 06/04/21 and For/2020/0074, dated: 24/02/2020) to help build the capacity of the field personnel in conducting wildlife surveys in Sukhna Wildlife Sanctuary, the only Protected Area (PA) of the UT.

Subsequently, WII prepared an outline for the wildlife surveys for which initial training of the field personnel was considered as a prerequisite to further the survey program. Following this, WII conducted a capacity building and training workshop to train the frontline staff so that they collect scientifically robust data and get acquainted with the methods to be employed during the execution of project activities. Thus, the whole exercise was divided into three major phases as shown below:



A general schema for the survey protocol proposed

2.1.1 Preparation and Training

A day-long training workshop was held at the Chandigarh Botanical Garden, on 22nd April 2021 in the presence of 17 attendees. The DFW-CH personnel were trained in employing different field techniques such as Distance sampling, sign surveys, point counts, and use of equipment (e.g. GPS units, binoculars, range finders, etc.) required during the surveys. In-field exposure to the techniques and equipment was made before starting the main survey to validate the sampling techniques. Shri Debendra Dalai, Chief Conservator of Forests and Chief Wildlife Warden (CCF & CWLW, DFW-CH), and Dr. Abdul Qayum, Deputy Chief Conservator of Forests (DCF, DFW – CH) also presided over the training workshop.

2.1.2 Execution

Status assessment and monitoring exercise has an ultimate objective that is the findings of the study which are then used for conservation management and policy formulation. To do that, the agencies responsible for wildlife management must be involved in the assessment so that they can make required changes in management and policy implementation. Hence, the primary data collection process or the execution of actual wildlife surveys was done by the DFW-CH for Sukhna WLS in a five day programme. The surveys were conducted starting from 5th May to 9th May, 2021 as presented in Table 1 below. Two major taxonomic categories *viz*. mammals and birds were targeted during the survey. Different methods such as line transect, sign survey, point count, and habitat characteristics assessment were used.

CCF&CWLW and DCF, DFW-CH and frontline personnel and WII team at the Training Workshop organised on 22nd April, 2021 at the Botanical Garden, Chandigarh.

To commemorate the occasion of annual Earth Day (22nd April) and to demonstrate support for environmental protection, a plantation drive was also led by the CCF&CWLW and DCF, DFW-CH in the Botanical Garden, Chandigarh.

Table 1: Summary of survey activity and time schedule followed during the wildlife surveys in Sukhna WLS between 5th May and 9th May, 2021

Day	**Day 1**		**Day 2**		**Day 3**	**Day 4**	**Day 5**
Activity	Morning (AM)	Evening (PM)	Morning (AM)	Evening (PM)	Morning (AM)	Morning (AM)	Morning (AM)
Line Transect (Total 14; 2 km each)	06:00 – 08:00	04:30 – 06:30	06:00 – 08:00	04:30 – 06:30			
Vegetation Sampling (3 points per transect)	08:00 – 11:00						
Sign Survey (10; 4–5.5 km trail walk)					06:00 – 09:30		
Point Count (3 points per transect; 10 min duration each)						06:00 – 08:00	06:00 – 08:00

2.1.2.1 Line Transect Sampling

This part of the execution phase started with the delineation of transects across different habitats of the Sukhna WLS. For ungulates (Chital, Sambar, Nilgai, barking deer, etc.) and ground dwelling birds (e.g. Indian peafowl and Red junglefowl) line transect of 2 km length was set for monitoring in a beat or habitat. Each transect was sampled four times during morning and evening for two consecutive days (Table 1). For each transect the point of beginning and end point coordinates were recorded by a hand held GPS unit. The perpendicular distance at which the animal was sighted at first was recorded. Animals were considered to belong to two different groups if they were separated by a distance of 30 m or more. For each sighting data on time of the sighting, perpendicular distance of the species, name of the species, group size, and the composition of the group (age and sex) was recorded in a prescribed format (Appendix I).

2.1.2.2 Sign Survey

For all the major mammalian predator or carnivore species of the Sukhna WLS sign surveys were carried out. Sign surveys were conducted along trails, riverbeds, and *nullahs* by searching for the signs intensively as most of the animals tend to use these landscape features. Trail covering *ca*. 5 km distance was surveyed. The GPS coordinates of the beginning and endpoints of each path trail were recorded. A brief description of the topography and forest type along with GPS coordinates were also recorded for each sign encountered. In case of pugmark trails, each trail set was considered as one sign and not each pugmark as one sign. All the data to be collected was instructed to be recorded in the prescribed format. (Appendix II)

2.1.2.3 Habitat and Vegetation Characteristics

In order to get information about the habitat characteristics, quantification of vegetation and habitat parameters was conducted along each transect (as mentioned above). For each transect line, the broad habitat type and associated terrain types were recorded along with time and GPS location. A circular plot of a 10 m radius was used to record the required information like tree number, tree species (if possible to identify), canopy cover, shrub cover was estimated visually. Thus, three plots spaced at every 400 m along a transect line, were used for vegetation and habitat sampling. Data on disturbance caused by human and livestock presence was also recorded within the same plots. All the data was recorded in the prescribed format (Appendix III).

2.1.2.4 Point Count

In order to sample the bird fauna of the Sukhna WLS, point counts (Bibby et al. 1992) were conducted on the pre-defined transect lines. A point count of 10 min duration was conducted at three points (at same place where vegetation sampling plots were located) on the transect line. Point count sampling was done early in the morning for two hours (06:00 h to 08:00 h) in each beat for two consecutive days (Table 1). All the data was recorded in the prescribed format (Appendix IV).

3. Status of Wildlife in Sukhna WLS

3.1 Line transect

A total of 10 line transects (Buckland et al. 2015) spreading across forest beats of Sukhna WLS were marked and laid for wildlife survey. Additionally, four transects were also marked in forest patches lying outside the Sukhna WLS which were sampled only once (Fig. 2). Thus, an overall effort of 88 km of transect walk was attempted during the wildlife surveys of which 80 km walk effort was made inside Sukhna WLS and 8 km walk effort in forest patches outside the Sukhna WLS (Table 2). This effort yielded a total of 223 direct observations (195 inside and 28 outside Sukhna WLS) consisting 13 wildlife species that included four ungulates, two primates, two carnivore species, one rodent and reptile species each, two bird species, and also free ranging stray dogs (Appendix V).

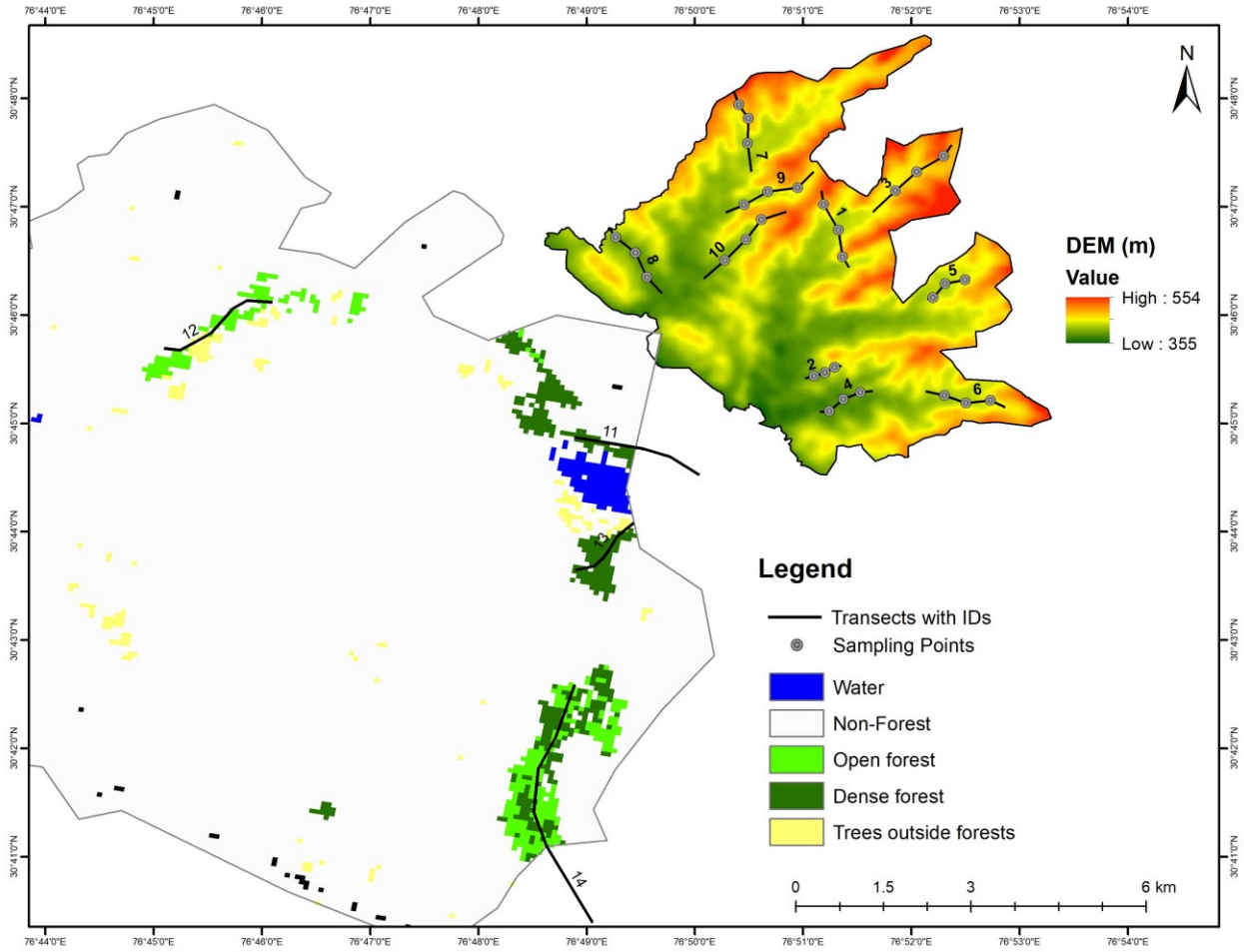


Figure 2: Distribution of line transects laid in Sukhna WLS during the wildlife survey between 5th and 9th May, 2021

Table 2: Details of transect walk effort attempted inside and outside of Sukhna WLS during the wildlife surveys between 5th and 9th May, 2021.

	Inside Sukhna WLS	Outside Sukhna WLS
No. of Beats Surveyed	10	-
No. of Transects Walked	10	04
Length of Each Transect (km)	2	2
No. of Temporal Replication on Each Transect	4	1
Total Distance Covered (km)	80	8
Total No. of Observations	195	28
No. of Species Recorded	12	5

Transect No./ID	Start and End	Beat Name	Forest Division	Range
1	Dam No. 2 Bolion wala to Saluni wala Choe	Tootawali - Piplanwala	Chandigarh (U.T.)	Nepli
2	Ghatiwala to Latanwala trail (500 m)	Ghatiwala to Latanwala trail (Lower Nepli)	Forest & Wildlife Department, Chandigarh	Nepli
3	Budhewala Choe to Karondawala Dam No. 1	Ambika beat/ Nathewala block	Chandigarh	Nepli
4	Jhulahewala to Jhulahewala top	Lower Ghaheri	Chandigarh	Nepli
5	Neemwala chowk to Neemwala Dam No. 1	Nepli upper block	Chandigarh	Nepli
6	Nepli inspection hut to Chamranvala Dam No. 1	upper Nepli & upper Ghareri	Chandigarh	Nepli
7	Mundrawala Dam to Punjab boundary	Broti wala range (South & North)	Chandigarh	Chandigarh
8	Road to gagianwala Choe (Dam No. 1)	Khuda Ali Sher	Chandigarh	Chandigarh
9	Memnewala Choe in Kansal beat, Kansal Block, Chandigarh	Kansal beat, Kansal Block	Chandigarh	Chandigarh
10	Near Jamonwala Dam No. 4 to top of Jamonwala Choe	Kansal beat	Chandigarh	Chandigarh
11	Nature trail, Lake forest (Outside Sukhna WLS)	Lake beat	Chandigarh	Chandigarh
12	Patiala ki rao (Outside Sukhna WLS)	Patiala ki rao	Chandigarh	Chandigarh
13	Manimajra forest area Sector 26 (Outside Sukhna WLS)	Manimajra	Chandigarh	Nepli
14	CTU Workshop to Raipur Khurd Hallo Majra (Outside Sukhna WLS)	Hallo Majra	Chandigarh	Nepli

3.1.1 Wildlife species observed inside Sukhna WLS

Amongst the four ungulate species observed during the transect walks, the highest number of observations were made for Sambar (N=134) followed by Wild boar (N=9) and Nilgai (N=7). Chital was the least observed species with total number of sightings as five only (Fig. 3).

In case of the two primate species recorded from the Sukhna WLS, Hanuman langur dominated the frequency with a total number of 13 observations. No observation of Rhesus macaque was recorded during the whole transect walk effort inside the sanctuary (Fig. 3).

During the whole survey using line transect the two ground dwelling avian species recorded were Red junglefowl and the Indian peafowl. The Indian Peafowl had most number of sightings (N=14) whereas, the Red junglefowl was observed only once during the whole transect walk effort (Fig. 3).

Other wild species recorded during the transect walks included Golden jackal (N=1), Indian porcupine (N=5), common monitor (N=2), and Indian grey mongoose (N=2). Apart from these wild species, presence of free ranging feral dogs was also recorded at two occasions within the sanctuary.

3.1.2 Wildlife species observed outside Sukhna WLS

Line transect based surveys conducted outside Sukhna WLS yielded only 28 sightings of wildlife majority (N=27) of which were of ungulate fauna. Amongst the four ungulate species observed outside, the highest number of observations were that of Nilgai (N=17) followed by Sambar (N=4) and Wild boar (N=05). Chital was the least observed species with only one sighting (Fig. 4).

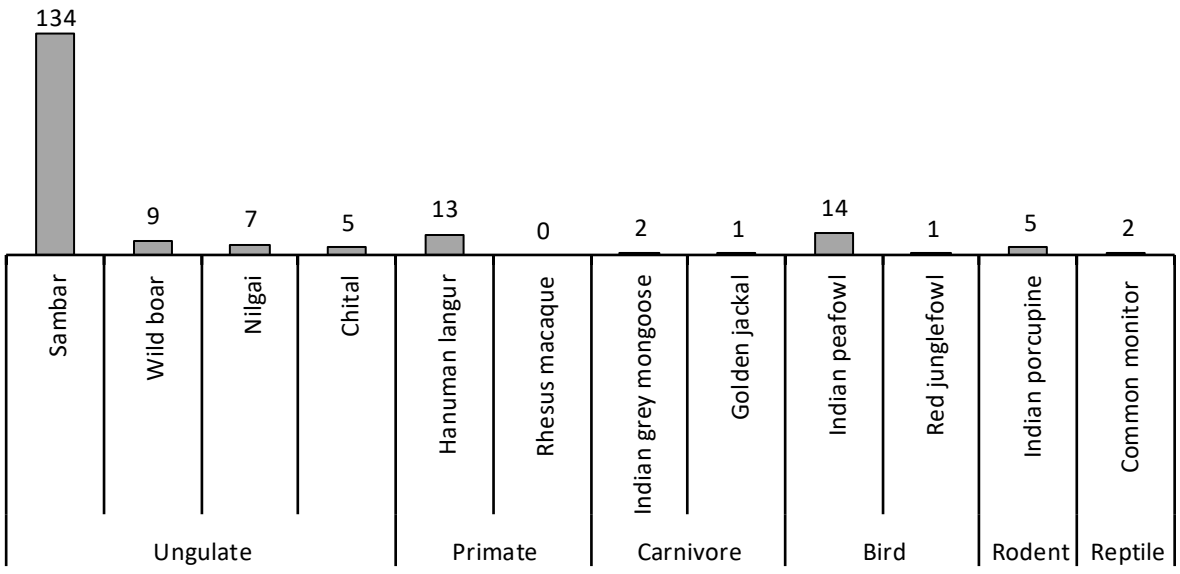


Figure 3: Number of observations of species recorded during the line transects based wildlife survey **inside Sukhna WLS**, Chandigarh between 5th and 9th May, 2021.

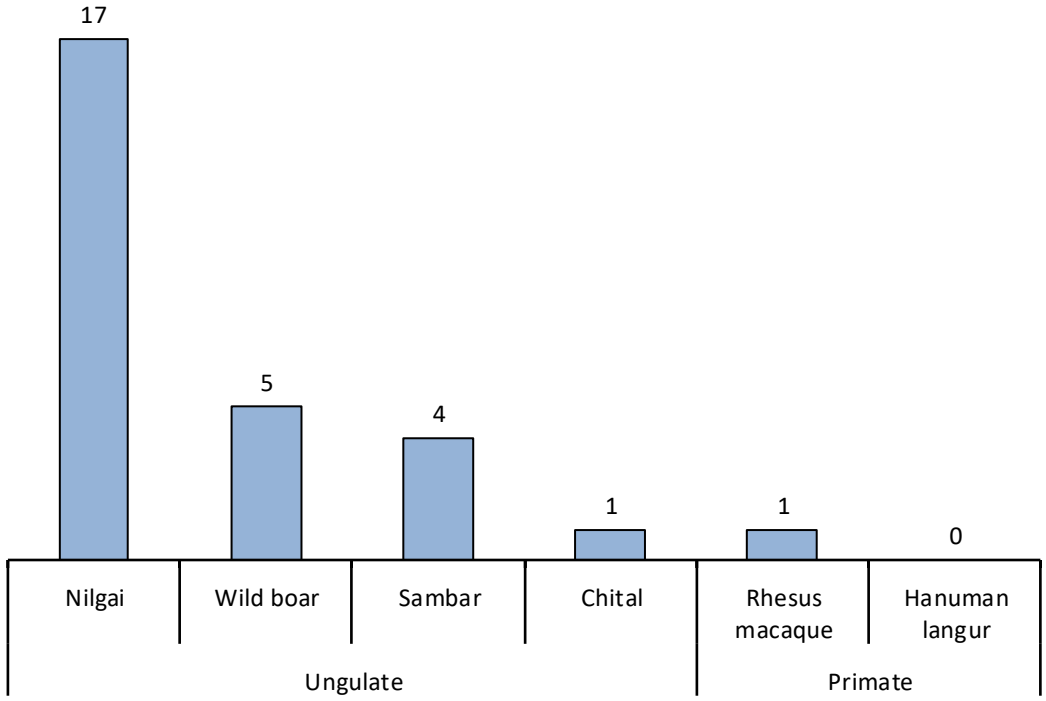


Figure 4: Number of observations of species recorded during the line transects based wildlife survey **outside Sukhna WLS**, Chandigarh between 5th and 9th May, 2021.

3.1.3 Estimation of density and other parameters

Density estimation and the estimation of other parameters were done for five species, Sambar, Nilgai, Hanuman langur, Wild boar and Indian Peafowl using Distance software version 7.0 (Buckland et al. 2015). The density and other parameters of other species were not calculated because of the very low sample sizes as n>40 were considered adequate for data analysis in Distance software. Thus, data from all 14 transects of Sukhna WLS (transects which were inside as well as those monitored outside the sanctuary) were pooled for density and other parameters estimation for Sambar. Observations of other species such as Nilgai, Wild boar and Hanuman langur were pooled to estimate global detection probability which then was used to estimate the density estimates for these species (Burnham et al. 1980; Buckland et al. 1993), assuming they have uniform detectability in the environment. Therefore, the estimates obtained should be considered for the whole landscape surveyed comprising the sanctuary and the immediate surroundings surveyed.

A) Individual density

Amongst the ungulate species for which densities were estimated, Sambar had the highest individual density (number of individuals/km^2) with 18.08±4.22 in the Sukhna WLS (Table 3). The estimates obtained for pooled observations of three species are also presented in Table 3. Based on these estimates and detection probability, the density estimate obtained for Nilgai was 2.01±0.57. Wild boar individual density was estimated to be 1.17±0.33 in Sukhna WLS during the survey. In case of Hanuman langur had individual density of

1.005±0.28. Density estimate for Indian peafowl could not be estimated owing to low sample size.

B) Group Density

In Sukhna WLS, the group density (number of groups of animals/km^2) of Sambar was 9.25±2.09 (Table 3). For other species when pooled the group density was estimated as (1.04±0.27).

C) Group Size

The mean group size of Wild boar was the highest with 4.28±0.89 (median = 4; range = 1–12) followed by Chital (3.5±0.5; median = 4; range = 2–5), and Nilgai (3.20±0.55; median = 2; range = 1–10) (Fig. 4). Sambar had the mean group size of 2.57±0.22 (median = 2; range = 1–16). In case of primates, Hanuman langur was the only primate species that had enough observations for group size estimation and its grouping averaged at 2.54±0.72 (median = 1; range = 1–8). Amongst bird species observed, the Indian peafowl had mean group size of 2.42±0.29 (median = 2; range = 1–5) (Fig. 5).

D) Encounter Rate

The encounter rate (no. seen /km walk) estimated based on direct observations was highest for Sambar (1.38) (Table 3). For other species when pooled the encounter rate was estimated as 0.18.

E) Detection probability

The detection probability varied from lowest of 0.41 to 0.56 for Sambar and pooled prey species, respectively (Table 3). The variation of detection probability against the perpendicular distance is shown in Fig. 6.

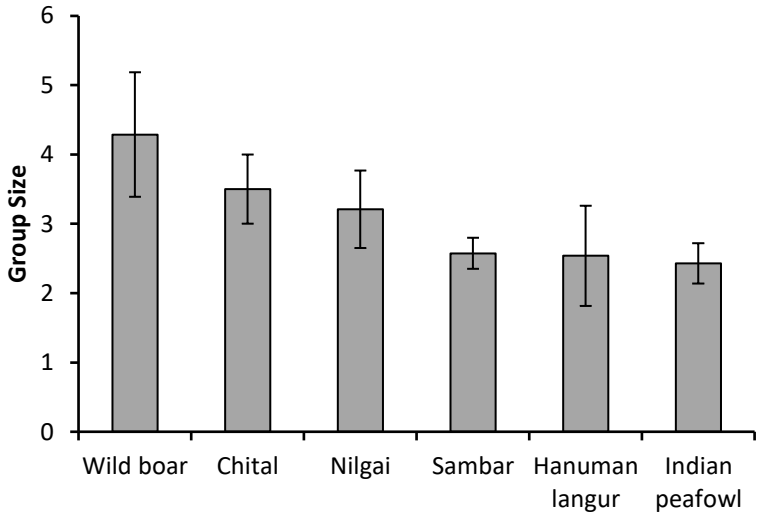


Figure 5: Overall group size variation in some species (species with >5 observations) observed during the wildlife survey in Sukhna WLS between 5th and 9th May, 2021.

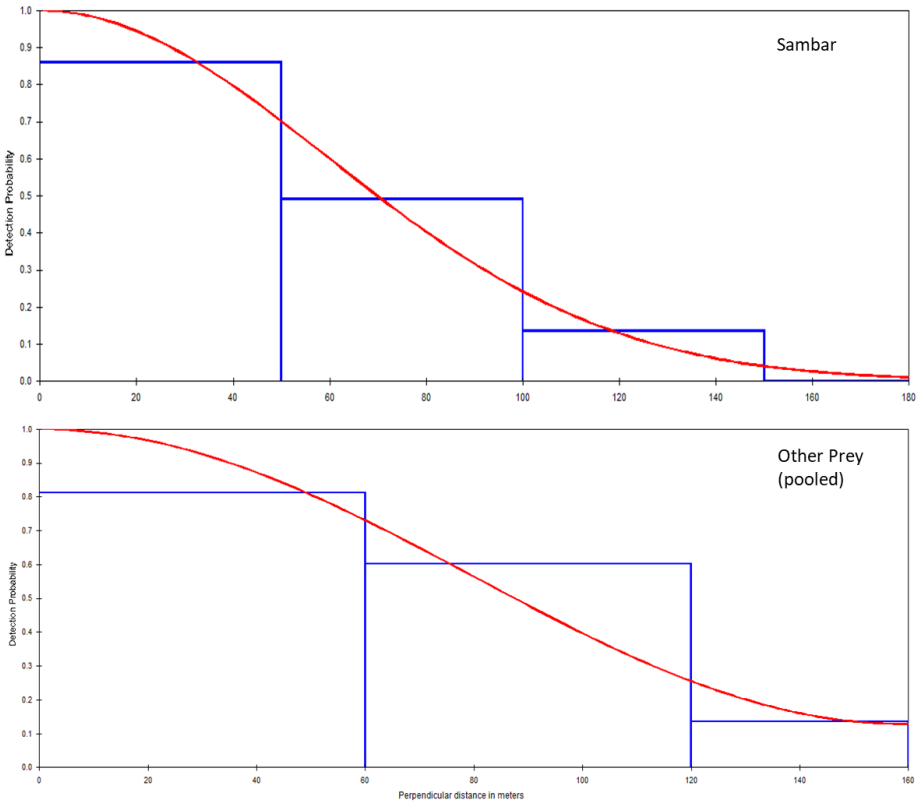


Figure 6 Variation of detection probability against perpendicular distance for Sambar and other prey species (Nilgai, Wild boar and Hanuman Langur - when pooled) observed during the wildlife survey in Sukhna WLS between 5th and 9th May, 2021.

Table 3: Individual density, group density, effective strip width, detection probability and encounter rate of Sambar and other prey species (Nilgai, Wild boar and Hanuman Langur - when pooled) recorded during the wildlife survey in the Sukhna WLS, Chandigarh between 5th and 9th May, 2021.

	Model* & Adjus.	Individual Density (±SE) (No./km^2)	%CV	Group Density (±SE) (No./km^2)	%CV	Effective Strip Width (±SE) (m)	%CV	Detection Probability (±SE)	%CV	Encounter Rate (No. seen /km walk)	%CV	*P* of χ^2
Sambar	HN + Cosine	18.08±4.22	23.37	9.25±2.09	22.6	74.26±5.29	7.13	0.41±0.29	7.13	1.38	21.45	0.58
Prey (Pooled observations of Nilgai, Wild boar and Hanuman langur	UN + Cosine	4.19±1.2	29.84	1.04±0.27	26.54	90.23±7.9	8.78	0.56±0.49	8.78	0.18	25.04	0.56

* - HN = Half Normal, UN = Uniform

3.2 Sign survey

A total of 10 trails or routes (detailed in Table 2; S. No. 1 to 10) of variable length (average=5.05 km; 4–5.5 km) and totalling an effort of 50.5 km (with 34:54 man hours) were walked in 10 beats across Sukhna WLS during the wildlife survey period. A total of 286 observations were made based on which 13 species could be identified based on their indirect signs such as droppings, scats, footprints/pugmarks, scratch marks, pellets, etc. (Appendix VI).

Maximum number of signs was recorded for Sambar (173), followed by Wild boar (33), and Nilgai (27) amongst the large herbivore mammals. Interestingly, the barking deer (*Muntiacus muntjac*), which was not observed directly during the transect walks, pellets were also observed in one of the survey routes. In case of carnivores, leopard (*Panthera pardus*) pugmarks were also recorded which could not be confirmed based on direct observations in the previous sections (Table 4). The signs of disturbance were also recorded in some beats in the form of catlle dung and free ranging stray dogs.

Distribution of observations and species and proportion of species across the surveyed routes or trails is presented in Figures 7 and 8, respectively. Maximum number of observations of signs made and number of species identified was in areas where trails 7–10 were located (Fig. 7). Furthermore, among the species observed across these areas with trails (7–10), Sambar, Wild boar, Nilgai were the most observed species (Fig. 8).

Table 4: Number of observations and species recorded during the sign survey conducted in Sukhna WLS between 5th and 9th May, 2021.

Species	**Name**	**Family**	**No. of observations**
Sambar	*Rusa unicolor*	Cervidae	173
Chital	*Axis axis*	Cervidae	3
Barking deer	*Muntiacus muntjac*	Cervidae	1
Wild boar	*Sus scrofa*	Suidae	33
Nilgai	*Boselaphus tragocamelus*	Bovidae	27
Hanuman langur	*Semnopithecus entellus*	Cercopithecidae	1
Leopard	*Panthera pardus*	Felidae	3
Jungle cat	*Felis chaus*	Felidae	2
Indian porcupine	*Hystrix indica*	Rodentia	19
Golden jackal	*Canis aureus*	Canidae	11
Indian pangolin	*Manis crassicaudata*	Manidae	2
Indian peafowl	*Pavo cristatus*	Phasianidae	6
Cattle	*Bos domesticus*	Bovidae	5
		Total	286

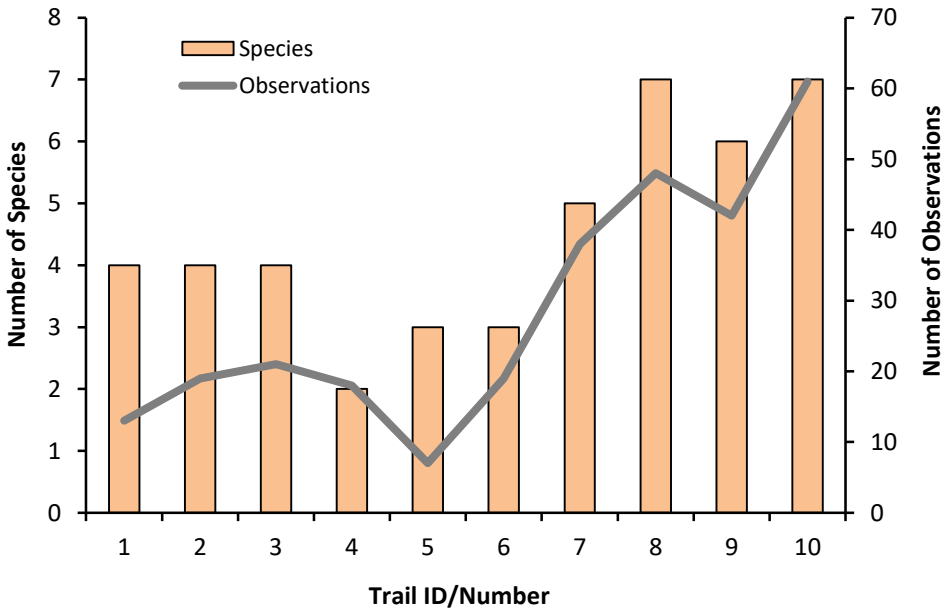


Figure 7: Distribution of observations made and number of species recorded along the survey routes/trails during the sign survey in Sukhna WLS between 5th and 9th May, 2021.

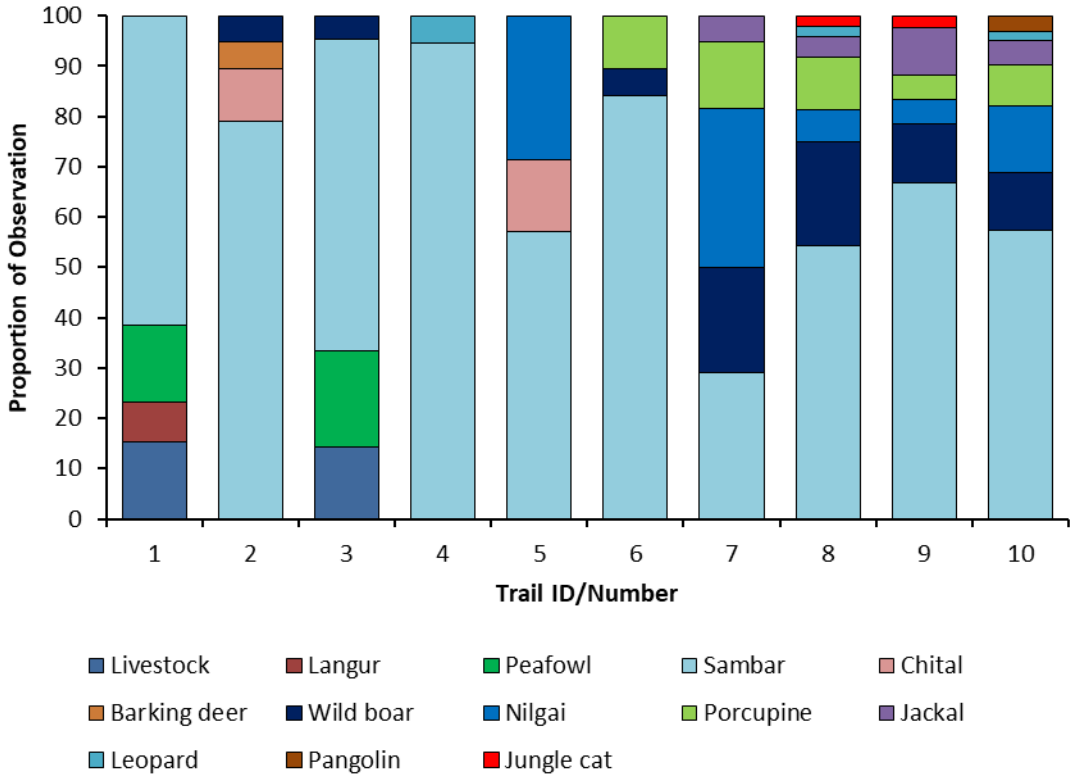


Figure 8: Proportion of species observed across the survey routes/trails during the sign survey in Sukhna WLS between 5th and 9th May, 2021.

3.2.1 Encounter rate

The encounter rates (Marsden et al. 2016) based on indirect evidences or signs of species identified were calculated and the highest encounter rate was found to be that of Sambar (3.373±0.534), followed by Wild boar (0.625±0.225), Nilgai (0.516±0.254). The encounter rates of other species are provided in Table 5. Hotspot maps generated for a few species are provided in Appendix VII.

Table 5: Encounter rates (No./km) of species based on indirect evidences recorded during the sign surveys in Sukhna WLS during 5th to 9th May, 2021.

S. No.	Species	Mean Encounter Rate (±SE)
1	Sambar	3.373±0.534
2	Chital	0.070±0.052
3	Barking deer	0.025±0.025
4	Wild boar	0.625±0.225
5	Nilgai	0.516±0.254
6	Hanuman langur	0.020±0.020
7	Leopard	0.056±0.029
8	Jungle cat	0.036±0.024
9	Indian porcupine	0.358±0.136
10	Golden jackal	0.204±0.088
11	Indian pangolin	0.036±0.036
12	Indian peafowl	0.120±0.085
13	Cattle	0.100±0.068

3.3 Point count

Point transects were conducted for estimating the density of bird species inside the Sukhna WLS. Point count sampling was conducted on three points at each transect (inter-point separation of 400 m) and the same transect lines were used for laying the sampling points as detailed in the previous section. Thus, a total of 30 points were sampled across the 10 transects laid in Sukhna WLS. Each point was temporally replicated twice during morning hours for two consecutive days. Hence, a total effort of 60 point samplings were conducted yielding a total of 67 species of birds belonging to 32 families and 15 orders were identified in the point transect in Sukhna WLS (Appendix VIII).

Since, data obtained through this method was not enough to conduct the Distance sampling analysis for density estimates using Distance software, therefore only species numbers and counts were used to characterise the areas surveyed. Transect 2 was most rich (N=34), followed by Transect 6 (N=32) and Transect 9 (N=29) in terms of number of bird species recorded with a mean of 21.33±0.88, 13.33±3.33, and 18.00±0.00, respectively during the two days of survey (Fig. 9). Lowest number of bird species recorded (N=16) was on Transect 3 with mean of two days as 10.67±4.26 (Fig. 9).

Of the 67 species of birds observed, *ca*. 28% of the species had more than 10 observations (Fig. 10). Indian peafowl was the most abundant (N=59) of the species recorded, followed by red-wattled lapwing (N=30) and the red junglefowl (N=26). Among the species recorded with less frequency 20 species were recorded only once.

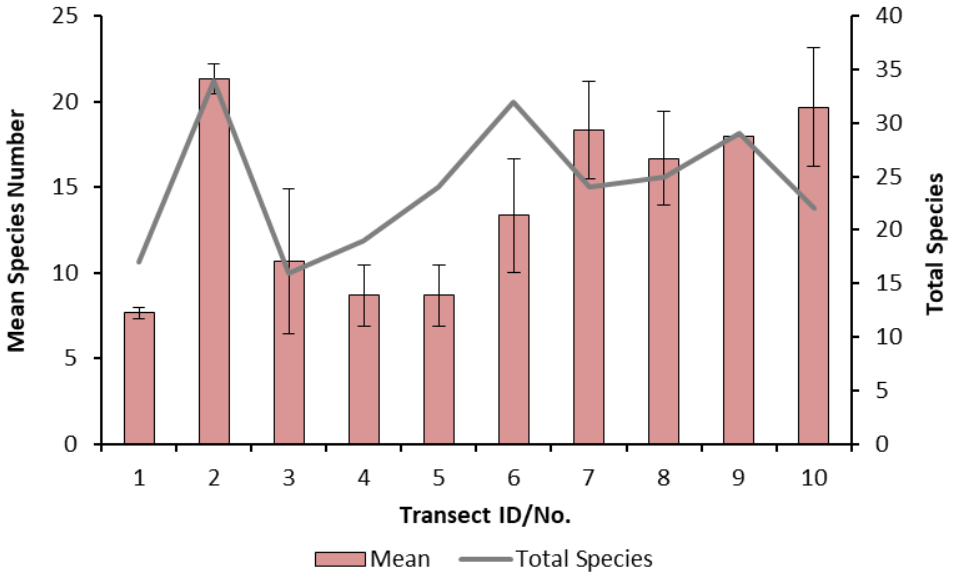


Figure 9: Mean species number of birds observed across the transects sampled (data of three point counts pooled for each transect) using three circular plots at each transect in Sukhna WLS during 5th and 9th May, 2021.

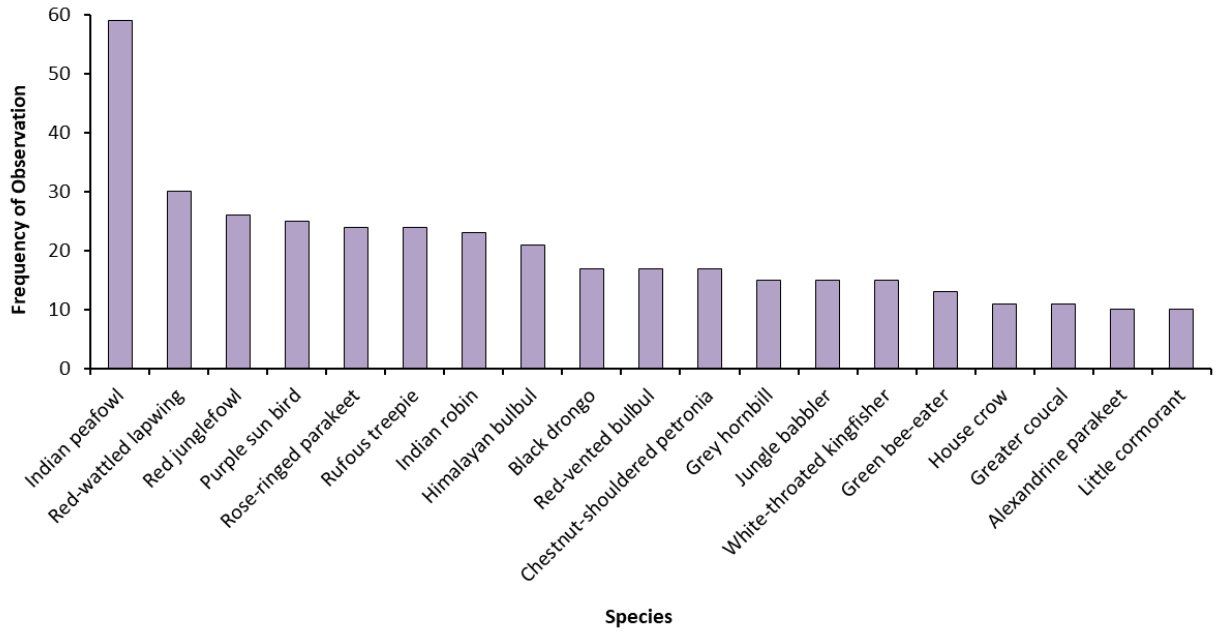


Figure 10: Frequency of observations of bird species observed during the point count surveys in Sukhna WLS between 5th and 9th May, 2021.

3.4 Habitat Characteristics

To quantify the habitat and vegetation parameters, sampling was done along the same line transect (explained above). A circular plot of a 10 m radius was used to record the required information like tree number, tree species, canopy cover, shrub cover was estimated visually. Sampling was done at the same points which were used for point counts as described above. For each transect the broad habitat type and associated terrain type was also recorded along with time and GPS location.

Of all the information required to be filled in the prescribed data format, only some information was entered due to which very limited inference about habitat could be generated. Thus, only data on trees was used for analysis which is presented as tree density and tree species identified (Appendix IX).

Transect 2 had the highest mean (±SE) tree density with 679.41±46.27 trees per hectare followed by Transect 10 (583.86±76.55 /ha), and Transect 5 with mean tree density of 488.32±28.09 /ha. Lowest tree density was recorded at Transect 6 with mean tree density of 127.39±31.85 /ha (Fig. 11). Similarly, Transect 5 had the highest number of tree species recorded (5.00±2.08) and the least number of species was recorded at Transect 3 (2.33±0.88) (Fig. 12).

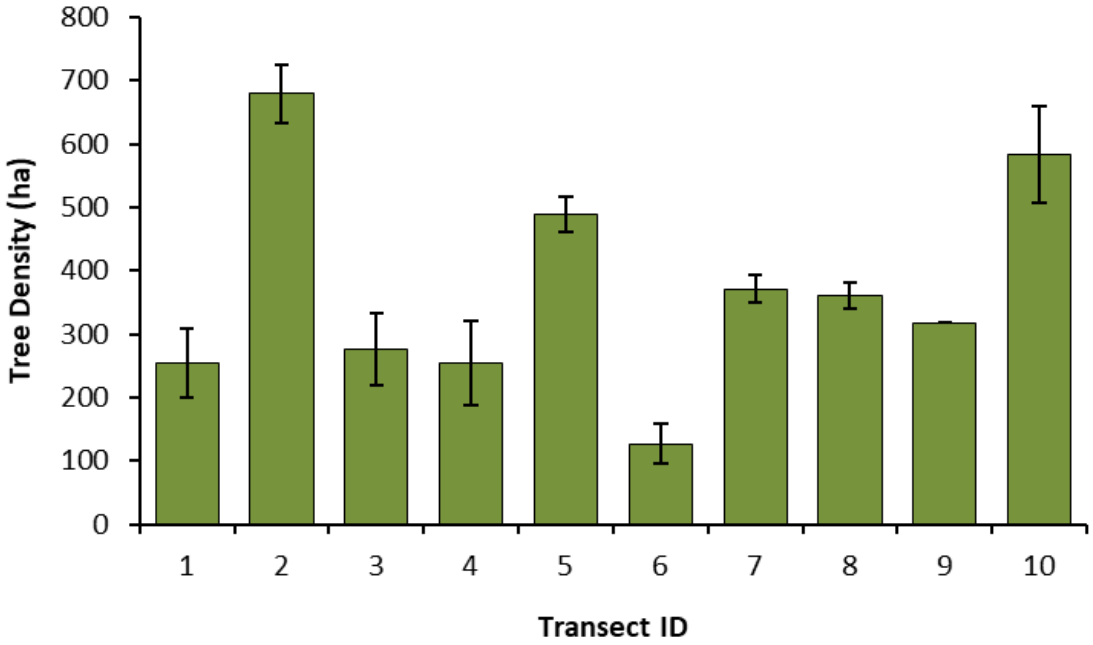


Figure 11: Mean tree density (per hectare) across the transects sampled using three circular plots at each transect in Sukhna WLS during 5th and 9th May, 2021.

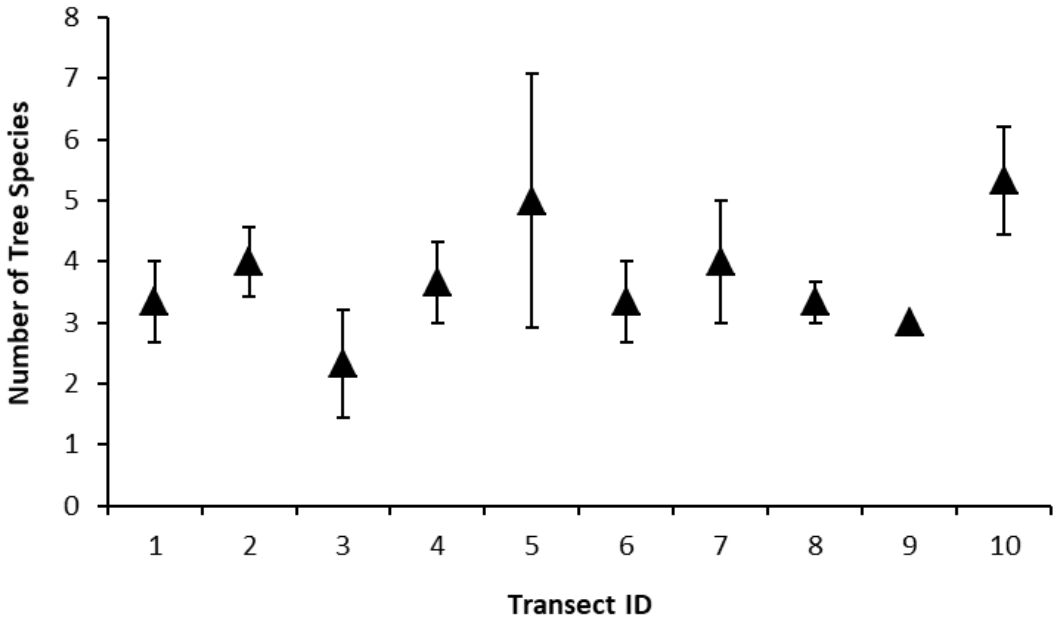


Figure 12: Mean number of tree species identified across the transects sampled using three circular plots at each transect in Sukhna WLS during 5th and 9th May, 2021.

4. Discussion

The Department of Forest and Wildlife, Chandigarh (DFW-CH) in technical collaboration with Wildlife Institute of India (WII) conducted the 5 days long wildlife survey after a long gap of *ca*. 10 years to obtain estimates of the wildlife population and trend of Sukhna WLS. The current survey is more comprehensive and covered more area in comparison to the previous survey that was conducted in 2010 only for two days (Habib et al. 2011). The survey shows that the population density of wild animals was quite variable in Sukhna WLS. In spite of several limitations and weaknesses in the data collection process by the field personnel, the survey has shown potentiality of both distance sampling and sign surveys to estimate the density and relative abundance of wildlife species in rugged terrain of Sukhna WLS.

The surveys conducted for mega herbivores and some bird species of the sanctuary confirmed the presence of total 16 species which includes 13 mammalian species (both carnivores and herbivores). The major bird species of conservation importance included the Indian peafowl and the red junglefowl. Apart from the wild species, presence of feral cattle and free ranging stray dogs also got confirmed which needs timely management interventions.

Sambar is the dominant and most abundant species among the wild ungulate fauna the sanctuary. Density estimate (individual/km^2) of Sambar in Sukhna WLS (18.08±4.22) is comparable to estimates reported from other protected areas (PAs) of the Himalayan foothills ecosystem such as Rajaji Tiger Reserve (TR) (18.06±1.82) and Corbett TR (11.38±0.90) (Jhala et al. 2020). The Nilgai density estimated (2.01±0.57) in Sukhna WLS is lower than the density estimate reported from nearest PA- Rajaji TR (4.18±1.23; Jhala et al. 2020). Similarly, the Wild boar density in Sukhna WLS estimated as 1.17±0.33 is lower than the estimates reported from the Corbett TR (8.50±1.31) and Rajaji TR (4.18±1.23). The langur density (1.005±0.28) in Sukhna WLS is the lowest as compared to these PAs i.e. Rajaji (4.18±1.23) and Corbett TR (20.39±3.02) (Jhala et al. 2020). Due to low sample size of observations the density of species other than Sambar could not be estimated with robustness. Therefore, further conservation and management strategies should consider these findings with caution.

In case of grouping behaviour of ungulates observed, the mean group size of Sambar was 4.28±0.89 in Sukhna WLS which is higher than reported in Rajaji TR (2.34±0.10) and Corbett TR (2.26±0.07). Groups of 1–5 individuals made up *ca*. 91% of herd formations in Sukhna WLS, this has been the most common behaviour of grouping in Sambar and widely reported (Khan and Johnsingh 2015). We removed two observations of large congregations of Sambar (group sizes of 47 and 60; observed in the forest patches outside the Sukhna WLS during the survey) from the analysis to remove the leverage on the mean group size of Sambar. These observations, although less in number, show large grouping of Sambar which has been considered essentially a non-social species (Khan and Johnsingh 2015). Although, large congregations of Sambar have also been reported but these do not represent the typical group structure and generally are formed around feeding sites, at waterholes or to avoid predators (Khan and Johnsingh 2015). Outside Sukhna WLS these were observed in thick mature forest nearby water body (pers. comm.; Devendra Chauhan, RFO, DFW-CH).

Although non-invasive methods such as sign surveys are primarily conducted for carnivores and other shy and elusive species, but here in Sukhna WLS the encounter rate of carnivore species turned out to be very low and only at two occasions indirect evidence of leopard presence could be established. Therefore, a more comprehensive survey employing camera traps and targeting carnivore species is warranted.

As mentioned earlier, the current survey was conducted after a gap of more than a decade therefore, a comparison of species recorded between the previous and current surveys is presented in Table 6. The current survey being more comprehensive in terms of more area coverage and effort, presents more number of species records and reliable estimates as compared to the previous survey (Habib et al. 2011). As far as population estimates are concerned, there seems a decrease in populations of Sambar and Indian peafowl based on the comparison of estimates (Table 6).

Table 6: Species recorded and population estimates of some species based on wildlife surveys conducted during the previous (2010; Habib et al. 2011) and current (2021) wildlife surveys in Sukhna WLS (Species which could not be analysed for population estimates due to low sample size are represented as NA).

Species	Name	Species recorded in 2010	Species recorded in 2021
Carnivores			
Leopard	*Panthera pardus*	+	+
Jungle cat	*Felis chaus*	-	+
Golden jackal	*Canis aureus*	+	+
Indian grey mongoose	*Urva edwardsii*	-	+
Herbivores			
Sambar	*Rusa unicolor*	+	+
Chital	*Axis axis*	+	+
Wild boar	*Sus scrofa*	+	+
Nilgai	*Boselaphus tragocamelus*	-	+
Barking deer	*Muntiacus muntjac*	-	+
Hanuman langur	*Semnopithecus entellus*	+	+
Rhesus macaque	*Macaca mulatta*	-	+
Black-naped hare	*Lepus nigricollis*	+	+
Indian pangolin	*Manis crassicaudata*	+	+
Indian porcupine	*Hystrix indica*		
Birds			
Indian peafowl	*Pavo cristatus*	+	+
Red junglefowl	*Gallus gallus*	+	+
Reptiles			
Common monitor lizard	*Varanus bengalensis*		
Stray species			
Stray dogs	*Canis lupus familiaris*	-	+
Stray cattle	*Bos domesticus*	-	+
Total species		10	17
Bird species		63	67
Population Estimates			
Sambar			290–763
Nilgai			NA
Wild boar			NA
Hanuman langur			NA
Indian peafowl			NA

5. Conclusions and Recommendations

1. Despite being small in area, Sukhna WLS supports good biological diversity and has the potential to be considered as one of the important wildlife and biodiversity conservation area. Therefore, steps should be undertaken to have plans for regular monitoring and research programs targeting not only the sanctuary but also its surrounding forested areas.

2. Sambar is the most abundant ungulate species in the Sukhna WLS with highest density similar to Rajaji TR. Estimated population of Sambar in the sanctuary stands at *ca*. 290–763.

3. For the first time, adjacent areas lying outside the Sukhna WLS were also surveyed during the current survey. Although, Nilgai observations were dominated but large congregations of Sambar were observed in these forest areas which are adjacent to Sukhna forest areas. It is established based on the observations that species move out of the sanctuary therefore, understanding the quality of these habitat patches and connectivity between these areas is necessary.

4. Presence of feral cattle and free ranging stray dogs inside Sukhna WLS also got confirmed. Their presence can be a potential source of many problems to wildlife in terms of creating competition for resources, potential of disease transfer to wildlife, etc. This problem needs to be dealt with timely and appropriate management interventions. This aspect needs to be studied thoroughly in a long term research project.

5. Long term monitoring employing advanced research methods such as camera trapping should be conducted through a research project of at least 2 years is recommended so that sound, reliable and robust data can be collected and ecological parameters can be assessed.

6. Independent long term bird surveys for resident breeding as well as wintering birds are recommended so that sound, reliable and robust data is collect on ecological parameters of the species.

7. Given the high abundance of Sambar and presence of other important wildlife in the sanctuary it is also recommended that a detailed study on habitat characterisation and vegetation community structure should be undertaken to understand wildlife–habitat relationships in the sanctuary.

8. Awareness programs need to be conducted regularly so that local people get involved pro-actively in the biodiversity conservation process.

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Appendix I

Data Collection format for Line Transect Monitoring

Observer Name		**Date**	
Start time		End time	
Start GPS Location	**Lat.**		**Long.**
End GPS Location	**Lat.**		**Long.**

S. No.	Species	Time	Perp. Distance (m)	Total	Group composition						Habitat	Remarks
					AM	AF	SAM	SAF	YRL	FN		
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												

AM-Adult Male; AF-Adult Female; SAM-Sub-adult Male; SAF-Sub-adult Female; YRL-yearling; FN-Fawn

Appendix II

Data Collection Format for Sign Encounter Rate Survey

Observer Name			**Date**
Whether Condition/Cloudy day:			**Trail/Survey route ID:**
Start time			**End time**
Start GPS location	**Lat.**		**Long.**
End GPS location	**Lat.**		**Long.**
Time spent in any other activity (min)			**Total kilometer walked (km)**

S. No.	Species[1]	Sign type[2]	Habitat type	GPS Location	Terrain type	Remarks
1				Lat.		
				Long.		
2				Lat.		
				Long.		
3				Lat.		
				Long.		
4				Lat.		
				Long.		
5				Lat.		
				Long.		
6				Lat.		
				Long.		
7				Lat.		
				Long.		
8				Lat.		
				Long.		
9				Lat.		
				Long.		
10				Lat.		
				Long.		

1 - Carnivore species to be recorded are Leopard, Jackal, Jungle cat, Striped hyena, etc.

2 - Sign types to be recorded are pugmarks, scats, scrapes, rake, vocalisation/ call, direct sightings.

Appendix III

Data Sheet for Recording Habitat Characteristics and Disturbance

Observer Name		**Date**	
Start time		**End time**	
Point 1 **GPS location:** **Lat.** **Long.**	**No. of trees**		
	No. of tree species		
	Tree cover		
	No. of lopped trees		
	No. of cut trees		
	No. of Livestock Dung/Pellets		
	Shrub cover		
	Distance to nearest road		
	Distance to nearest trail		
	Distance to nearest village		
	No. of wild ungulate pellets	**Species**	**Number**
Point 2 **GPS location:** **Lat.** **Long.**	No. of trees		
	No. of tree species		
	Tree cover		
	No. of lopped trees		
	No. of cut trees		
	No. of Livestock Dung/Pellets		
	Shrub cover		
	Distance to nearest road		
	Distance to nearest trail		
	Distance to nearest village		
	No. of wild ungulate pellets	**Species**	**Number**
Point 3 **GPS location:** **Lat.** **Long.**	No. of trees		
	No. of tree species		
	Tree cover		
	No. of lopped trees		
	No. of cut trees		
	No. of Livestock Dung/Pellets		
	Shrub cover		
	Distance to nearest road		
	Distance to nearest trail		
	Distance to nearest village		
	No. of wild ungulate pellets	**Species**	**Number**

Appendix IV

Data Collection Format for Point Counts

Observer Name		Date	
Start time		End time	
Start GPS Location	Lat.		Long.
End GPS Location	Lat.		Long.

S. No.	Species	Time	Radial Distance (m)	Total No.	Group composition			Habitat	Remarks
					M	F	YNG		
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									

M-Male; F-Female; YNG-Young

Appendix V

Species and their number of observations recorded during the line transect surveys in Sukhna WLS between 5th and 9th May, 2021

S. No.	Transect Name/ID	Sambar	Nilgai	Chital	Wild boar	Hanuman Langur	Rhesus macaque	Indian Peafowl	Red Junglefowl	Golden Jackal	Indian Porcupine	Indian Grey Mongoose	Common Indian Monitor	Stray dog
1	Dam No. 2 Bolion wala to Saluni wala Choe	7	0	0	0	1	0	8	0	0	2	1	0	0
2	Ghatiwala to Latanwala trail (500 m)	1	1	1	0	1	0	6	0	0	0	0	0	0
3	Budhewala Choe to Karondawala Dam No. 1	15	0	0	1	0	0	0	1	0	0	0	0	0
4	Jhulahewala to Jhulahewala top	5	0	0	0	2	0	0	0	0	0	0	0	0
5	Neemwala chowk to Neemwala Dam No. 1	1	4	4	3	0	0	0	0	0	1	0	0	2
6	Nepli inspection hut to Chamranvala Dam No. 1	14	0	0	0	1	0	0	0	0	0	0	0	0
7	Mundrawala Dam to Punjab boundary	23	0	0	0	5	0	0	0	0	0	0	0	0

8	Road to gagianwala Choe (Dam No. 1)	20	2	0	3	2	0	0	0	1	2	1	1	0
9	Memnewala Choe in Kansal beat, Kansal Block, Chandigarh	26	0	0	1	1	0	0	0	0	0	0	0	0
10	Near Jamonwala Dam No. 4 to top of Jamonwala Choe	21	0	0	1	0	0	0	0	0	0	0	1	0
11	Nature trail, Lake forest (Outside Sukhna WLS)	2	1	1	1	0	0	0	0	0	0	0	0	0
12	Patiala ki rao (Outside Sukhna WLS)	2	4	0	4	0	1	0	0	0	0	0	0	0
13	Manimajra forest area Sector 26 (Outside Sukhna WLS)	0	5	0	0	0	0	0	0	0	0	0	0	0
14	CTU Workshop to Raipur Khurd Hallo Majra (Outside Sukhna WLS)	0	7	0	0	0	0	0	0	0	0	0	0	0

Appendix VI

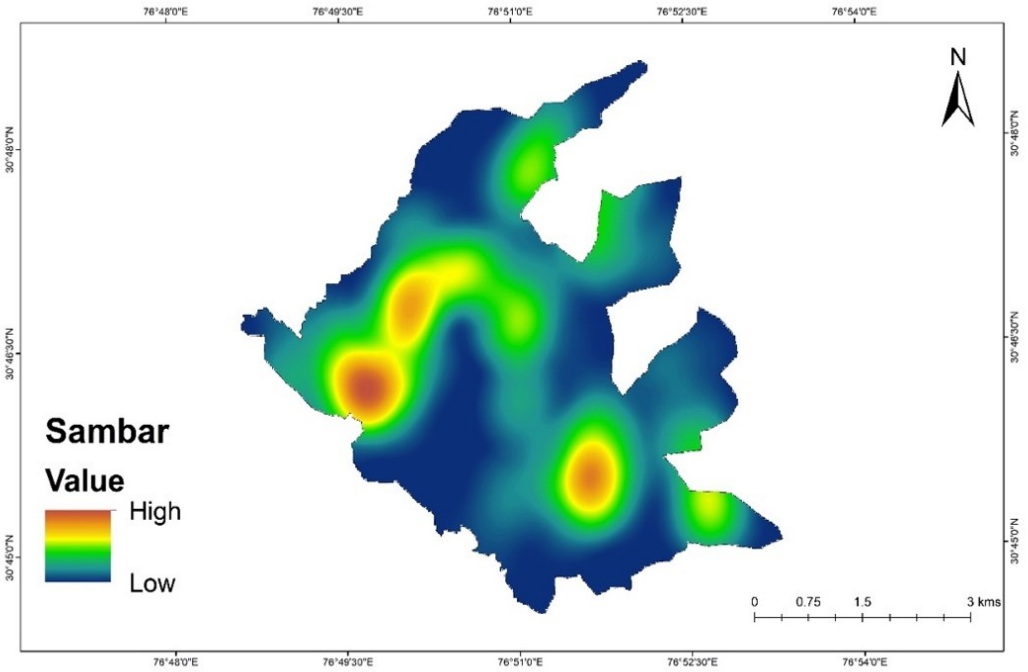
Species and their number of observations ecorded during the sign surveys in Sukhna WLS between 5th and 9th May, 2021

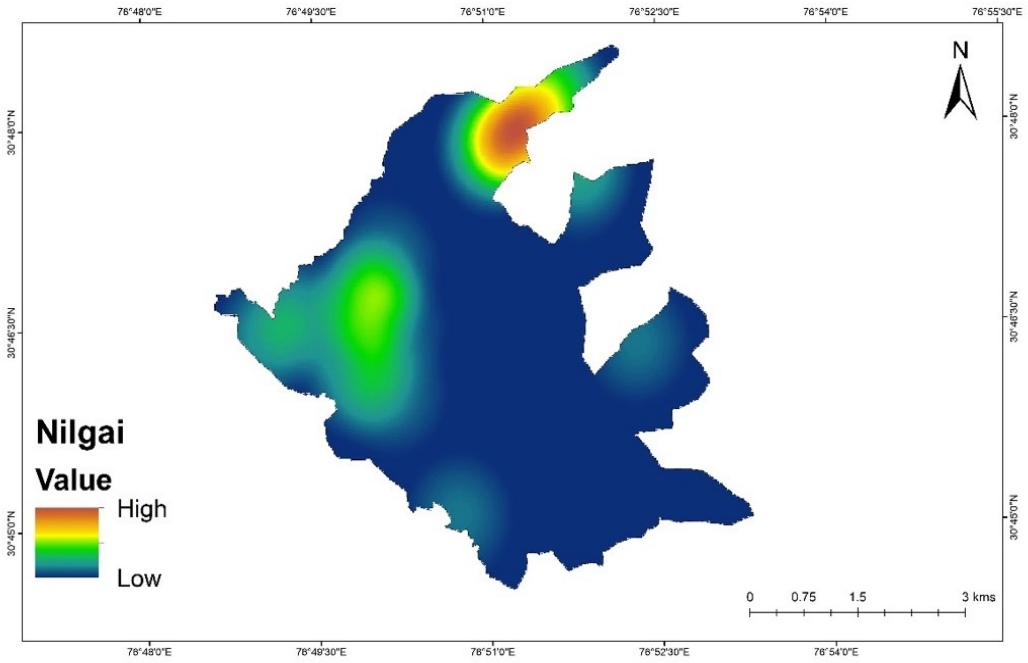
S. No.	Trail Name/ID	Leopard	Jungle cat	Jackal	Sambar	Nilgai	Chital	Barking deer	Wild boar	Langur	Indian Peafowl	Indian Pangolin	Indian Porcupine	Cattle/ Livestock
1	Dam no. 2 Bolion wala to Saluni wala choe	0	0	0	8	0	0	0	0	1	2	0	0	2
2	Ghatiwala to Latanwala trail (500 m)	0	0	0	15	0	2	1	1	0	0	0	0	0
3	Budhewala choe to Karondawala dam no. 1	0	0	0	13	0	0	0	1	0	4	0	0	3
4	Jhulahewala to Jhulahewala top	1	0	0	17	0	0	0	0	0	0	0	0	0
5	Neemwala choe to Neemwala dam no. 1	0	0	0	4	2	1	0	0	0	0	0	0	0
6	NEPLI Inspection Hut to Chamranvala Dam no. 1	0	0	0	16	0	0	0	1	0	0	0	2	0
7	Mundrawala dam to Punjab boundary	0	0	2	11	12	0	0	8	0	0	0	5	0
8	Road to Gagianwala choe dam no. 1	1	1	2	26	3	0	0	10	0	0	0	5	0
9	Road to Memnewala choe dam no. 1 in Kansal beat, Kansal block,Chandigarh	0	1	4	28	2	0	0	5	0	0	0	2	0
10	Near Jamonwala dam no. 4 to top of Jamonwala choe	1	0	3	35	8	0	0	7	0	0	2	5	0

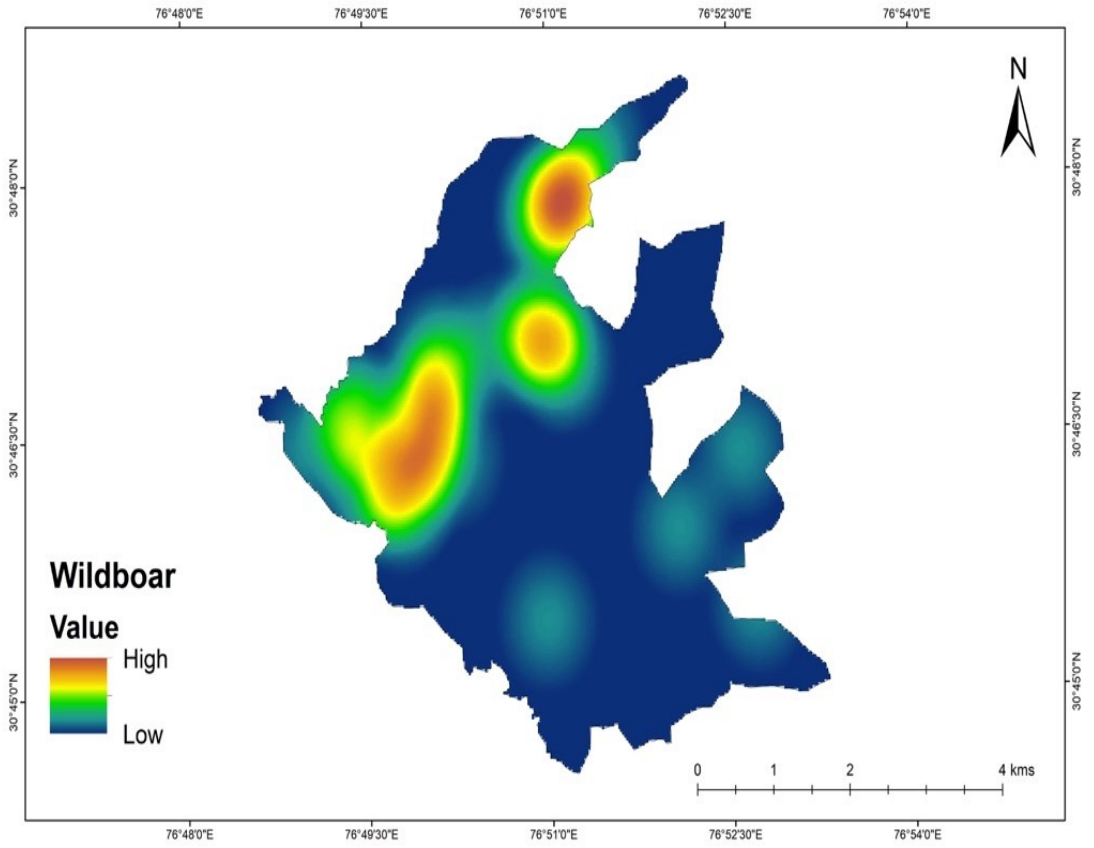
Appendix VII

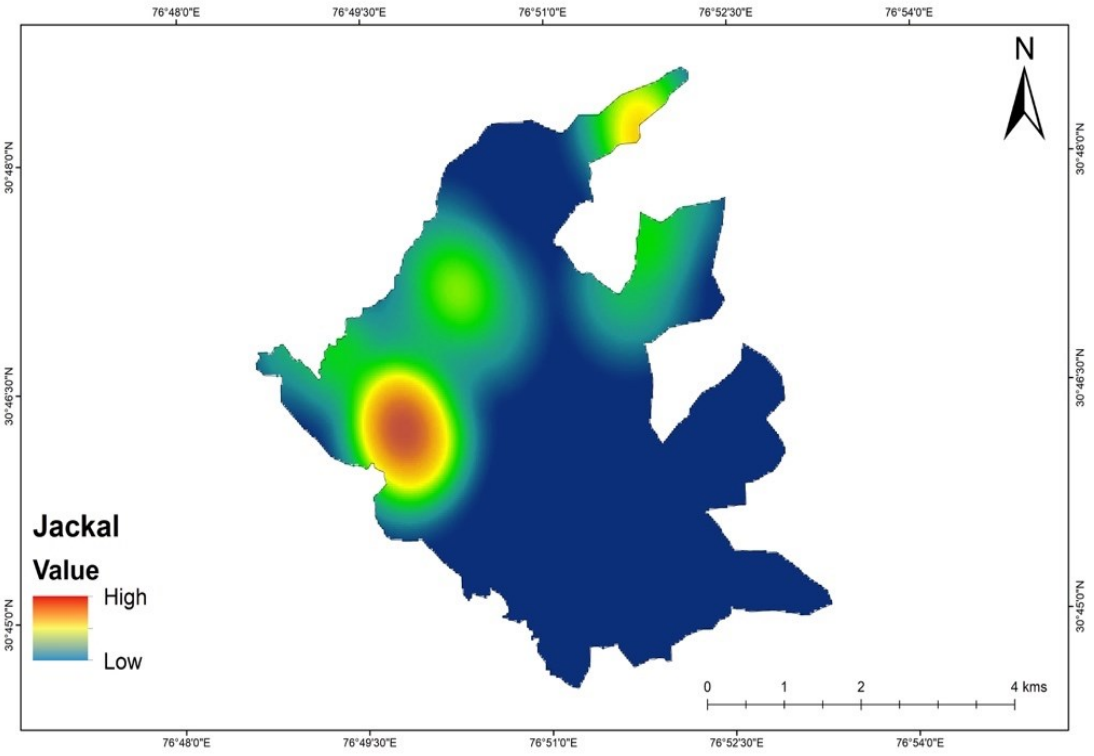
Hotspot distribution mapping for some species

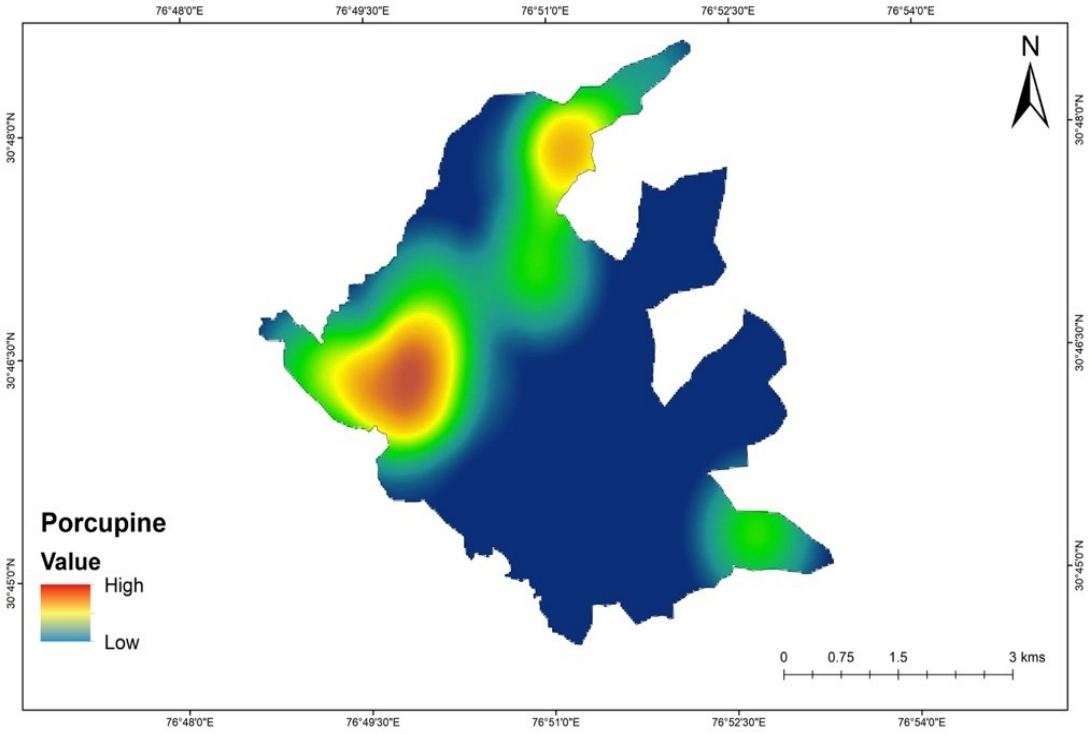
Hotspot distribution heat maps using kernel densities of different species were generated based on their signs recorded during the survey.






76°48'0"E
76°49'30"E
76°51'0"E
76°52'30"E
76°54'0"E
30°48'0"N
30°46'30"N
30°45'0"N
N
Wildboar
Value
High
Low
0
1
2
4 kms


76°48'0"E
76°49'30"E
76°51'0"E
76°52'30"E
76°54'0"E
30°48'0"N
30°46'30"N
30°45'0"N
N
Jackal
Value
High
Low
0
1
2
4 kms


76°48'0"E
76°49'30"E
76°51'0"E
76°52'30"E
76°54'0"E
30°48'0"N
30°46'30"N
30°45'0"N
N
Porcupine
Value
High
Low
0
0.75
1.5
3 kms

Appendix VIII

Checklist of avian species recorded during the survey in Sukhna WLS during 5th and 9th May, 2021

Species	Scientific name	Family	Order	IUCN status	WPA status (Schedule)
Alexandrine parakeet	*Psittacula eupatria*	Psittaculidae	Psittaculiformes	LC	NT
Ashy drongo	*Dicrurus leucophaeus*	Dicruridae	Passeriformes	LC	IV
Ashy prinia	*Prinia socialis*	Cisticolidae	Passeriformes	LC	IV
Asian koel	*Eudynamys scolopaceus*	Cuculidae	Cuculiformes	LC	IV
Black drongo	*Dicrurus macrocercus*	Dicruridae	Passeriformes	LC	IV
Black kite	*Milvus migrans*	Accipitridae	Accipitriformes	LC	I
Black redstart	Phoenicurus ochruros	Muscicapidae	Passeriformes	LC	IV
Black-winged stilt	Himantopus himantopus	Recurvirostidae	Charadriiformes	LC	IV
Blue whistling thrush	*Myophonus caeruleus*	Muscicapidae	Passeriformes	LC	IV
Blue-cheeked bee-eater	*Merops persicus*	Meropidae	Coraciiformes	LC	IV
Blue-tailed bee-eater	*Merops phillipinus*	Meropidae	Coraciiformes	LC	IV
Brown headed barbet	*Psilopogon zeylanicus*	Megalaimidae	Piciformes	LC	IV
Chestnut-shouldered petronia	*Gymnoris xanthocollis*	Passeridae	Passeriformes	LC	IV
Common chiffchaff	*Phylloscopus collybita*	Phylloscopidae	Passeriformes	LC	IV
Common hawk cuckoo	*Hierococcyx varius*	Cuculidae	Cuculiformes	LC	IV
Common myna	*Acridotheres tristis*	Sturnidae	Passeriformes	LC	IV
Common tailor bird	*Orthotomus sutorius*	Cisticolidae	Passeriformes	LC	IV
Crimson sunbird	*Aethopyga siparaja*	Nectariniidae	Passeriformes	LC	IV
Eurasian crag martin	*Ptyroprogne rupestris*	Hirundinidae	Passeriformes	LC	IV
Fulvous- breasted pied woodpecker	*Dendrocopos macei*	Picidae	Piciformes	LC	IV
Great hornbill	*Buceros bicornis*	Bucerotidae	Bucerotiformes	VU	I
Greater coucal	*Centropus sinensis*	Cuculidae	Cuculiformes	LC	IV

Green bee-eater	*Merops orientalis*	Meropidae	Coraciiformes	LC	IV
Greenish leaf warbler	Phylloscopus nitidus	Phylloscopidae	Passeriformes	LC	IV
Grey breasted prinia	*Prinia hodgsonii*	Cisticolidae	Passeriformes	LC	IV
Grey Heron	Ardea cinerea	Ardeidae	Pelecaniformes	LC	IV
Grey hornbill	*Ocyceros birostris*	Bucerotidae	Bucerotiformes	LC	IV
Himalayan bulbul	*Pycnonotus leucogenis*	Pycnonotidae	Passeriformes	LC	IV
House crow	*Corvus splendens*	Corvidae	Passeriformes	LC	V
Hume's leaf warbler	*Phylloscopus humeii*	Phyllocsopidae	Passeriformes	LC	IV
Indian golden oriole	*Oriolus kundoo*	Oriolidae	Passeriformes	LC	IV
Indian peafowl	*Pavo cristatus*	Phasianidae	Galliformes	LC	I
Indian pond heron	*Ardeola grayii*	Ardeidae	Pelecaniformes	LC	IV
Indian robin	*Saxicoloides fulicatus*	Muscicapidae	Passeriformes	LC	IV
Indian roller	*Coracias benghalensis*	Coraciidae	Coraciiformes	LC	IV
Indian spot-billed duck	*Anas poecilorhyncha*	Anatidae	Anseriformes	LC	IV
Jungle babbler	*Turdoides striata*	Leothrichidae	Passeriformes	LC	IV
Large billed crow	*Corvus macrorhynchos*	Corvidae	Passeriformes	LC	IV
Laughing dove	*Streptopelia seneghalensis*	Columbidae	Columbiformes	LC	IV
Lesser golden-backed woodpecker	*Dinopium benghalense*	Picidae	Piciformes	LC	IV
Lesser whistling duck	*Dendrocygna javanica*	Anatidae	Anseriformes	LC	IV
Little cormorant	*Microcarbo niger*	Phalacrocoracidae	Suliformes	LC	IV
Little grebe	*Tachybaptus ruficolis*	Podicipedidae	Podicipediformes	LC	IV
Oriental white eye	*Zosterops palpebrosus*	Zosteropidae	Passeriformes	LC	IV
Oriental darter	*Anhinga melanogaster*	Anhingidae	Suliformes	NT	IV
Oriental honey buzzard	*Pernis ptilorhynchus*	Accipitridae	Accipitriformes	LC	I
Oriental magpie robin	Copyschus saularis	Muscicapidae	Passeriformes	LC	IV
Oriental turtle dove	*Streptopelia orientalis*	Columbidae	Columbiformes	LC	IV
Pied bushchat	*Saxicola caprata*	Muscicapidae	Passeriformes	LC	IV
Plain prinia	*Prinia inornata*	Cisticolidae	Passeriformes	LC	IV
Purple sun bird	*Cinnyris asiaticus*	Nectariniidae	Passeriformes	LC	IV

Red billled blue magpie	*Urocissa erythrorhyncha*	Corvidae	Passeriformes	LC	IV
Red junglefowl	*Gallus gallus*	Phasianidae	Galliformes	LC	IV
Red-vented bulbul	*Pycnonotus cafer*	Pycnonotidae	Passeriformes	LC	IV
Red-wattled lapwing	*Vanellus indicus*	Charadriidae	Charadriformes	LC	IV
Rose-ringed parakeet	*Psittacula krameri*	Psittaculidae	Psittaculiformes	LC	IV
Ruddy shelduck	*Tadorna ferruginea*	Anatidae	Anseriformes	LC	IV
Rufous treepie	*Dendrocitta vagabunda*	Corvidae	Passeriformes	LC	IV
Shikra	*Accipiter badius*	Accipitridae	Accipitriformes	LC	I
Slaty-headed parakeet	*Psittacula himalayana*	Psittaculidae	Psittaculiformes	LC	IV
Stork-billed kingfisher	*Pelargopsis capensis*	Alcedinidae	Coraciiformes	LC	IV
Sulphur-bellied warbler	*Phylloscopus griseolus*	Phylloscopidae	Passeriformes	LC	IV
Western crowned leaf warbler	*Phylloscopus occipitalis*	Phylloscopidae	Passeriformes	LC	IV
White breasted water- hen	*Amaurornis phoenicurus*	Rallidae	Gruiformes	LC	IV
White-eyed buzzard	*Butastur teesa*	Accipitridae	Accipitriformes	LC	I
White-throated kingfisher	*Halcyon smyrnensis*	Alcedinidae	Coraciiformes	LC	IV
Yellow legged green pigeon	*Treron phoenicopterus*	Columbidae	Columbiformes	LC	IV

Appendix IX

List of plant species identified during the wildlife survey in Sukhna WLS between 5th and 9th May, 2021

Sr. No.	Species	Name	Family
1	Chall	*Terminalia arjuna*	Combretaceae
2	Tendu	*Diospyros melanoxylon*	Ebenaceae
3	Khair	*Senegalia catechu*	Fabaceae
4	Karaunda	*Carissa carandas*	Apocynaceae
5	Jhingan	*Lannea coromandelica*	Anacardiaceae
6	Ber	*Ziziphus mauritiana*	Rhamnaceae
7	Kari patta	*Murraya koengii*	Rutaceae
8	Kandai	*Flacourtia indica*	Salicaceae
9	Safedo	*Eucalyptus globulus*	Myratceae
10	Masquit	*Prosopis juliflora*	Fabaceae
11	Hing	*Ferula assa-foetida*	Apiaceae

Appendix X

List of observers who participated in the wildlife surveys conducted in Sukhna WLS during 5th and 9th May, 2021

Transect /Trail No.	Transect Name/ID	Range	Activity	Observer Name
1.	Dam no 2 Bolion wala to Saluni wala Choe	NEPLI	Line transect, Sign survey, point count	Rajinder Singh
2.	Ghatiwala to Latanwala trail (500 m)	NEPLI	Line transec, Sign survey	J.K. Ranjan (Forester)
			Point count	J.K. Ranjan and Naveen kahlon
3.	Budhewala choe to Karondawala dam no. 1	NEPLI	Line transect, Sign survey	Ajay Sharma
			Point count	Dinesh Verma & Sudheer Saxena
4.	Jhulahewala to jhulahewala top	NEPLI	Line transect, Sign survey	Sultan Singh
			Point count	Kailash Sharma
5.	Neemwala chok to Neemwala dam no. 1	NEPLI	Line transect, Sign survey	Ajay Kumar
			Point count	Ajay kumar, Kulbhushan Kanwar, Anu Garg, Tilak Raj Sharma
6.	NEPLI inspection hut to Chamranvala Dam no. 1	NEPLI	Line transect, Sign survey, Point count	Balwinder Singh
7.	Mundrawala dam to Punjab boundary	Chandigarh	Line transect, Sign survey, Point count	Amrih Singh
8.	Road to gagianwala choe (Dam no. 1)	Chandigarh	Line transect, Sign survey, Point count	Kulbir Singh Gill
9.	Memnewala choe in Kansal beat,kansal	Chandigarh	Line transect, Sign survey	Rohit Kumar Saini
			Point count	Rohit Kumar Saini, Rina Dhilon & Nitish
10.	Near Jamonwala dam no. 4 to top of jamonwala choe	Chandigarh	Line transect, Sign survey, Point count	Jatinder Singh
11.	Nature trail, lake forest (Outside PA)	Chandigarh	Line transect	Radhey & Harjinder
12.	Patiala ki rao (Outside PA)	Chandigarh	Line transect	Ashok Kumar
13.	Manimajra forest area Sector 26 (Outside PA)	Chandigarh	Line transect	Balwinder Singh
14.	CTU Workshop to Raipur Khurd Hallo Majra (Outside PA)	Chandigarh	Line transect	Balwinder Singh

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