ASSESSMENT OF MAMMALIAN

DIVERSITY

DHAULADHAR WILDLIFE SANCTUARY
HIMACHAL PRADESH

APRIL 2022

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भारतीय वन्यजीव संस्थान
Wildlife Institute of India

SUBMITTED TO:

HAMIRPUR DIVISION,
HIMACHAL PRADESH FOREST DEPARTMENT

Further Contact:

Dr. Salvador Lyngdoh
Department of Animal Ecology and Conservation Biology
Wildlife Institute of India, Chandrabani
Dehradun, India 248001
Tel: 00 91 135 2646281
Fax: 00 91 135 2640117
E-mail: salvador@wii.gov.in

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Tushar Parab, Rahul Chaudhary, Neel Pokhariya

PROJECT COMPLETION REPORT, 2022

ASSESSMENT OF MAMMALIAN DIVERSITY IN DHAULADHAR WILDLIFE SANCTUARY, HIMACHAL PRADESH

PRINCIPAL INVESTIGATOR
DR. SALVADOR LYNGDOH

PROJECT BIOLOGIST
MR. TUSHAR PARAB

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भारतीय वन्यजीव संस्थान
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This survey would not have been possible without the support and dedication of the frontline staff and locals of Dhauladhar Wildlife Sanctuary. This was the first exhaustive study carried out for the Assessment of mammalian diversity in this area.

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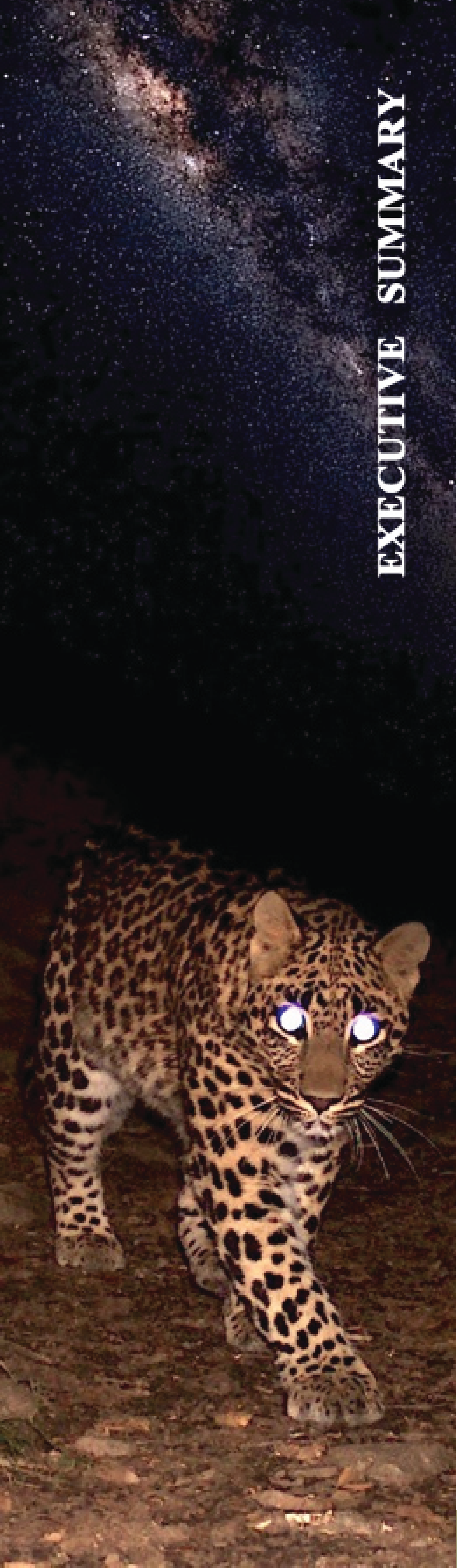
Sh. Rahul Chaudhary, Forest Guard, DWLS

Sh. Surjeet Patial, Forest Guard, DWLS

Sh. Sahil Chaudhary, Forest Guard, DWLS

Sh. Rohit Sharma, Forest Guard, DWLS

EXECUTIVE SUMMARY



Mammalian fauna of Himachal Pradesh is an admixture of Palearctic and Oriental elements since the state encompasses two bio-geographic zones i.e. 1 and 2, which are further subdivided into A & B (Roberts 1977); and the mountainous regions form a remarkable habitat for many animals, herbivores, and carnivores alike. They constitute a significant proportion of vertebrate diversity (Chakraborty et al. 2005, Saikia et al. 2004), and the state harbours about 27 percent of total mammalian species in India (Sharma and Saikia 2009). However, the State has come under a strong threshold of development, thereby inviting over exploitation and rapid destruction on natural resources but also has been open to many innovative steps to combat loss of biodiversity.

Dhauladhar Wildlife Sanctuary is of adequate ecological, faunal, floral, geomorphological, natural or zoological significance and has a wide variety of biodiversity. Due to the wide variation of altitudinal zoning, it hosts a wide range of wild animals viz. Common Leopard (*Panthera pardus*), Snow Leopard (Uncia uncia), Himalayan Black Bear (*Ursus thibetanus*), Himalayan Brown Bear (*Ursus arctos isabellinus*), Goral (*Naemorhedus goral*), Himalayan Tahr (*Hemitragus jemlahicus*), Himalayan Ibex (*Capra ibex*), Musk Deer (*Moschus chrysogaster*) along with Small carnivore species like Leopard Cat (*Prionailurus bengalensis*) and Red Fox (*Vulpes vulpes*).

These mammals acted as an excellent model for determining the state of landscape biodiversity. The information reported here would help to identify and further prioritize biodiversity rich areas within the landscape. This Landscape was a pilot site with no established methodological framework. Hence, different sets of methodologies were adopted for sampling. Camera trapping was conducted to gather evidences of animal presence and further analyze the diversity, abundance, probability of occurrence of species and activity patterns. Presence points of 8 potential indicator species were analyzed for generating habitat suitability maps. Locations of direct sightings, indirect evidences (scats, pellet, pugmark, hoof mark), animal attack sites and indigenous knowledge were accounted for. The species are selected by their ecological trends viz-population, distribution range, food habits and activity patterns which gave a brief idea about the surrounding habitats. Biologically significant areas were surveyed intensively with camera traps for the first time, which revealed the presence of rare species like Himalayan Musk Deer. The baseline inventory of 22 species of mammals found in the landscape has been generated with the help of direct observations and indirect evidences. Our findings highlights the potential of Dhauladhar Wildlife Sanctuary as a stronghold for conservation of several mammalian species.

1. Background

1.1 Exploring the past and present ecology of Mammalian biodiversity

Mammals show incredible flexibility in behaviour, eco-morphology, life-history and physiology and play a very important role in ecosystem. However, this macroecological processes underpinning past and present biodiversity patterns are only beginning to be explored at a global scale. It becomes so important to use this knowledge in order to prevent future biodiversity loss and eventually, loss of ecosystem services. Unfortunately lack of data hampers the efforts to understand mammalian diversity with more clarity. Equally important for understanding is that the diversity of mammals hides an even more interesting past, where the number of extinct species known outnumbers those which are present now.

Spatial and temporal variations, ecological community composition, species area relationships and geographical range sizes are somehow inextricably linked together. It is a fundamental fact in many taxa and over different spatial scales that number of species in an area tend to increase with the increase size of the region. Dhauladhar Wildlife Sanctuary being spread over 982 sq. km. has a potential to host many of these lifeforms. Understanding the distribution of megafauna is important for conservation planning and management of wild spaces.

Since, this project aims to estimate the diversity of mammals in Dhauladhar Wildlife Sanctuary, the state of landscape biodiversity within the Sanctuary would be collaterally understood. Inversely, landscapes are mosaics of different habitat types and serves as a large conservation umbrella for a variety of species. But livestock grazing, fodder collection, hunting and other anthropogenic activities in these pristine habitats affect the established ecology of mammals. Perhaps, human- wildlife interactions creates a challenge for co-existence.

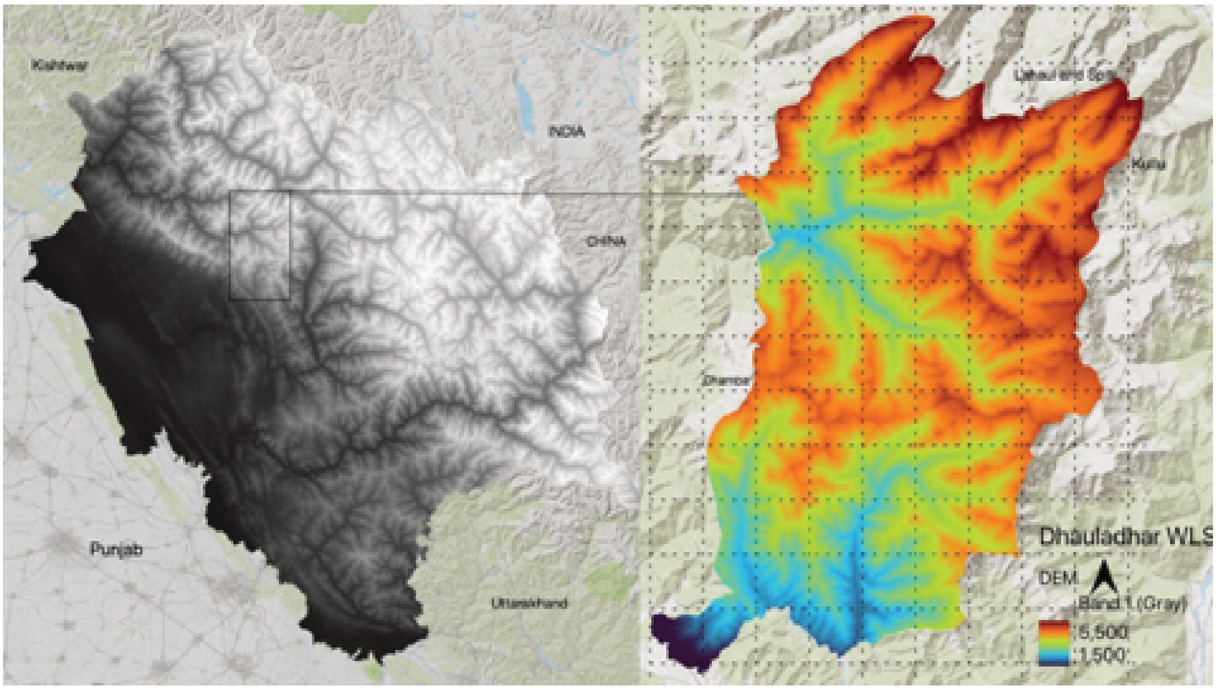


Figure 1(left) Location of Dhauladhar Wildlife sanctuary in Himachal Pradesh, India (right) Digital Elevation map of Dhauladhar

1.2 Dhauladhar Wildlife Sanctuary – Forest stratification and its importance to mammals.

Dhauladhar Wildlife Sanctuary, assemblage of diverse biomes was selected as a pilot site for this project. Covering a span of 982 sq. km., it encompasses subtropical, temperate and subalpine forests following Champion and Seth (1968). It covers three biomes- Eurasian high montane (Alpine and Tibetan- Biome 5), Sino-Himalayan temperate forests (Biome-7) and Sino-Himalayan subtropical forests (Biome-8) (IBCN-2015). Such wide combinations of habitats and altitudes make this sanctuary a biodiversity rich area.

These diverse characteristics of the landscape makes it home to a great variety of rare, threatened and endemic species of mammals. Other than mammals, we also tried to document and prepare inventories of ecologically important species of birds, medicinal and flowering plants, lichens, mushrooms and insects. The list may provide valuable insights about community structuring within the landscape.

The Trans Himalayan, Lash-alpine meadows and sub-alpine zones harbor elusive mammal species like Snow-leopard (*Uncia uncia*), Himalayan Ibex (*Capra sibrica hemalyanus*), Red Fox (*Vulpes Vulpes*), Himalayan Goral (*Naemorhedus goral*), Himalayan Musk Deer (*Mochus chrysogaster*), Stoat (*Mustela erminea*) and Himalayan Brown Bear(*Ursus arctos isabellinus*). Subtropical and temperate regions is home to species like Common Leopard (*Panthera pardus*), Leopard Cat (*Prionailurus bengalensis*), Himalayan Tahr (*Hemitragus jemalhicus*), Himalayan Black Bear (*Ursus thibetanus*) and Yellow Throated Marten (*Martes flavigula*).

Figure 2: Few important Mammals of Dhauladhar Wildlife Sanctuary (Clockwise from top left: Himalayan Brown Bear, Himalayan Black Bear, Leopard Cat. Red Fox, Himalayan Goral, Common Leopard.). All images are camera trap images taken during the study period.

2. STUDY AREA

The Dhauladhar Wildlife Sanctuary is bound to the north by the Mid Himalayan Range separating it from the district of Lahaul and Spiti and the Dhauladhar Range separating it from the district of Chamba, to the east by Kullu and Mandi. DWS is located between 32°01′42″ E to 32°27′27″ N Latitude and 76°41′41″ to 77°01′42″ E Longitude. The sanctuary is divided into two forest blocks and five beats with an area of 982.862 km^2. The whole area is primarily mountainous and hilly. The approximate altitudinal range is between 2000 and 6069 m. Due to the wide variation in altitude and configuration, the region has a diverse climate ranging from temperate to alpine at higher altitudes. Due to high altitudes, the winter is very severe, and most of the sanctuary area has been covered with snow for eight months. Precipitation is mainly distributed at lower elevations and snow at higher elevations. The bulk of rainfall is very heavy on the southern slopes of the Dhauladhar mountain range. The sanctuary is contiguous to the Manali, Kugti, Tundah, and Nargu Wildlife Sanctuaries, which form a bio-geographical location (western, northwestern, and trans-Himalayan ranges). This region is very significant from an ecological, geomorphological, and geographical point of view and is recognised as a World Heritage Site. The wide altitudinal zoning and the gradual to precipitous slopes combine to make it floristically and faunatically very rich. Many seasonal streams originate from this sanctuary and flow into the Ravi River. The sanctuary is located at the junction of 2C-Western, 1B-North West, and 1A-Trans Himalayan ranges.

Many perennial streams and rivers forming the tributary of the river Ravi originate from this sanctuary. Dhauladhar Wildlife Sanctuary is divided into two parts, known as Bara Bhangal (northern valley) and Chhota Bhangal (southern valley). The Dhauladhar range separates the two valleys. The valley of Chhota Bhangal is completely devoid of human habitation. It is made up of the woody growth of Deodar, Fir, Spruce, Moru, and Kharsu. Only one village of 143 households is inhabited in the Bara Bhangal. The village is located at an altitude of 2592 m and is inhabited only by the Kanet family locally known as Bhangalis. Their main occupation is agriculture, supplemented by animal husbandry. The sanctuary area is prone to landslides and avalanche. On the three sides, the slope of the mountain rises steeply from the bank of the river Ravi to a height of between 5183 and 6200 m. Near the bottom of some of the ravines, there is a good pine forest, higher up along barren slopes, which, when the snow melts, provides a splendid grazing ground for three months for flocks of sheep and goats from as far as Mandi, Palampur, and lower Bhangal. Above these grazing grounds are glaciers, barren cliffs, and snowfields. Forests in the Bara Bhangal region comprise mixed crops of various conifers and broad-leaved species and alpine pastures. The slope is steep to precipitous and requires complete protection. Besides this, the 5078 m high Thamsar Pass, flanked by huge glaciers in the north and several freshwater lakes, is situated on either side. The biggest of these lakes is known as Thamsar Dal. The sanctuary is known for its beautiful treks, which are very popular with hikers and adventurers alike.

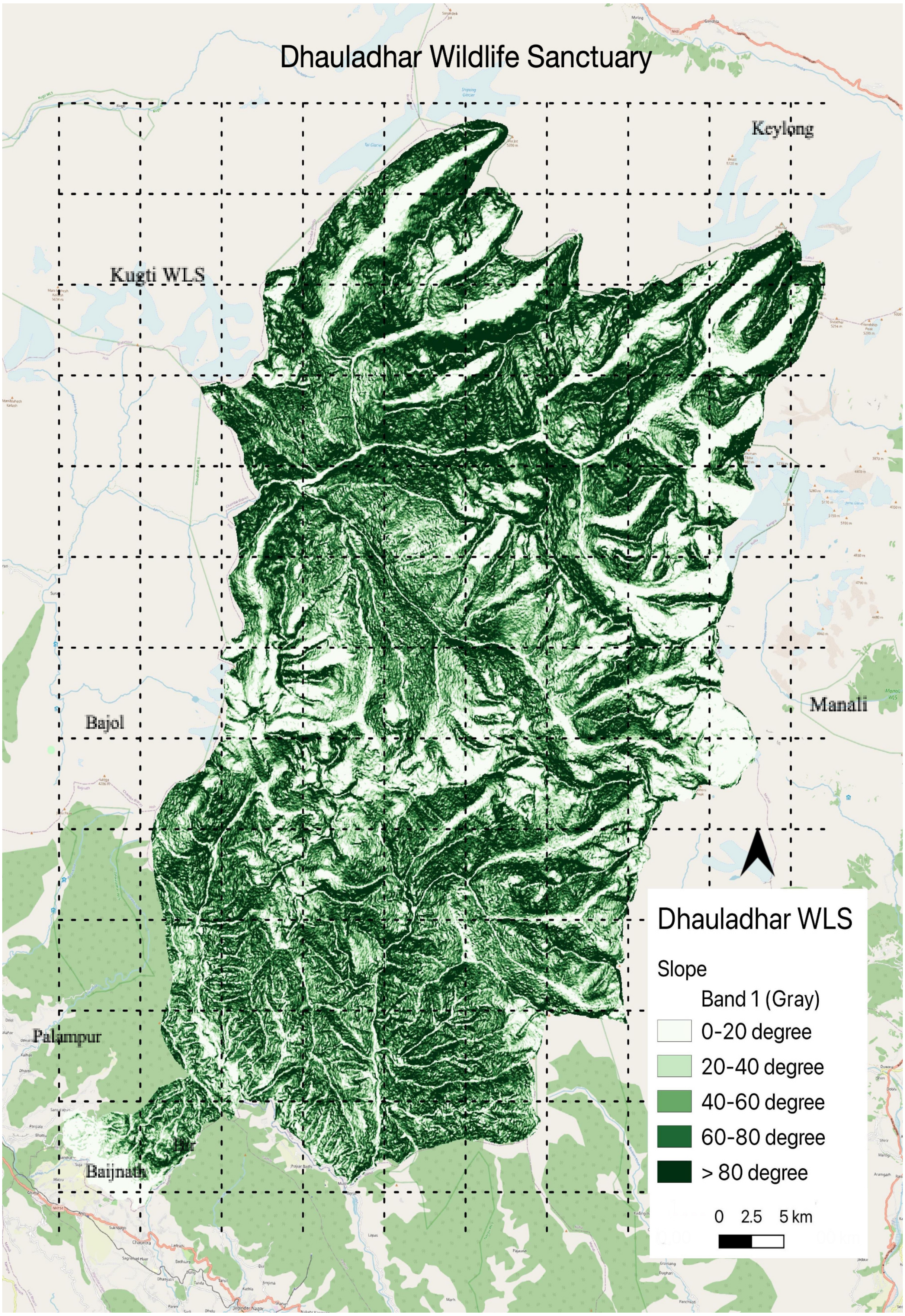
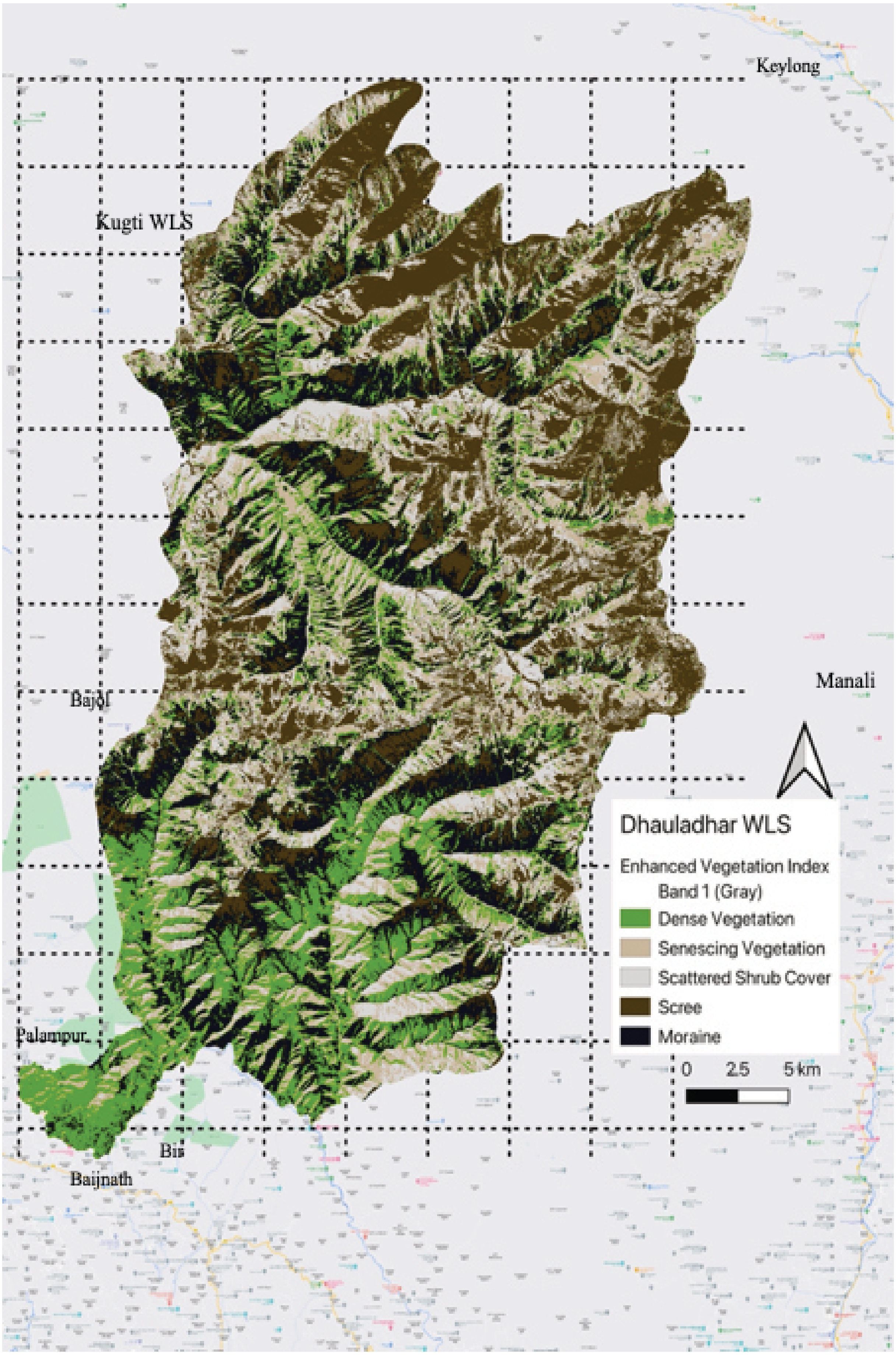


Figure 3(left): Slope map of Dhauladhar Wildlife Sanctuary and Figure 4(right): Enhanced Vegetation Index Map representing vegetative stratification across Dhauladhar Wildlife Sanctuary


Keylong
Kugti WLS
Manali
Bajol
Palampur
Bir
Baijnath
Dhauladhar WLS
Enhanced Vegetation Index
Band 1 (Gray)
Dense Vegetation
Senescing Vegetation
Scattered Shrub Cover
Scree
Moraine
0 2.5 5 km

3. Major Objectives:

This project by Himachal Pradesh Forest Department, Hamirpur Division intends to assess the mammalian population and its distribution within the sanctuary. Most of the area being unexplored and inaccessible, proper scientific studies with strategic methodologies were never conducted here. Therefore, the outcomes of this study would feed a dynamic decision support system. All the data obtained undergoes serious processing and comes out in form of ecological maps, tabular estimations and geo-spatial mapping about the hotspots for conservation in future. With the help of scientific study and geo-spatial information, the goals of this project were achieved. Present report deals with the objectives that were set from the month of July,2021 to March,2022.

It was mainly focused on:

- **To assess the diversity of mammalian fauna in Dhauladhar Wildlife Sanctuary**
- **To estimate encounter rates and relative abundance indices (RAI) of herbivores and carnivores in Dhauladhar Wildlife Sanctuary**
- **To develop a spatial database for the distribution of mammals and to produce species-wise distribution maps in Dhauladhar Wildlife Sanctuary**

To achieve these objectives in such a landscape, standard field equipment's were used. There is a huge difference in planning and execution of objectives on and off field. Though, complete planning was carried out off field, improvisations after discussions with Principal Investigator did happen after actual site visits throughout the project period. Rigorous field work in high altitude followed by equally exhausting data analysis led to completion of the mentioned objectives.

4. Materials and methods:

4.1. Camera-Trapping Survey:

The total area was divided into 4x4 km^2 grids using Arc GIS 10.3 (Geographic Information System). For simplicity, the area was categorised into different survey zones according to the habitat and elevation, viz., sub-tropical (3500 m), and then camera-traps were deployed corresponding to the area coverage of the survey zones and their accessibility. Since the species being studied are rare, and the area is vast, the strategy was to survey more sampling units less intensively rather than less sampling units more intensively (Mackenzie & Royle 2005). Monitoring of camera-traps were done at regular intervals of time to check the functioning and changing of the batteries and memory card. Infrared triggered Cuddeback cameras were used for the study. These traps were set at 3.5km-4km interval along 6 transects. Cameras were positioned within 25m of the transect line, selecting the specific locations using presence of trails and scat / animal signs. These cameras were left in the field for 30days. We used Wildlife Acoustic-song meter SM4BAT-FS to record ultra-sonics at 12 different locations to identify the Bats present within the sanctuary.

4.2. Trail Survey (Transect):

The total area was divided into 4 x 4 km^2 grids using Arc GIS 10.3 (Geographic Information System). Animal trails, human trails, riverside trails, etc. were walked for trail transect survey. In each grid, one trail survey was completed with 5 replicates each. Line transects routes of almost 6 km in length were established in four different areas comprising 3 beats; Thamsar, Shahnala and Bara Bhangal respectively. The transects were not of exactly the equal length, nor along straight lines and also not equally spaced as the forests are dense, closed and not been walked for several years and only follow old human trails and animal corridors. The survey was carried out early morning and five replicates of each transects were completed within two months (20^{th} July- 20^{th} September). On every animal sighting, the following data was recorded: (1) Species and group size: one or more animals of the same species within 30 m of each other and showing signs of coordinated movements was considered as a group; (2) Sighting angle: sighting angle to the centre of the group was calculated using a hand-held compass; (3) Sighting distance: the distance to the centre of group from the point of observation was measured using a range finder.

4.3. Presence/Absence Monitoring:

Methods implemented in this application are based on detection and non-detection data obtained on sampling units. Direct sightings and indirect signs, such as scat, pellet, pug mark, hoof mark, etc. of a given species in a given area were recorded. Maps, Google Earth, and topo-sheets were used for identifying sample units such as grid, trails, and plots. The sample unit size depended on the species of interest. While species with large home range sizes such as the snow leopard require a grid of considerable size, species with smaller home range sizes such as musk deer, barking deer, and small mammals require grids of smaller sizes (Sathyakumar et al. 2013). In the Himalayas, one could also use sampling units that can be easily demarcated based on natural features (Sathyakumar et al. 2013). A small catchment or watershed with ridges as natural boundaries were demarcated as a sampling unit. We further generated the presence/absence maps for each species.

4.4. Scanning Methods/ Point Counts:

Abundance estimation for animal population involved two issues. First, we are working in a area which is sufficiently large that ground surveys could not be conducted over the entire area of interest and second, was the detectability. Still, we conducted surveys at 106 sample points located at 7 different transects across the study area. Recording the number of mammals seen during a 10 min count period was done. Ungulates such as Himalayan Ibex, Himalayan Tahr and Himalayan Goral inhabit steep areas with open grassy slopes and less tree cover. Such habitats offered an excellent opportunity to scan for animals while they are feeding or resting. To apply this technique, careful scanning of such areas was done with a good pair of binoculars from predetermined vantage points. Early mornings and late evenings were selected for scanning time (Sathyakumar 1994). The scanning or point count was done during the period 06:00 to 09:00 h and 15:00 to 18:00 h; however, scan duration varied from one to three hours, depending on the weather conditions.

4.5. Scat Sampling

Scats are a reliable indicator of the animal's presence, abundance, and habitat use. Estimating the dung density of an ungulate species in a habitat is an indirect way to know about its abundance or density (Bennett et al. 1940, Sathyakumar 1994). Similar is the scenario with carnivores. The dung counts were made within a 20×2 m belt transect, while vegetation cover estimation was done within the 15×15 m plots at every 2km interval along the trail transects. Vegetation data near camera trap site was collected and herbariums of around 45 flowering plant species and 60+ shrub species were prepared. Two hundred thirty eight points were recorded for animal droppings and footprints. Scat and sign surveys too, were done on same days while transect survey was conducted.

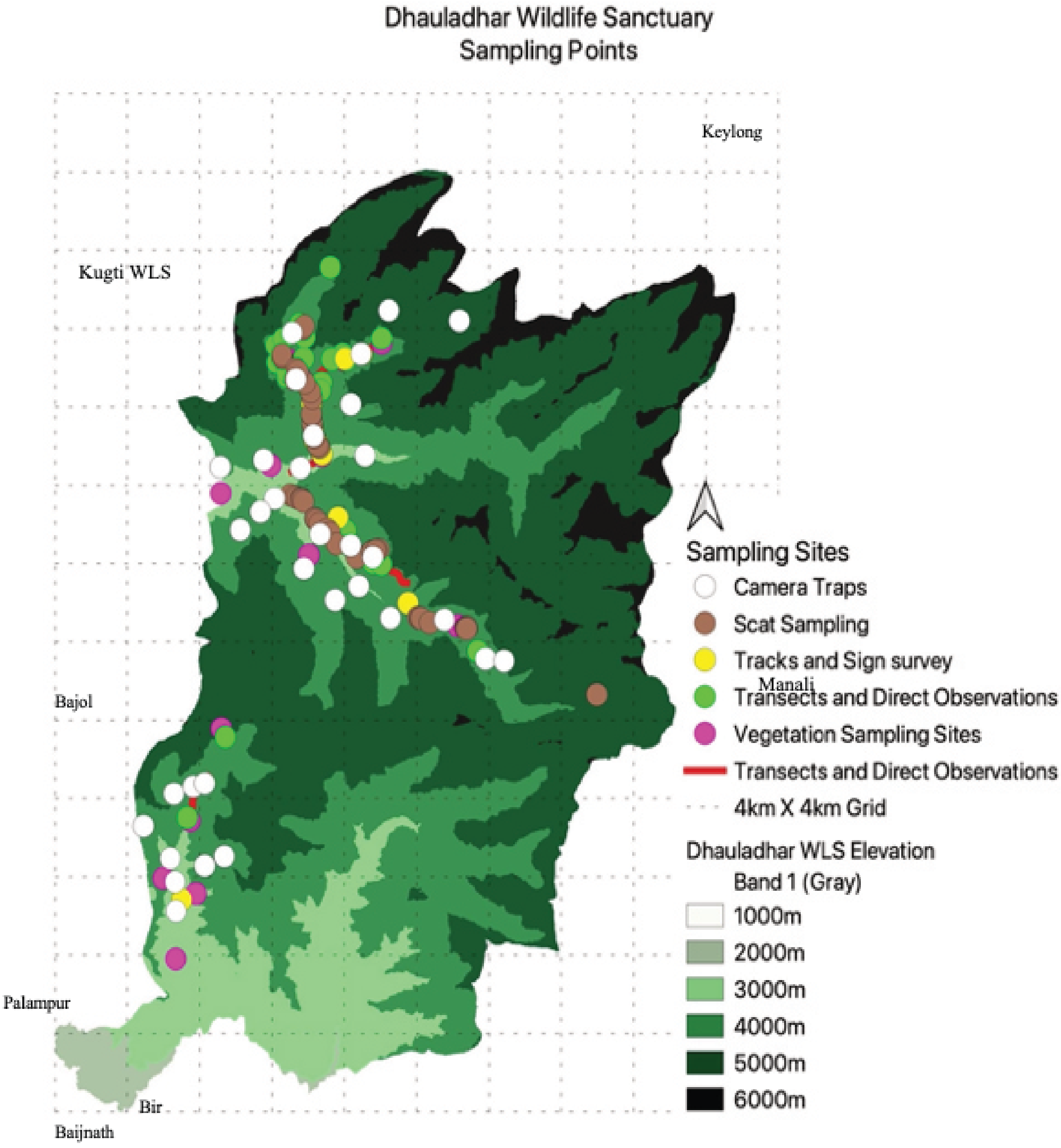


Figure 5: Elevation map of Dhauladhar Wildlife Sanctuary representing sampling points

4.6. Camera Trap Distance Sampling:

Mammals were photographed using camera traps in an accessible area of 450 km^2 in Dhauladhar WLS, Himachal Pradesh, India. Camera-trap locations were unbaited and selected based on accessibility, terrain features, animal trails, and nallahs (seasonal drainages) with carnivore signs (Marinho et al. 2018). At each location, a single Cuddeback X-Change™ colour model (Cuddeback, Green Bay, WI, USA) with motion sensors was deployed, and a time lag of 2s was set between animal detections. Cameras were fastened to trees at the height of 30-45 cm above the ground for an average of 32 days. A total of 33 camera-trap locations were utilised in a grid-based approach (grid size: 3.5-4 km^2) during August 2021-November, 2021.

Monitoring of camera-traps was done at least twice a month, including the change of batteries and memory card. After the completion of each camera-trapping session, the photographs were examined for images of animals. Mammals were identified with the help of literature (Jerdon 1874, Prater 1965, Jerdan 1984, Tritsch 2001, Menon 2014, Grewal & Chakravarty 2017). Then, the data from all camera stations of each sampling period was merged before further analysis. The amount of trapping effort required (unit: camera-days) was calculated for each camera from when the camera was mounted until the camera was retrieved, if the film had any remaining exposures, or until the time and date stamped on the final exposure. Total trapping effort in a sampling period was defined as the sum of the camera-days of all cameras.

5. Data Analysis:

5.1. Species richness and RAI_1 / ER / Photo capture rates:

Species richness was estimated as the total number of species detected during the study period. RAI_1 (Relative Abundance Index) was calculated as a total number of independent photographs for each species divided by total trap nights and multiplied by 100 (Carbone et al. 2001). The criteria to determine a photographic event (a species occurrence) were (1) consecutive photographs of the same species within 0.5 hours (30 minutes) were counted as one species occurrence, (2) the stamped time of the first photograph of these consecutive photographs was taken as the species-occurrence time. After 30 minutes, additional photos of the same species were considered another occurrence event, and (3) different identifiable individuals were treated as a separate occurrence even though they appeared in the same photograph, or the photographs were taken within 30 minutes (O'Brien et al. 2003). The analysis was carried out in a windows-based MS office excel worksheet using the data analysis tool.

$RAI_1 =$ (O'Brien et al. 2003)

Where A is independent photo captures, and N is trap nights.

5.2. Trap effort:

To understand the time required to detect mammals if they are present at a sampling location, we calculated RAI_2 (the number of trap nights required to get a single photograph of the species) and RAI_3 (the number of trap nights required to get a first photograph of the species) (Jenks et al. 2011). RAI_2 was calculated by dividing total trap nights by the number of independent photos of each species. RAI_3 was calculated through frequency distribution of nights to the first detection of each photo-captured species. All analysis was carried out in a windows-based MS office excel worksheet using the data analysis tool.

$RAI_2 =$ (Jenks et al. 2011)

Where A is independent photo captures, and N is trap nights.

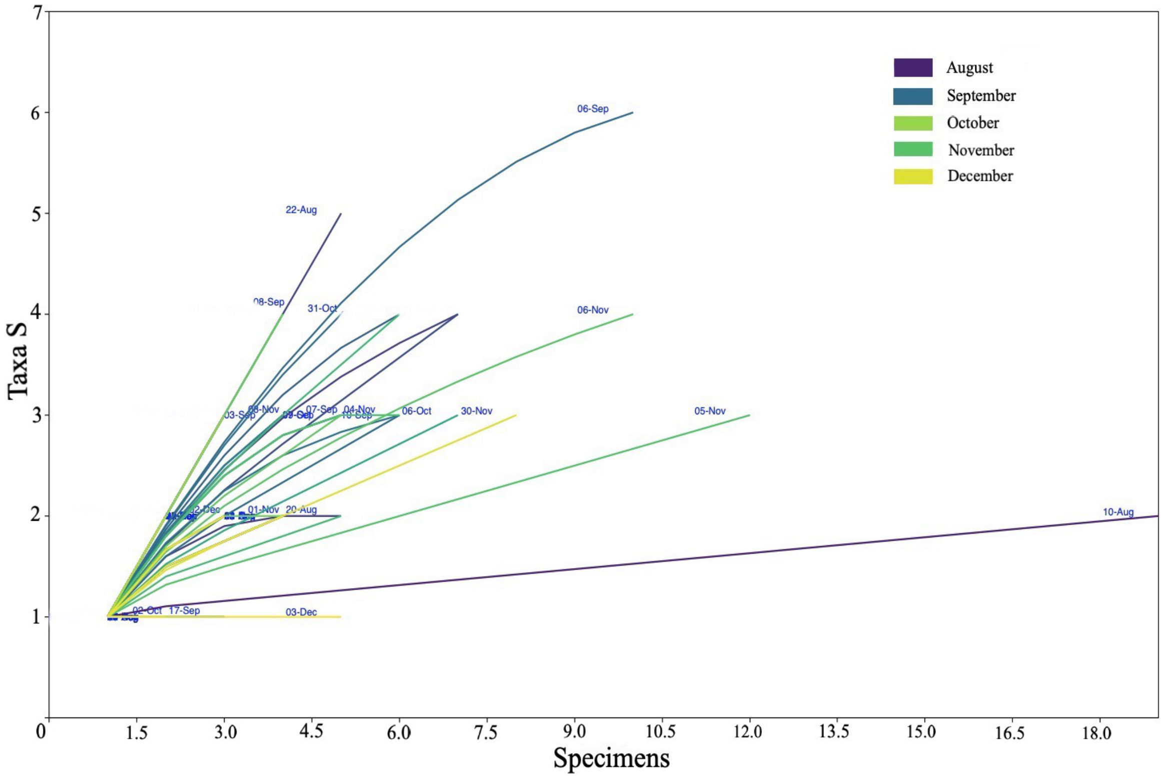


Figure. 6: Individual rarefaction curves representing date-wise camera trapping efforts for samples photo captured against taxon in Dhauladhar Wildlife Sanctuary.

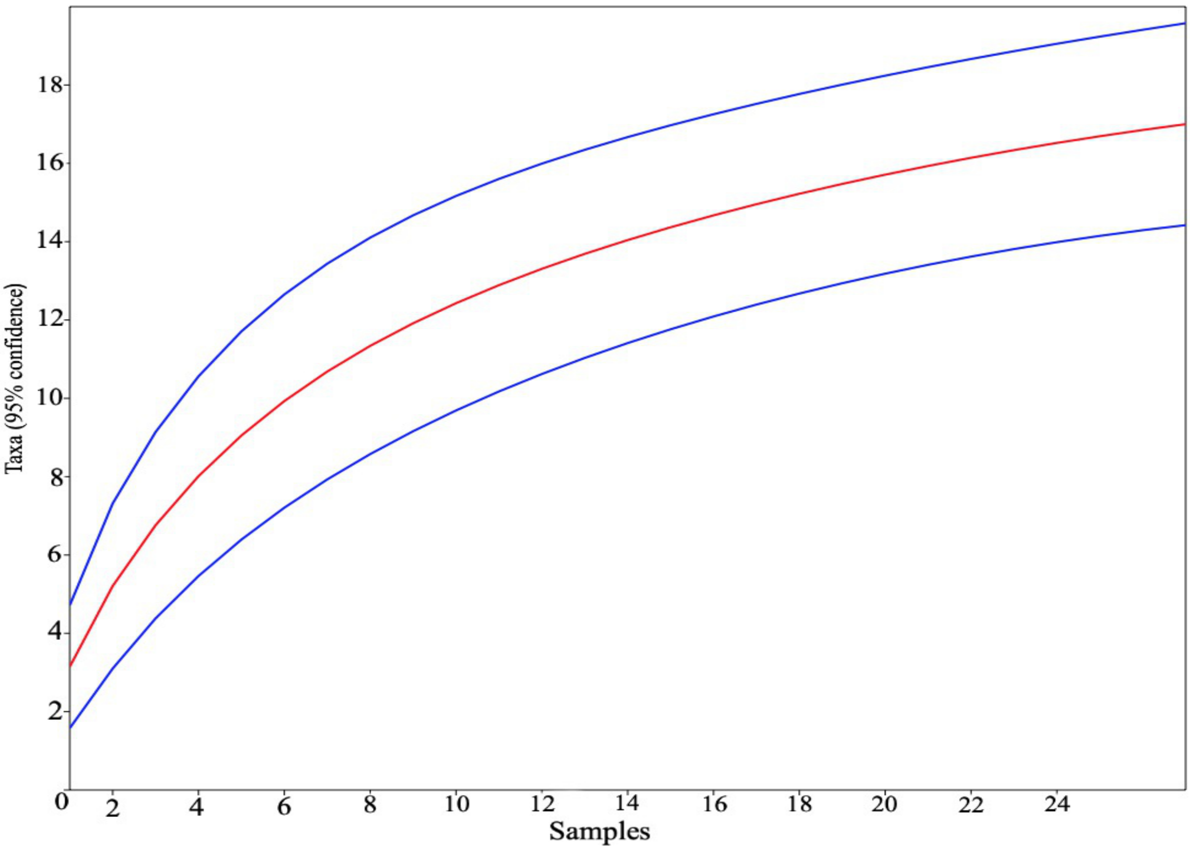


Figure 7: Sample rarefaction curve representing samples photo captured against taxon in Dhauladhar Wildlife Sanctuary

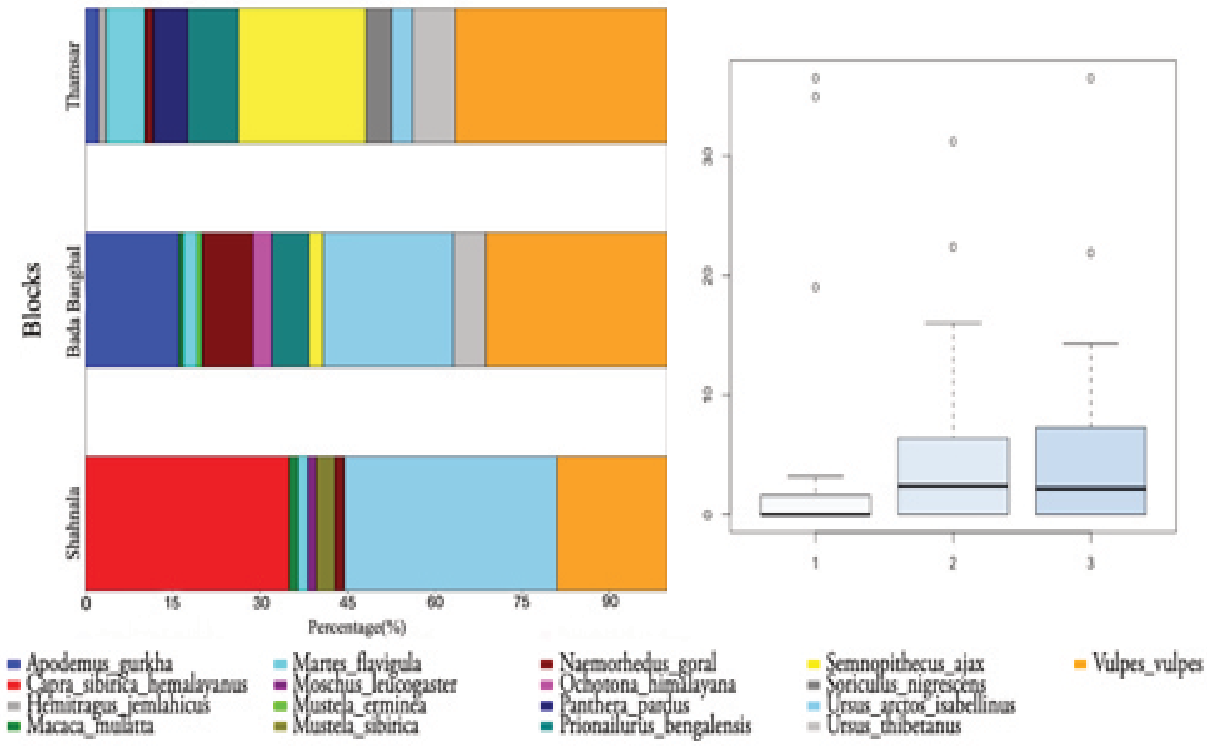


Figure 8: Stacked bar chard representing the percentage of various mammalian species encountered in different blocks(Block1-Shahnala, Block2- Bada Bhangal and Block3- Thamsar beat) with a percent boxplot with outliers (H= 40.336, df = 3, p-value =<0.001).

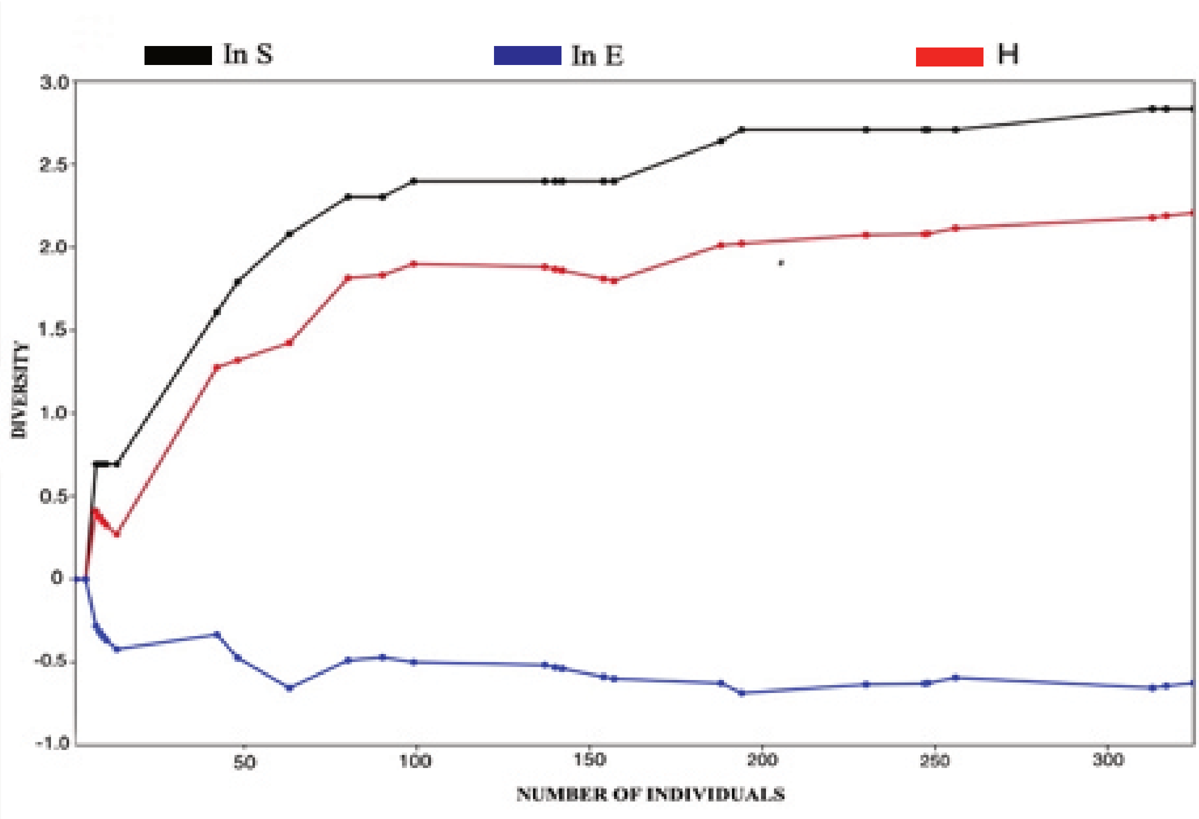


Figure 9: SHE analysis plot for mammalian species richness (ln S), Shannon-Wiener index (H), and evenness (ln E) from diversity derived from all three studied blocks.

5.3. Density Estimation of Identifiable individuals:

Camera-traps have been used to estimate densities of tiger, leopard, and clouded leopards in various landscapes (Borah et al. 2013, Macdonald 2017). In the study area, leopards and leopard cats were distinguished by their natural body and face markings with distinctive patterns, which enables the identification of individual animals. Since a single camera trap was deployed at each location, both flanks of all the captured individuals were not obtained. Therefore, only one flank was used with the maximum number of photographs. Individual detection histories were created using binary format (detection or non-detection of the individual), along with other trap-specific details such as spatial coordinates of the trap, time, and date. Camera stations were treated as "proximity detectors" allowing the animal to be detected at multiple traps on any given occasion. We used spatially explicit capture-recapture (SECR) methods to estimate density using a maximum-likelihood-based approach (Efford et al. 2009). These methods eliminate the subjectivity associated with calculating an effective trap area to estimate density (Borchers & Efford 2008, Royle & Young 2008). We defined the state space for each site by adding a 5 and 25 km buffer, for leopard cat and leopard respectively, to the outermost coordinates of the two trapping grids. (Mizutani et al. 1998, Chen et al. 2016).

5.4. Density estimation using camera-trap distance sampling:

The distance between the animal and the camera at snapshot moments is calculated in distance sampling with camera traps, to ensure that animal movement does not bias the distribution of detection distances (Howe et al. 2017). We thus defined a finite set of snapshot moments (2 s apart) within the sampling period (as suggested in Howe et al. 2017) for a total number of 31 camera traps (n=31). For each snapshot moment when the species was captured, the radial distance between each animal and the camera trap was estimated using a regression equation developed from the field calibration. This calibration was done for a total of thirty-one camera traps for distance sampling. In this equation, the dependent variable was the ratio of the actual height of an individual to its height in the photograph, and the explanatory variable was the distance at which the individual was photo captured.

The information on actual heights for different species was obtained by comparing the camera-trap photos of the species with the height of the calibration pole height. We obtained information on actual heights for different species by comparing the camera-trap photos of the species with the height of the calibration pole height.

Density was estimated following the equation for camera-trap point transects (Howe et al. 2017). We estimate D as

$$\hat{D} = \frac{\sum_{k=1}^{K} n_k}{\pi w^2 \sum_{k=1}^{K} e_k \hat{P}_k};$$

(Howe et al. 2017)

where n_k is the number of observations of animals at a point k (camera-trap location), e_k is the temporal effort and P_k is the estimated probability of obtaining an image of an animal that is within θ degrees (angle covered by the camera's field of view), K is the total number of camera-trap locations and w (truncation distance) in front of the camera at a snapshot of the moment. The effort at a point k was measured as $e_k = \theta\ T_k/2\ \pi t$ where $\theta/2\pi$ describes the fraction of a circle covered by a camera, T_k is the period of camera deployment (in seconds), and t is the unit of time used to determine a finite set of snapshot moments within T_k (also in seconds). We defined the period of camera deployment as the time the target species was expected to be active during the sampling period. We use the distances r_i to model the detection function and hence to estimate P_k. Distance data were censored accordingly and modelled with θ assumed to be 42° (0.733 radians). For the 'empirical' set-up, θ was estimated empirically: θ was assessed by walking in front of the camera, perpendicularly to the midline of the field of view, and measuring the distance from the operator to the midline that triggered the sensor, using the camera in setup mode. This procedure was repeated 3-4 times (walking five times from the left and five times from the right); the angle of view was calculated using basic trigonometric formulas, and was used as an estimate for realized θ.

We used the point transect distance sampling method in Distance (Thomas et al. 2010) for all analyses, where $e_k = \theta\ T_k/2\ \pi t$ is used to calculate the survey effort. For the analysis in Distance, we modelled the detection from using the same functions as Howe et al. 2017: half normal with 0, 1 or 2 Hermite polynomial adjustment terms; hazard rate with 0, 1 or 2 cosine adjustments; uniform with 1 or 2 cosine adjustments.

Adjustment terms were constrained, where necessary, to ensure the detection function was monotonically decreasing.

5.5. Line transect sampling:

To determine the ungulate density, line-transects were also used (Karanth et al. 2004; Ramesh et al. 2009). The terrain of undulating and dry riverbeds, and mixed and Sal dominated forests were covered during the survey on foot, while every animal visually detected was recorded (e.g. Karanth et al. 2002). A total of eight (N = 8) were covered in the landscape, and each transect was repeated six times resulting in a total effort of approximately 58 km of transects.

The perpendicular distance (x) of an animal from transect was then calculated using a range finder (Inesis, Telemeter, 900), and a compass to determine the sighting angle (θ); and the radial distance was then calculated via the equation $x = r \sin \theta$ (Thomas et al. 2002). The method assumes that every animal on the transect path will be detected, and thus the animal detection probability is therefore a declining function of perpendicular distance from the transect (Thomas et al. 2002). Detection metric is then fitted to the data to estimate the proportion of the population detected, and which can then be used to estimate species population abundance with the standard estimator of the form:

N = (Thomas et al. 2002)

where N is abundance, A is the total survey area, n is the number of animals counted, w is the approximate distance view on each side of the transect, L is the length of the transect, and P_a is the detection probability of each animal. We used the statistical software package DISTANCE (Thomas et al. 2001) to fit the models and estimate species abundance as it employs the models briefly described here and takes into account size bias associated with the increased probability of detecting larger animal groups.

5.6. Conservation Status

We identified the conservation status of recorded mammals based on the IUCN (International Union for the Conservation of Nature) Red List criteria viz. Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT) and Least Concern (LC) (IUCN 2020), the CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) appendices viz. I, II and III (CITES 2020), and the Indian Wildlife Protection Act (WPA), 1972 schedules *viz* I, II, III and IV (Anonymous 2006).

RESULTS

6.1. Species richness and RAI / ER / Photo capture rates:

Scientific Name	n	RAI_1	RAI_2	RAI_3	IUCN	CITES	WPA, 1972
Carnivores							
Leopard *Panthera pardus*	8	0.6 (±0.2)	136.5	97	VU	I	Sch I
Himalayan Brown Bear *Ursus arctos isabellinus*	56	5.59 (±1.2)	19.5	1	CR	I	Sch I
Asiatic Black Bear *Ursus thibetanus*	17	1.38 (±0.5)	64.23	67	VU	I	Sch II
Red fox *Vulpes vulpes*	101	8.56 (±3.0)	10.81	30	LC	III	Sch II
Leopard Cat *Prionailurus bengalensis*	20	1.61 (±0.7)	54.6	50	LC	I/II	Sch I
Yellow-throated Marten *Martes flavigula*	13	1.06 (±0.4)	84	45	LC	III	Sch II
Stoat *Mustela erminea*	1	0.1 (±0.1)	1092	67	LC	III	Sch I
Siberian weasel *Mustela sibirica*	2	0.22 (±0.1)	546	37	LC	III	Sch II
Field mouse *Apodemus gurkha*	23	2.22 (±2.0)	47.47	57	LC	NL	-
Himalayan Shrew *Soriculus nigrescens*	6	0.45 (±0.4)	182	128	LC	NL	-
Herbivores							
Asiatic Ibex *Capra sibirica hemalayanus*	22	2.59 (±2.1)	49.63	39	LC	III	Sch I
Himalayan tahr *Hemitragus jemlahicus*	2	0.15 (±0.1)	546	41	NT	NL	Sch I
Musk Deer *Moschus leucogaster*	1	0.11 (±0.1)	1092	51	EN	I	Sch I
Himalayan Goral *Nemorhaedus goral*	14	1.27 (±0.6)	78	47	NT	I	Sch III
Rhesus Macaque *Macaca mulatta*	2	0.19 (±0.1)	546	43	LC	II	Sch II
Gray Langur *Semnopithecus schistaceus*	33	2.53 (±1.8)	33.09	54	LC	I	Sch II
Himalayan Pika *Ochotona himalayana*	4	0.40 (±0.4)	273	59	LC	NL	Sch IV

Table 1. A checklist of mammals of DWLS, showing independent records (n), RAI_1 (Relative Abundance Index), RAI_2 (trap nights required to detect single photograph), RAI_3 (average day to first photographic detection), and conservation status. RAI_1 = (Independent photographs / trap nights) × 100. RAI_2 = Trap nights / independent photographs. RAI_3 was calculated through frequency distribution of nights to the first detection of photo-captured species. Abbreviations used are n = Independent Captures, IUCN = International Union for Conservation of Nature, LC = Least Concern, VU = Vulnerable, NT = Near Threatened, CITES = Convention on International Trade in Endangered Species of Wild Fauna and Flora, I = species listed under CITES Appendix I, II = species listed under CITES Appendix II, III = species listed under CITES Appendix III, NL = not listed, WPA = Wildlife Protection Act, 1972.

We recorded a total of 17 mammals (10 carnivores and 7 non-carnivores or herbivores) with 325 independent records over the whole sampling period of 1219 trap nights (). The independent records (n) and relative abundance index (RAI_1) for the photo-captured species ranging from *Mustela erminea* (n=1, RAI_1=0.1) to *Vulpes vulpes* (n=101, RAI_1=8.56) for carnivores, and from *Moschus leucogaster* (n=1, RAI_1=0.11) to *Semnopithecus ajax* (n=33, RAI_1=2.53) for herbivores.

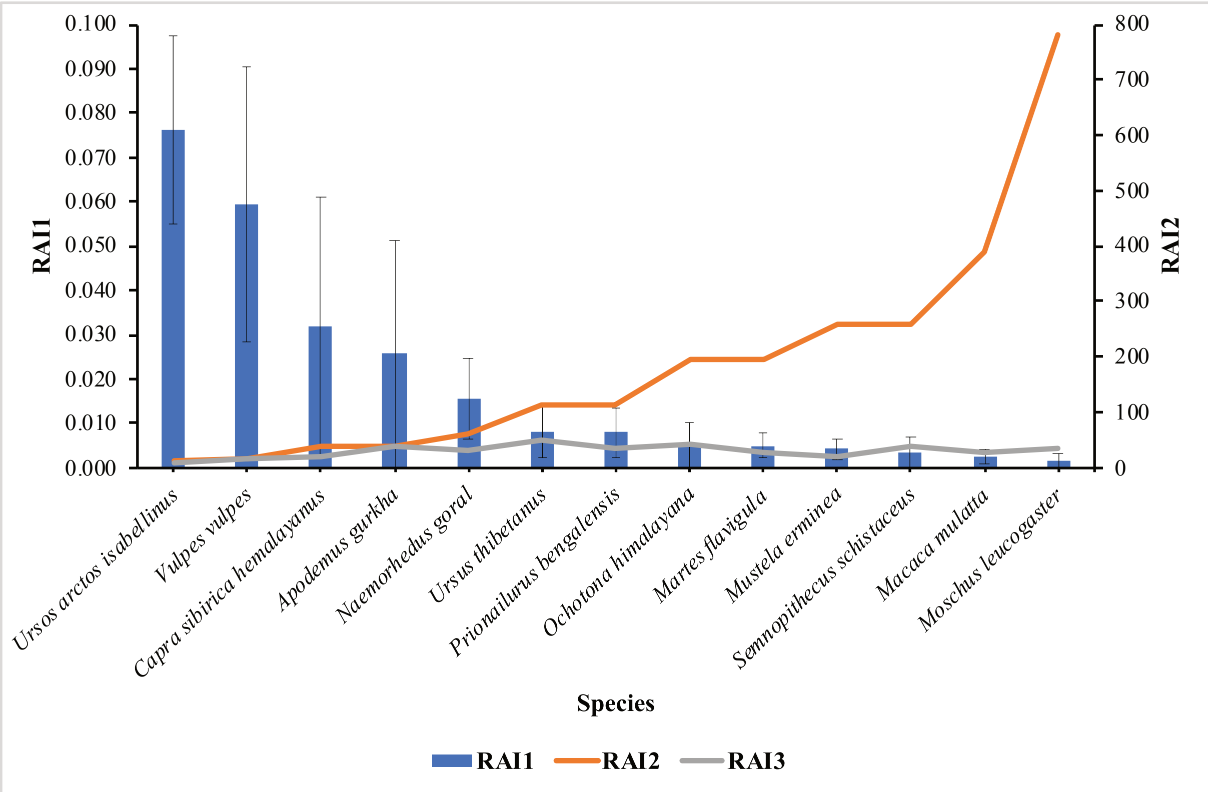


Figure 10: RAI_1 (Relative Abundance Index), RAI_2 (minimum time, i.e., trap nights required to detect single photograph), and RAI_3 (Average day to first photographic detection) of photo-captured mammals in SNP, H.P. India. RAI_1 = (Independent photographs / trap nights) × 100. RAI_2 = Trap nights / independent photographs. $RAI_3$was calculated through frequency distribution of nights to the first detection of photo-captured species.

Sr. No	Species	Direct Sighting	Camera-trap image	Scat or Pellets/ Dung	Pugmark/ Hoof marks	Scrape marks
1.	**Snow Leopard**			✓		
2.	**Leopard**		✓	✓	✓	
3.	**Himalayan Brown Bear**	✓	✓	✓	✓	✓
4.	**Himalayan Black Bear**		✓	✓	✓	✓
5.	**Himalayan Red Fox**	✓	✓	✓	✓	
6.	**Leopard Cat**		✓	✓	✓	
7.	**Himalayan Palm CIvet**	✓		✓		
8.	**Himalayan Stoat**	✓	✓		✓	
9.	**Himalayan Pika**	✓	✓			
10.	**Yellow Throated Marten**	✓	✓		✓	
11.	**Himalayan Goral**	✓	✓	✓	✓	
12.	**Himalayan Tahr**	✓	✓	✓		
13.	**Himalayan Ibex**	✓	✓	✓		
14.	**Himalayan Musk Deer**		✓	✓		
15.	**Rhesus Macaque**	✓	✓	✓	✓	
16.	**Himalayan Langur**	✓				
17.	**Northern Flying Squirrel**	✓		✓		

Table- : A checklist of mammals identified through direct and indirect methods across the landscape.

6.2. Trap Effort

Two herbivore species, i.e., Himalayan Musk Deer (RAI_2=1092) and Himalayan Tahr (RAI_2=546), and one carnivore, i.e., Leopard (RAI_2=136.5), took the highest number of trap nights for a single detection. Hinalayan Brown Bear (RAI_3=1) took only one trap night to detect for the first time, whereas 30 trap nights were required for the first detection of Red Fox (RAI_3=30). In herbivore species, Himalayan Ibex (*Capra sibrica*), took the least number of trap nights for a single detection, and thus the relative abundance for the species was observed to be the highest, followed by that of Himalayan Tahr (*Hemitragus* j*emlahicus*) and Himalayan Goral (*Naemorhedus goral*). The relative abundance for the major carnivore species of the landscape i.e. leopard (*Panthera pardus*) has been observed low and it took the highest number of trap nights for a single detection, and no sighting and/or direct/indirect signs of the species were observed in the field during the survey. During the survey, three species of rodents and/or shrews were observed through direct sighting *viz* Himalayan shrew (*Soriculus nigrescens*), Himalayan Field mouse (*Apodemus gurkha*), and Himalayan Pika (*Ochotona himalayana*), and were also captured in the camera trap.

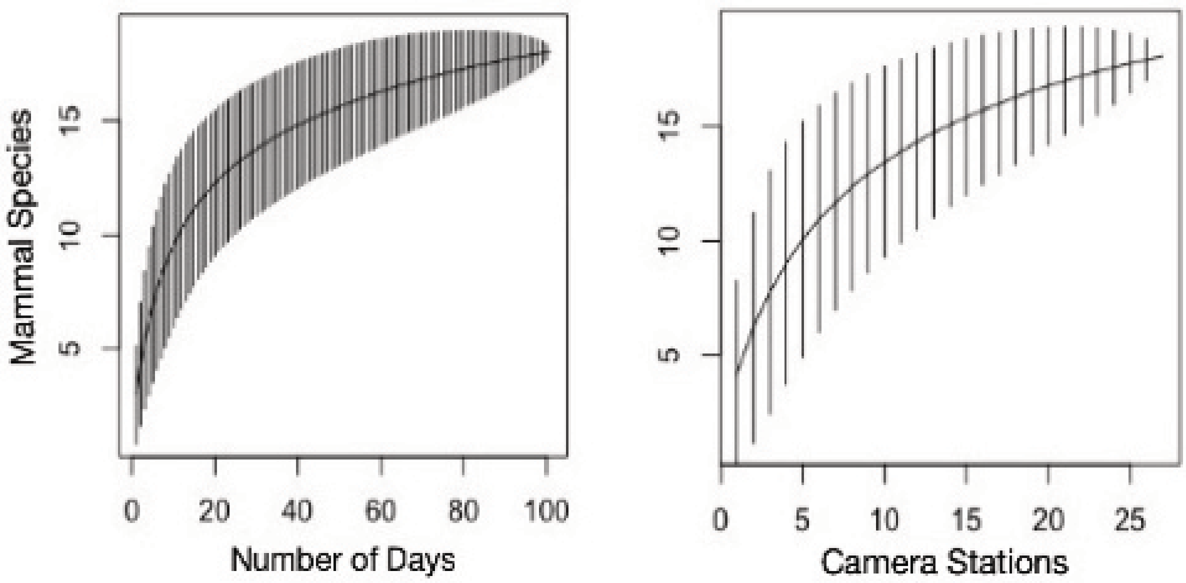


Figure 11: Species accumulation curve for mammals estimated using the R package vegan (Oksanen et al. 2018), depicting the relationship to the number of mammal species (n=17) detected over (left) 100 days, and (right) 33 camera stations. The black line indicates the modelled species accumulation curve, and the shaded area indicates 95 % confidence interval.

6.3. Density estimation using camera-trap distance sampling:

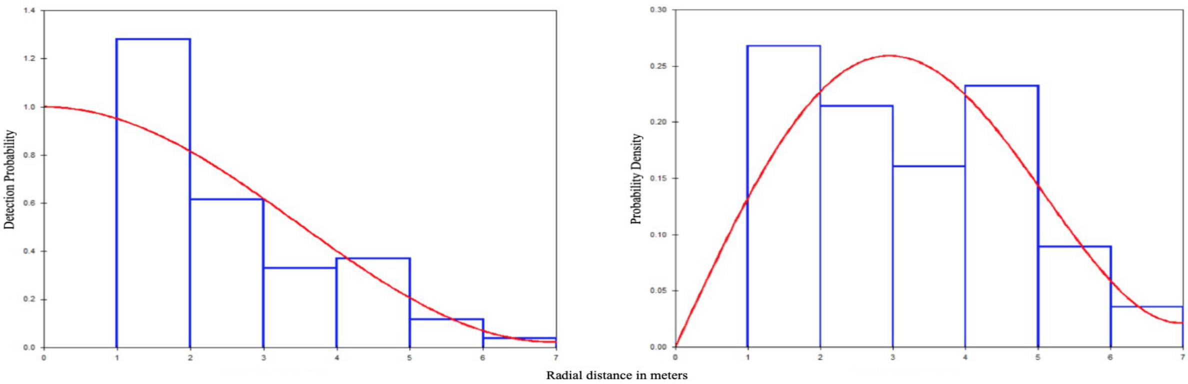
The highest and lowest density per km^2 is that of *Semnopithecus schistaceus* (5.5 ± S.E. 2.1 individuals/km^2) and *Ursus thibetanus* (1.0 ± S.E. 0.4 individuals/km^2) respectively (**Table 1**). Detection probability and probability density for the models selected for estimating density. The bars show the data distribution, and the line represents the model fit. The heights of the bars are scaled so that they cover the same total area as the area under the line, to show how well the detection function fits the data.

Species	Density (individual/km^2)	CV	95% CI	Model
Himalayan Brown Bear *Ursus thibetanus*	0.22 ± S.E. 0.14	14.91	0.4 - 1.05	Half-normal/hermite polynomial
Asiatic Black Bear *Ursus thibetanus*	0.19 ± S.E. 0.43	19.25	0.3 – 2.64	Half-normal/hermite polynomial
Himalayan Langur *Semnopithecus schistaceus*	0.93 ± S.E. 0.5	24.41	0.7 – 5.62	Uniform/Cosine
Red fox *Vulpes vulpes*	0.73 ± S.E. 0.3	18.58	1.0 – 2.47	Uniform/Cosine
Yellow throated Marten *Martes flavigula*	0.64 ± S.E. 0.3	19.50	0.33 – 2.23	Uniform/Cosine
Leopard Cat *Prionailurus bengalensis*	0.66 ± S.E. 0.2	17.35	0.4 – 1.55	Half-normal/hermite polynomial
Himalayan Ibex *Capra sibrica hemalayanus*	1.81 ± S.E. 0.5	16.69	0.6 – 3.38	Half-normal/hermite polynomial
Himalayan Goral *Naemorhedus goral*	1.21 ± S.E. 0.7	20.18	0.5 – 3.10	Half-normal/hermite polynomial

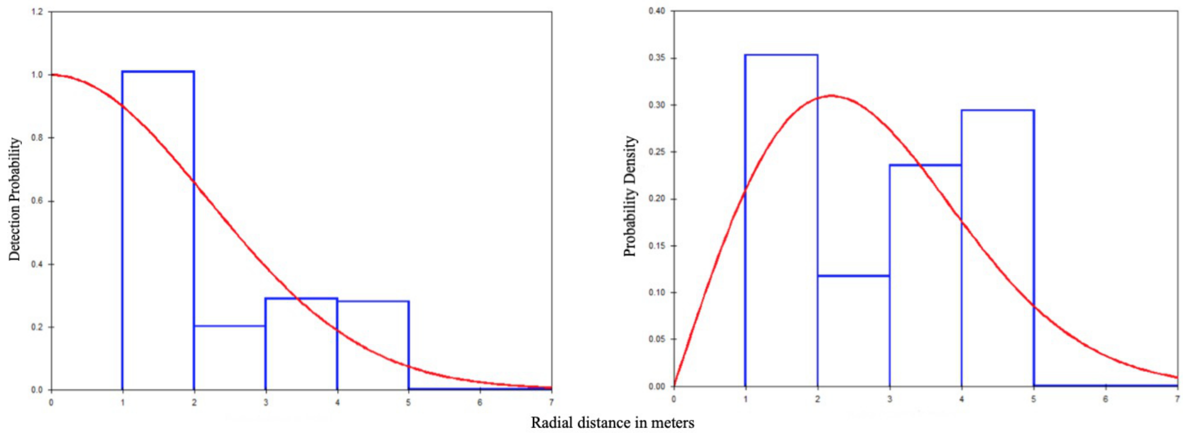
Table 1. Densities of various species in Dhauladhar WLS estimated via field calibration through camera trap distance sampling, and analysis using point transect method in DISTANCE software.

Figure 12. The detection probability and probability density for the models selected for estimating density. The bars show the data distribution, and the line represents the model fit. The heights of the bars are scaled so that they cover the same total area as the area under the line, to show how well the detection function fits the data. The following has been conducted by considering camera-traps as point transects.

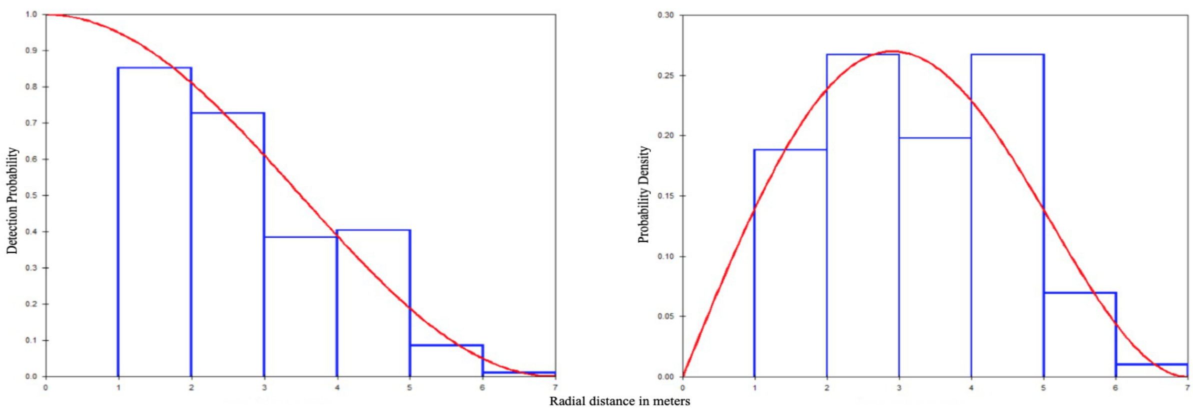
(a) **Probability density functions of observed distances (left) and detection probability as a function of distance (right) for point transect data for *Ursus arctos isabellinus.***



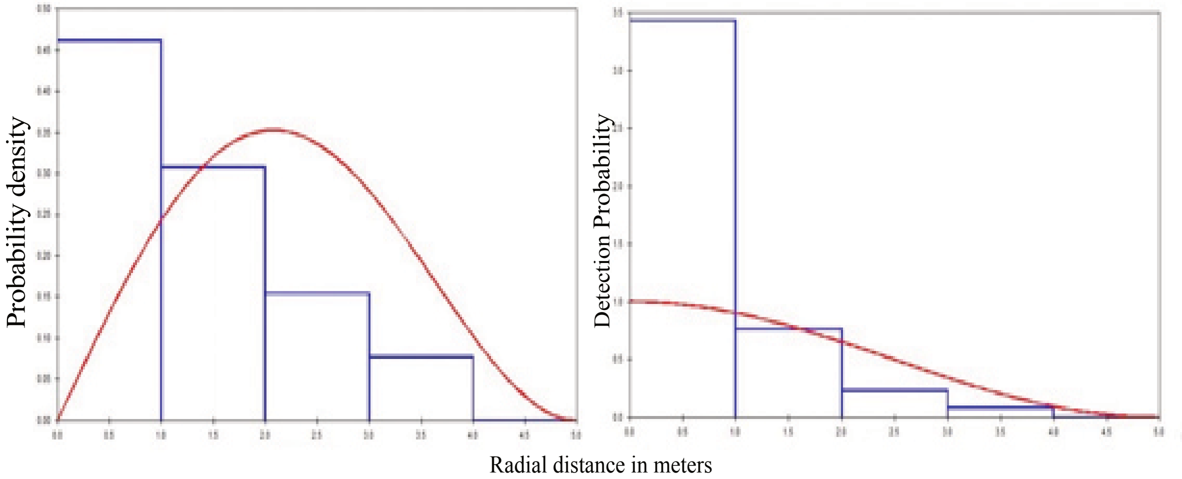
(b) **Probability density functions of observed distances (left) and detection probability as a function of distance (right) for point transect data for *Ursus thibetanus.***



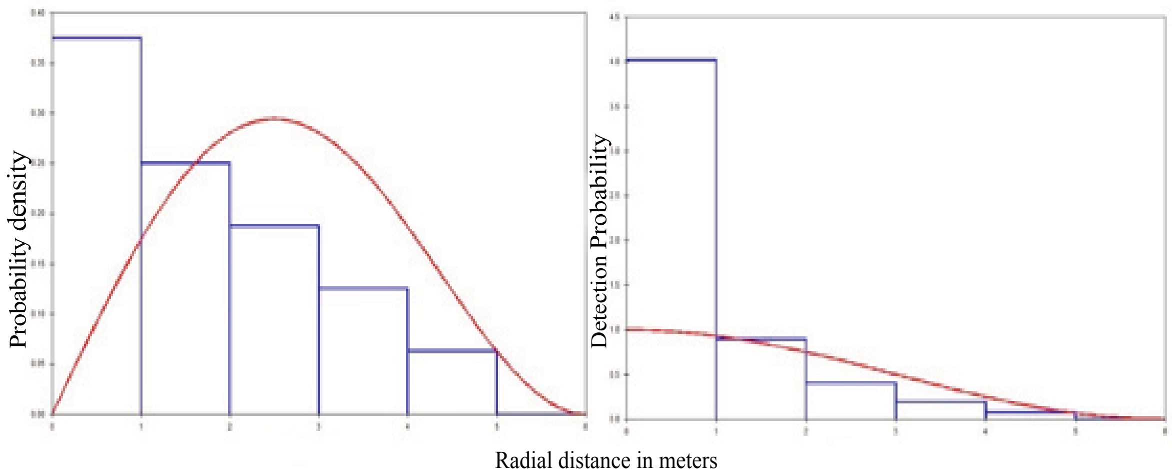
(c) **Probability density functions of observed distances (left) and detection probability as a function of distance (right) for point transect data for *Vulpes Vulpes.***



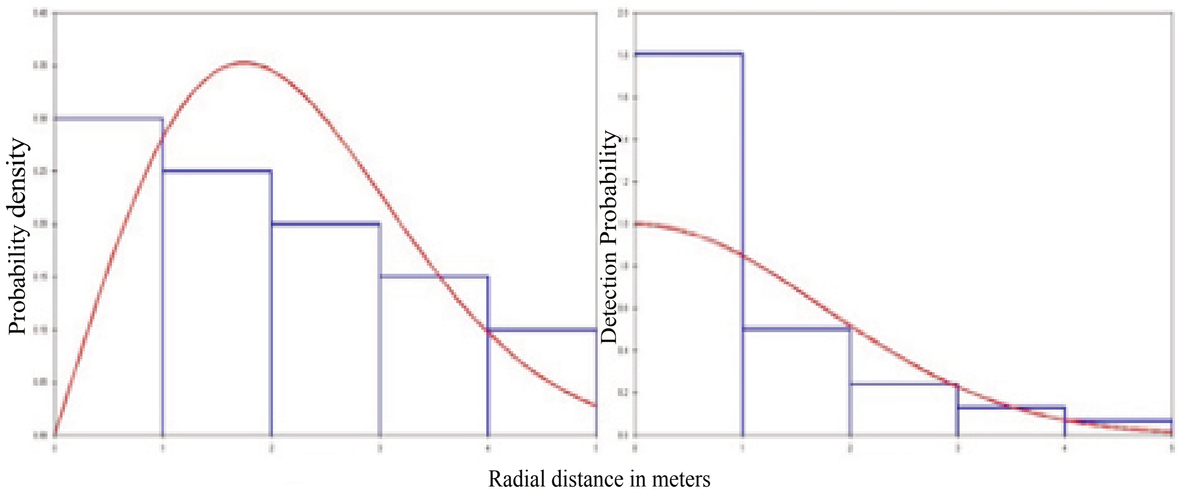
(d) **Probability density functions of observed distances (left) and detection probability as a function of distance (right) for point transect data for *Martes flavigula.***



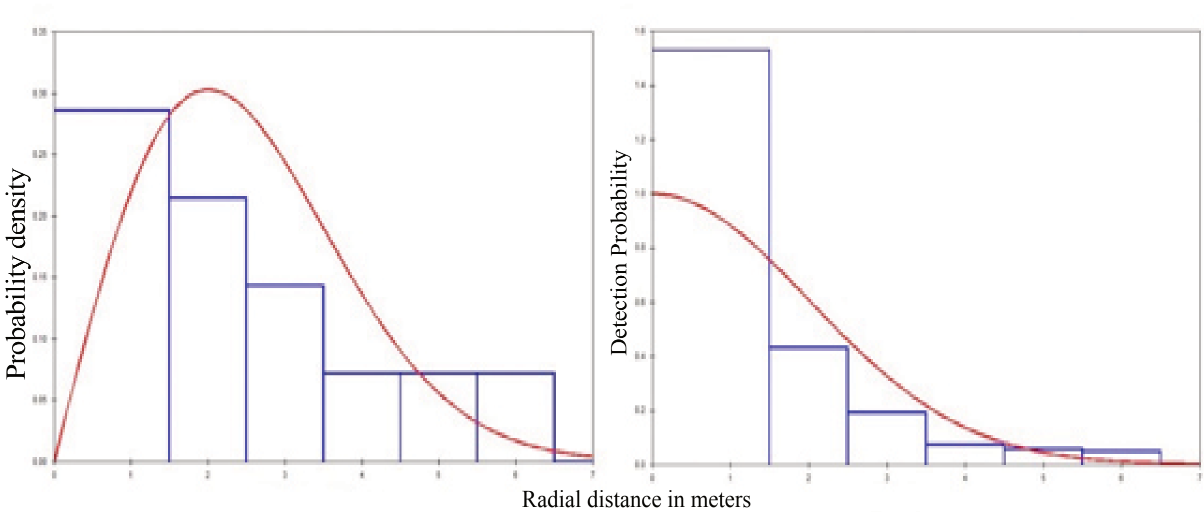
(e) **Probability density functions of observed distances (left) and detection probability as a function of distance (right) for point transect data for *Semnopithecus schistaceous.***



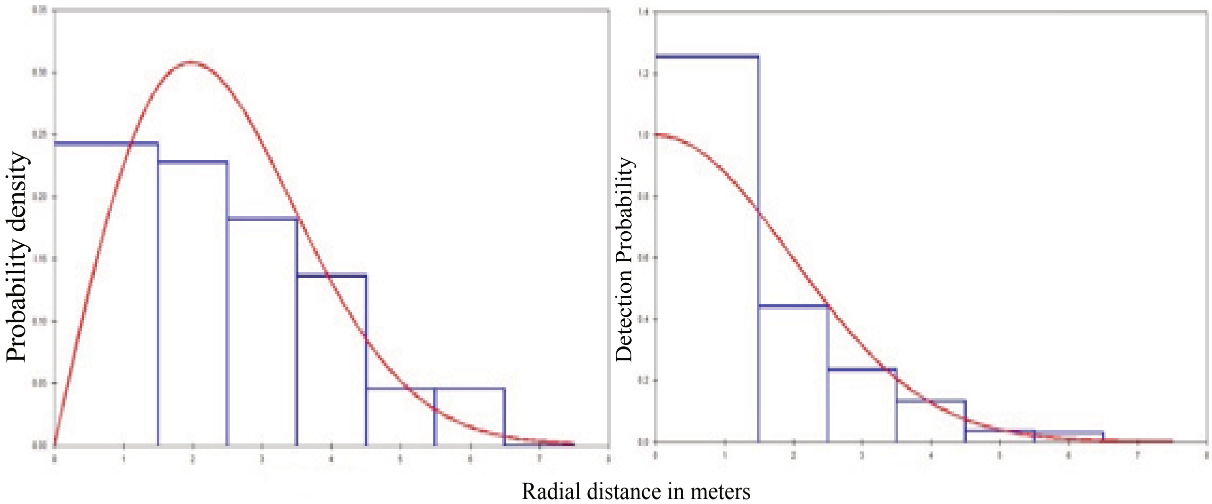
(f) **Probability density functions of observed distances (left) and detection probability as a function of distance (right) for point transect data for *Prionailurus bengalensis.***



(g) **Probability density functions of observed distances (left) and detection probability as a function of distance (right) for point transect data for *Naemorhedus goral***



(h) **Probability density functions of observed distances (left) and detection probability as a function of distance (right) for point transect data for *Capra sibrica hemalayanus***



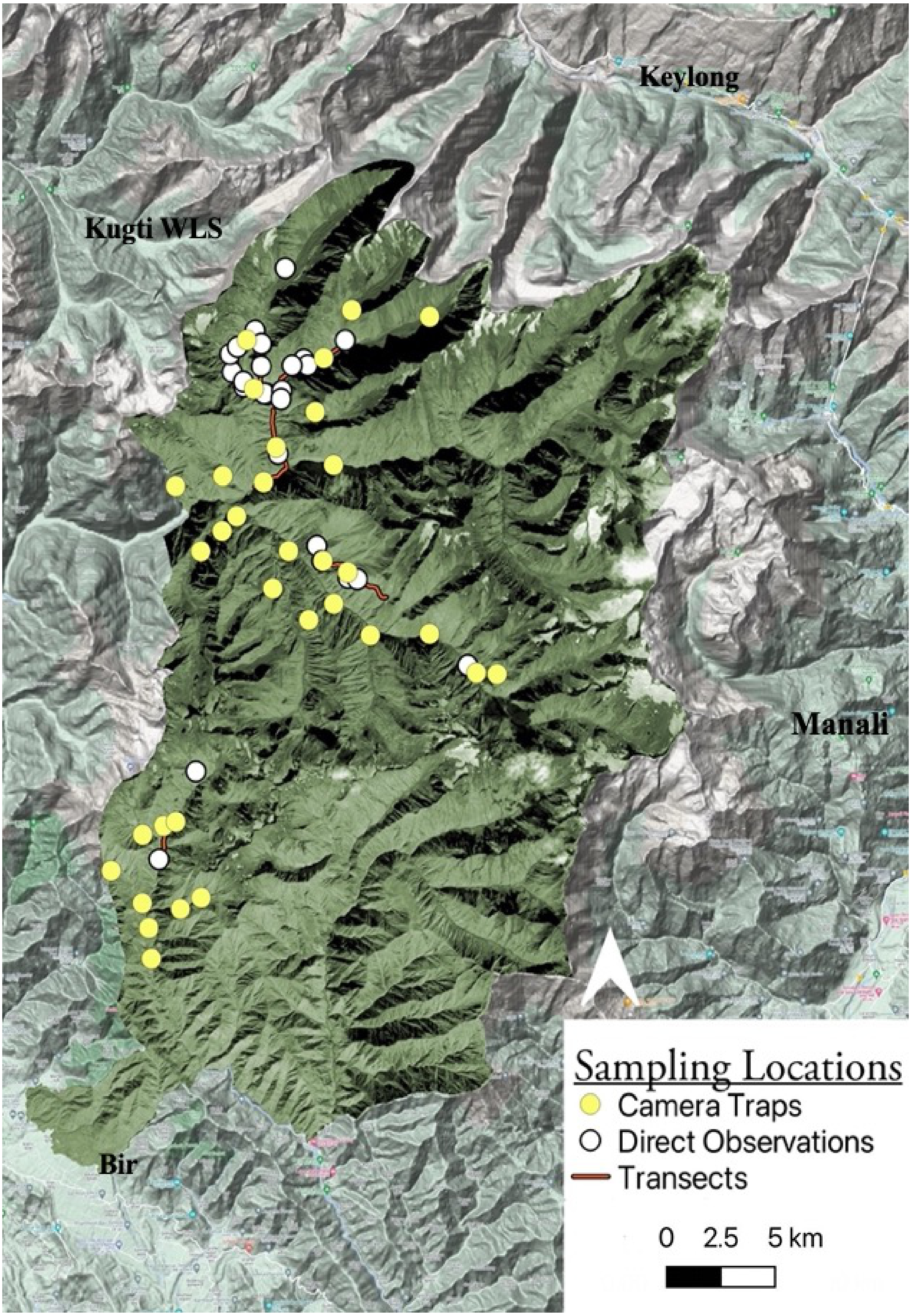
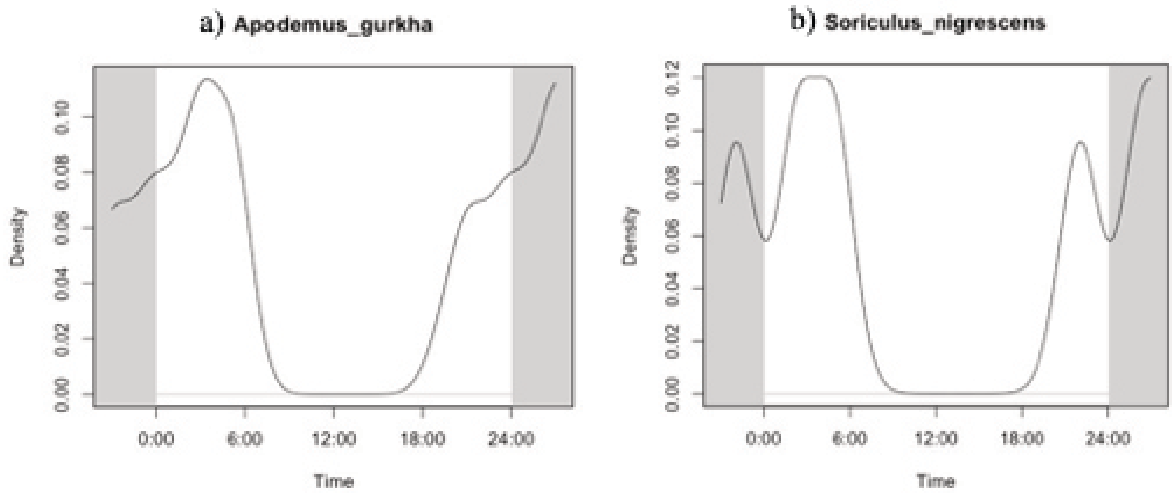
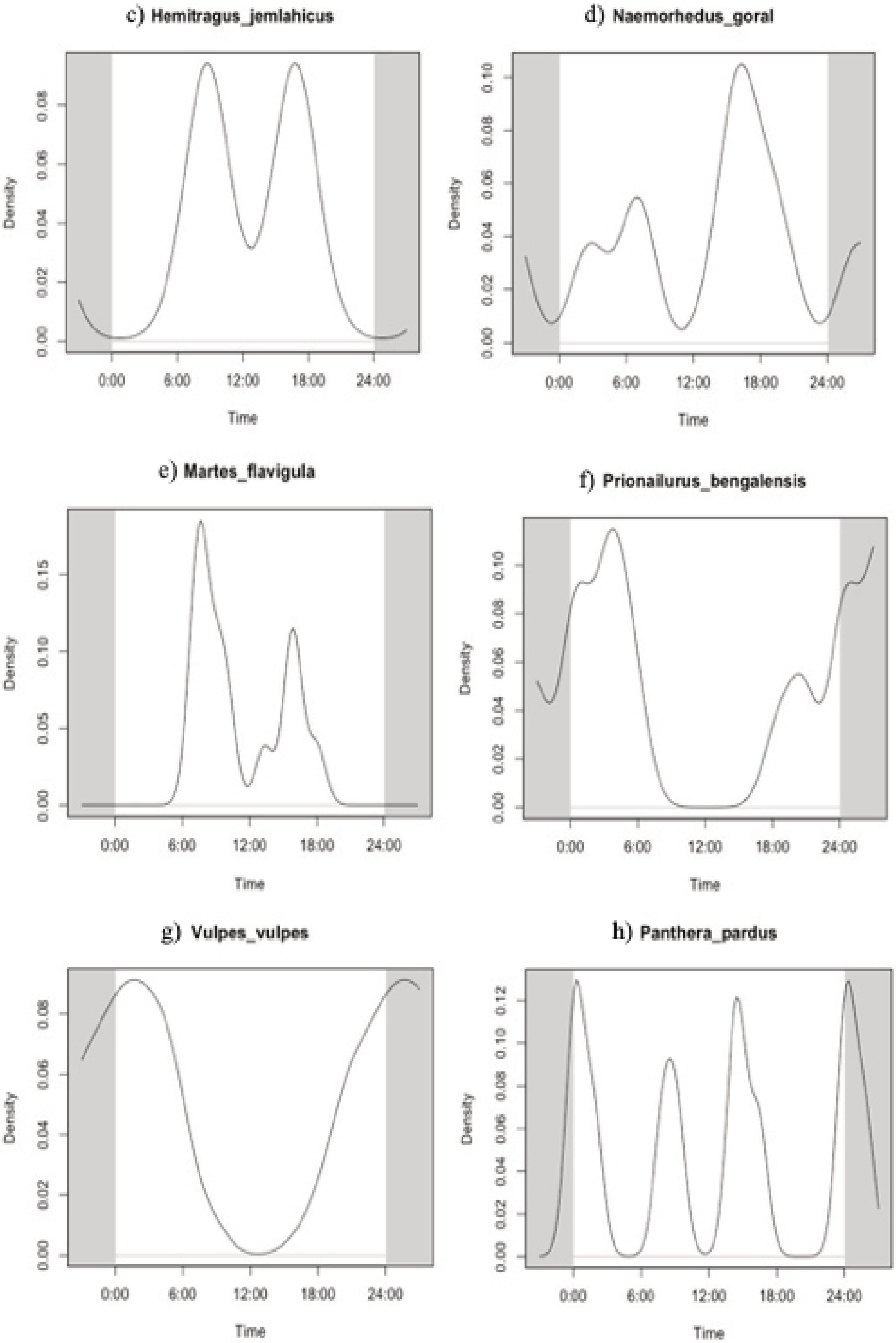


Figure 13: The map representing all 33 camera trap locations utilized to carry out distance sampling as well as six line transects laid for surveying the mammalian species spread across the landscape of Dhauladhar WLS.

6.4. Temporal Activity Patterns:

Camera traps captured a total of 8712 photographs over 840 trap nights during the study period. After all the empty photographs were removed, 2959 photographs were retained overall out of which only 325 independent records were considered. Images were considered to be independent when they were at least 30 min apart (Linkie and Ridout, 2011; Rovero and Zimmerman, 2016) and a detection was coded as (1), non-detection was coded as (0). Species with more than 20 captures were used to analyse temporal activity patterns. Kernel density estimation curves were used to generate activity pattern plots for each species as it is a well-known nonparametric way to estimate the probability density function of distribution of records which assumes that at any time, an animal is equally likely to be captured, as long as it is active (Linkie & Ridout, 2011). Overlap among the daily activity patterns of sympatric species were estimated using overlap package (Linkie & Ridout, 2011) (Bhatt et, al. 2020) in R-software version 3.1.2 (R Development Core Team, 2011).




c) Hemitragus_jemlahicus
d) Naemorhedus_goral
e) Martes_flavigula
f) Prionailurus_bengalensis
g) Vulpes_vulpes
h) Panthera_pardus
Density
Time
0:00
6:00
12:00
18:00
24:00

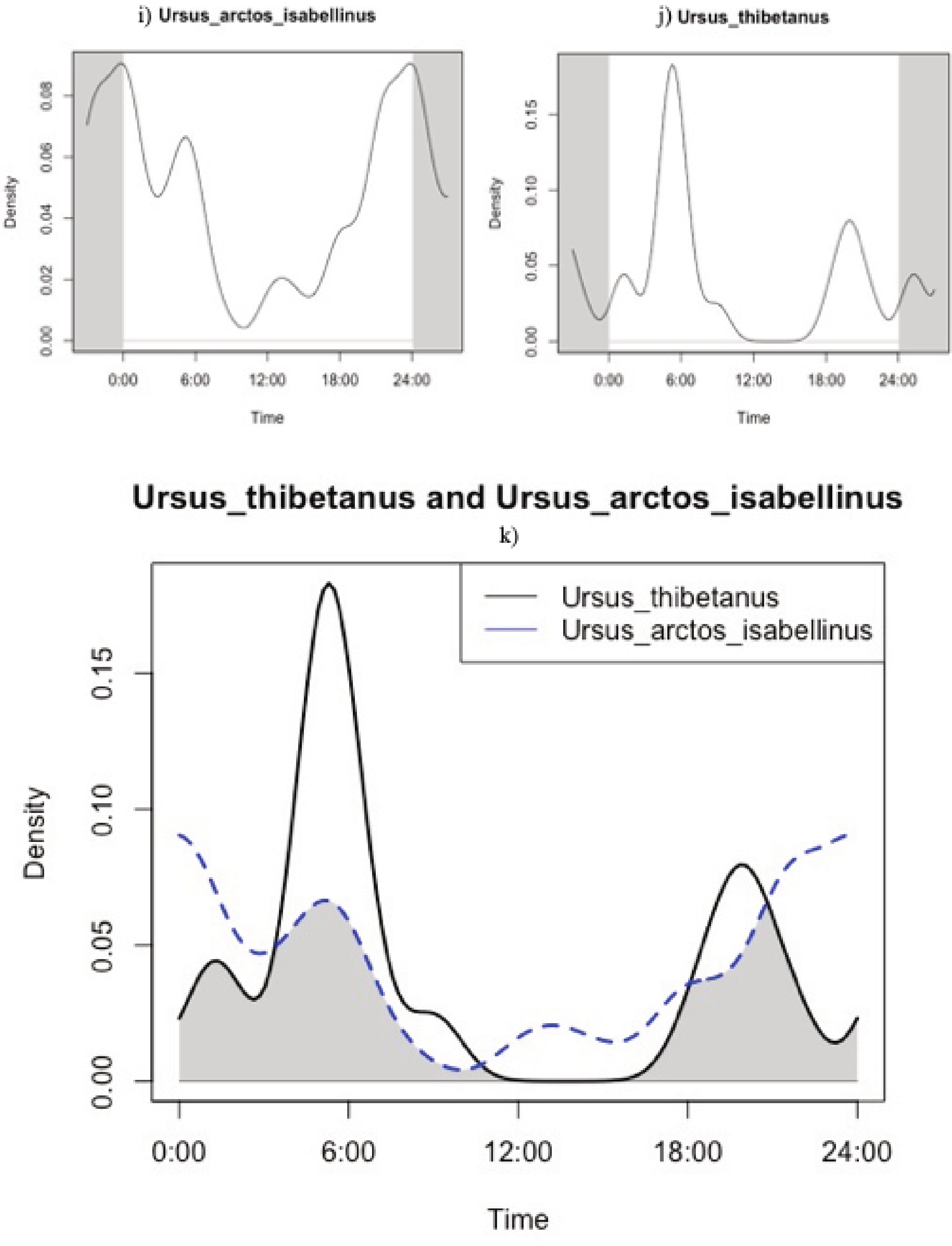


Figure 14: Hourly species activity patterns of a) *Apodemus gurkha* (Himalayan Field Mouse) b) *Soriculus nigrescens* (Himalayan Shrew) c) *Hemitragus jemlahicus* (Himalayan Tahr) d) *Naemorhedus goral* (Himalayan Goral) e) *Martes flavigula* (Yellow-throated Marten) f) *Prionailurus bengalensis* (Leopard Cat) g) *Vulpes vulpes* (Red Fox) h) *Panthera pardus* (Common Leopard) i) *Ursus arctos isabellinus* (Himalayan Brown Bear) j) *Ursus thibetanus* (Asiatic Black Bear) k) Comaprison of (i) and (j).

OVERLAP OF ACTIVITY PATTERNS OF SMALL CARNIVORES AND THEIR PREY IN DWLS

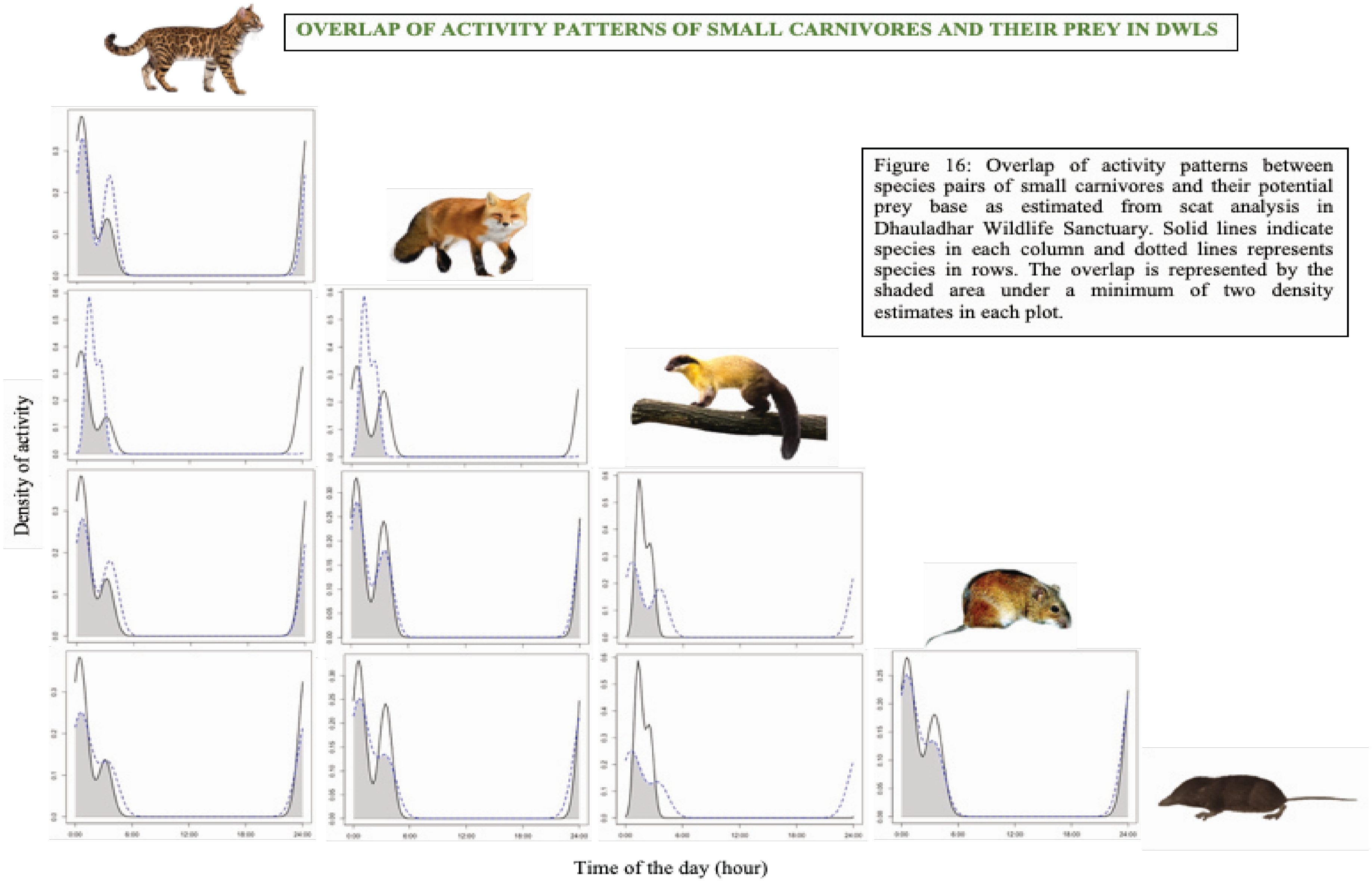


Figure 16: Overlap of activity patterns between species pairs of small carnivores and their potential prey base as estimated from scat analysis in Dhauladhar Wildlife Sanctuary. Solid lines indicate species in each column and dotted lines represents species in rows. The overlap is represented by the shaded area under a minimum of two density estimates in each plot.

6.5. Identification of potential indicator species:

Based on the available literature and village surveys lasting for 4 months, an important aspect of identification of bioindicator species within Dhauladhar Wildlife sanctuary was pursued. It becomes a complicated task as irrational or unbalanced approaches may lead to biased results while making decisions because selecting either long term or practical indicators may reduce the chances of other species to become potential indicators for the landscape in immediate future. To overcome this problem, a list of potential indicator species was prepared keeping an eye on both the fronts. Firstly, those which were easily recognized by local people and were sighted frequently and secondly, species which were important for research purposes for long term monitoring depending on their conservation status.

6 potential bioindicator species based on the available literature were selected considering their distribution, frequency of occurrence in human disturbed areas, habitat specialists/generalists, body size, easy to identify and locate, taxon at risk, economic importance, taxonomic status, Tolerance, area requirement and sensitivity. Due to the harsh climatic conditions for ground research work it was also kept in mind that list of the selected indicator species require similar methodologies.

To prioritize the areas for conservation, we tried to visualize probable distribution of species across the landscape based on our findings and from GIS-based information about species distribution. The species distribution maps along with species hotspots maps will give a clear idea about particular regions in the landscape where the species possibly occur to further apply conservation measures.

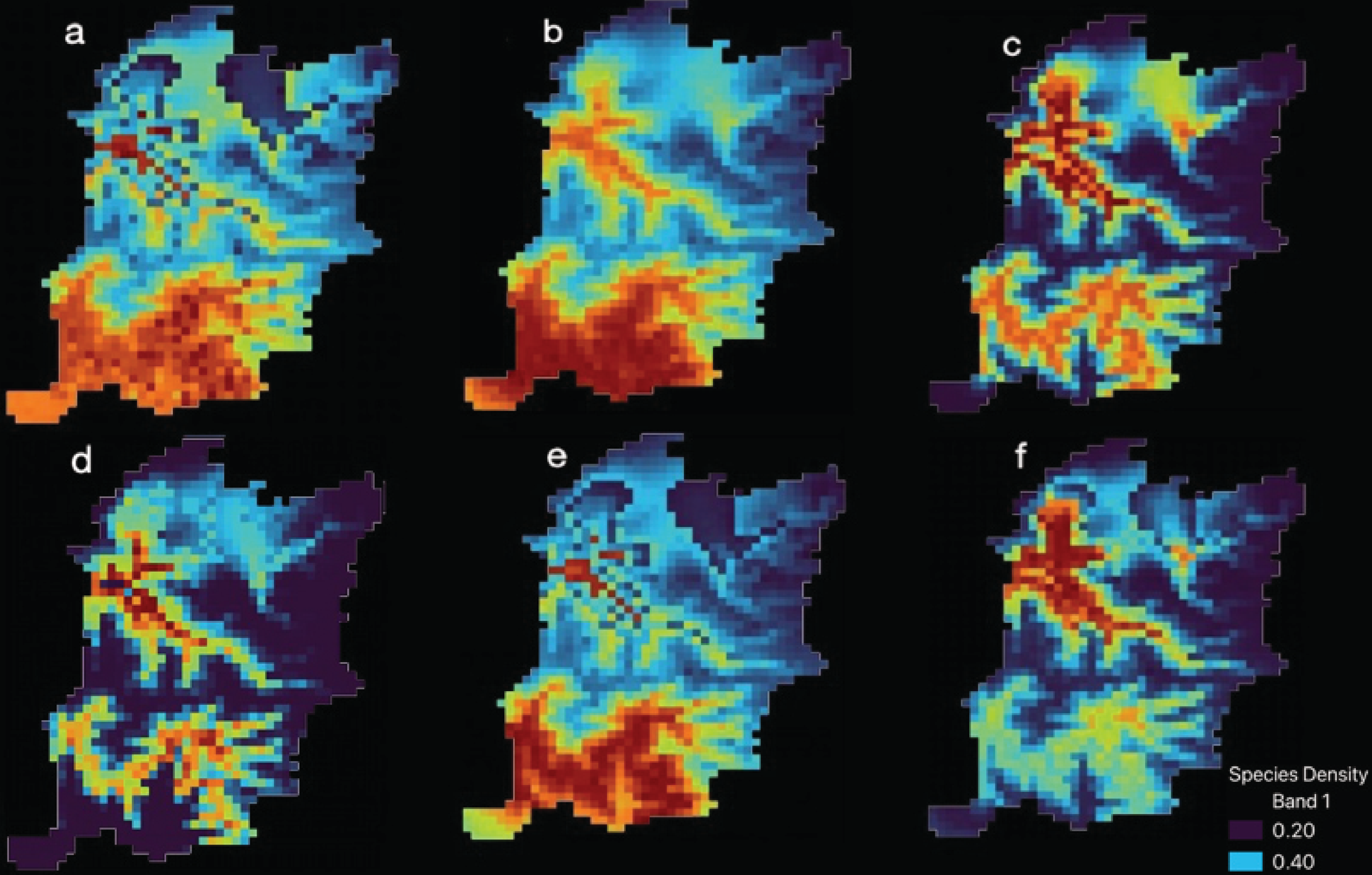
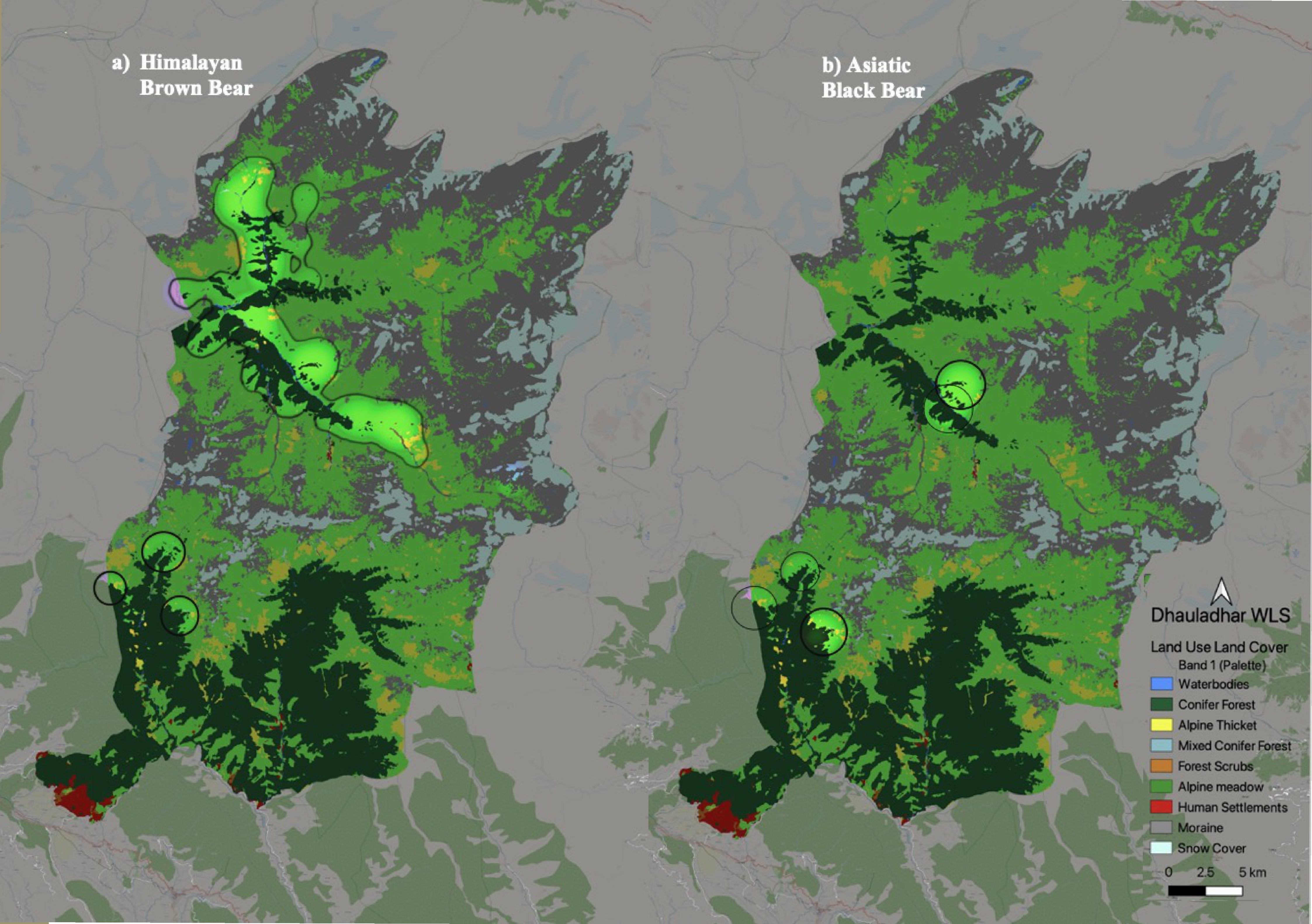


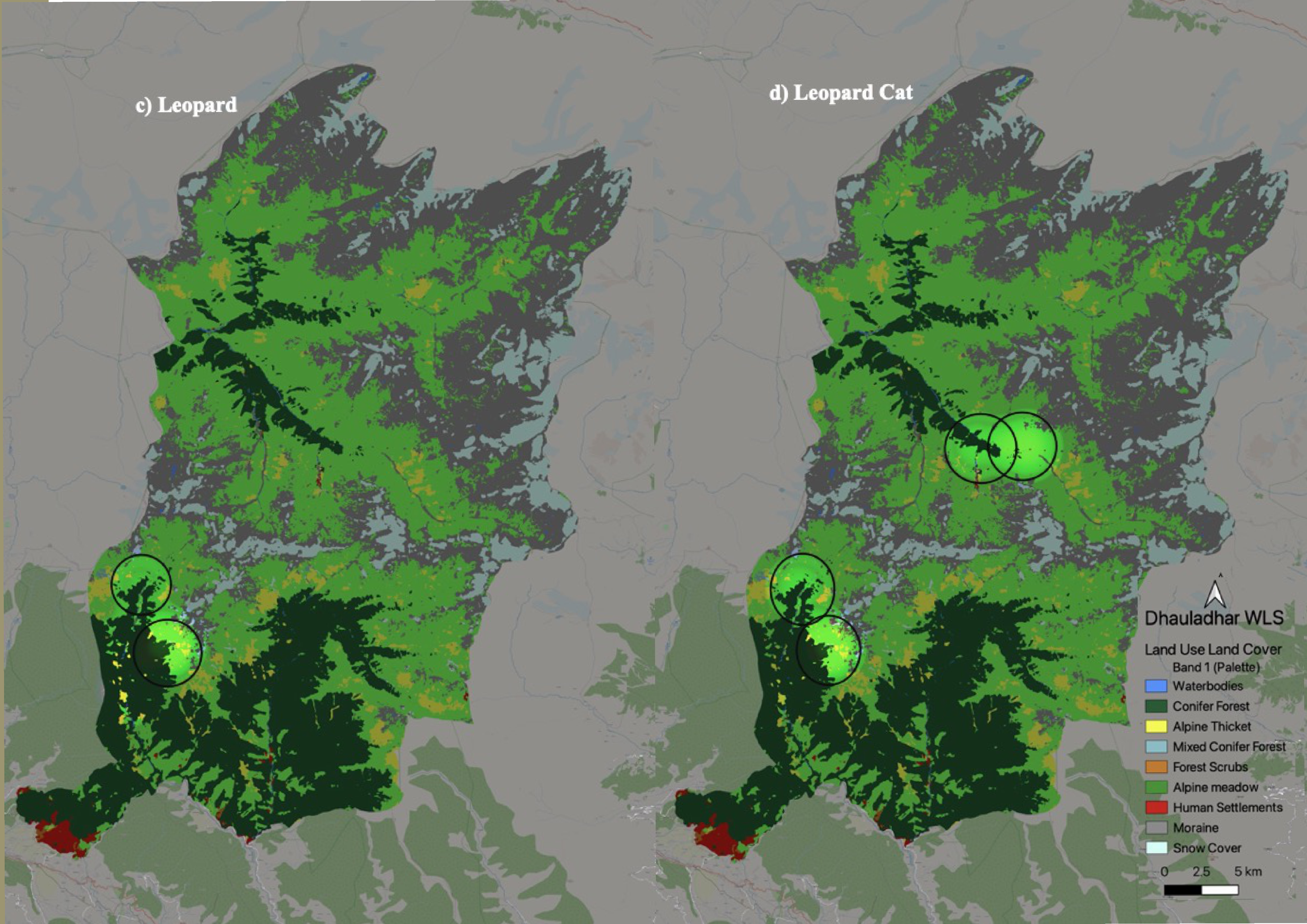
Figure 17: Potential species distribution maps based on elevation and five important bioclimatic predictor variables for a) *Martes flavigula,* b) *Prionailurus bengalensis* c) *Vulpes vulpes* d) *Naemorhedus goral* e) *Ursus thibetanus* and f) *Ursus arctos isabellinus* in Dhauladhar Wildlife Sanctuary, Himachal Pradesh, India.

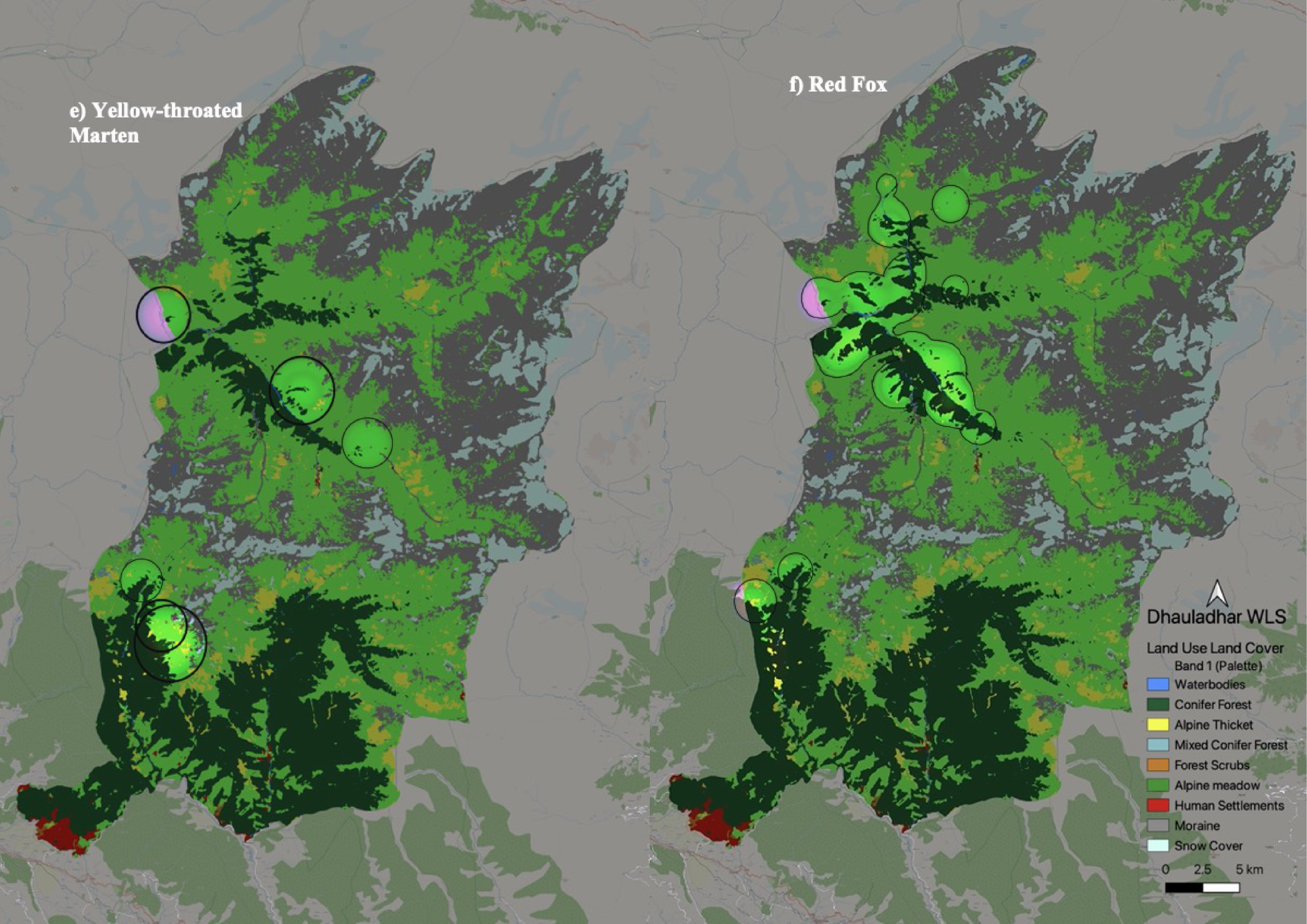
6.6. Species Hotspots, Land Use and Land Cover:

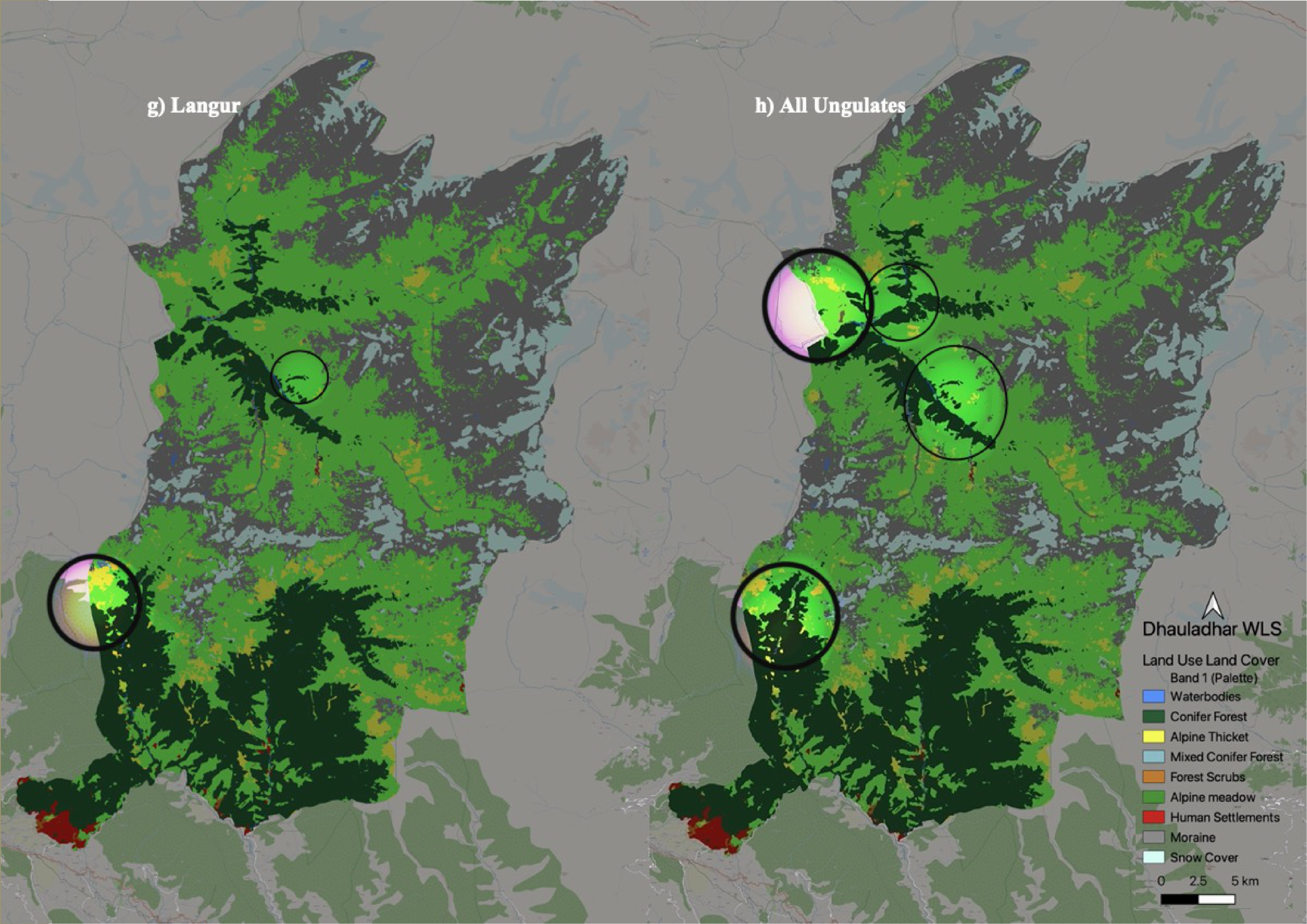
An important objective of this project is to map the species distribution of mammals. This modeling involves the use of artificial representation of wildlife presence within the land use and land cover systems to explore the possible dynamics for future conservation work. LULC analysis is vital for understanding the environment, habitats and its transformation and also to study the rising conflicts between human and wild animals. Being a complex landscape comprising of varying forest types, using object-oriented classification approach would help to understand the interactions. Species density maps are plotted on a combination of LULC variables with Enhanced vegetation index for assessing the differences in habitat usage and understand the proximity of species hotspots to human settlements. It can also help us understand how regional scale biodiversity planning should consider opoen habitats and moraines in addition to densely forested habitats. Competition for resources in this landscape can be traced back to 1900's through literature review and land use changes show strong acceleration since 1970's when livestock rearing and agriculture started to expand rapidly. Despite the threats indicated by LULC in Dhauladhar can be well recognised on field, the paucity of detailed information on species distribution and density has prevented progrss to understand potential consequences for regional biodiversity. Until now, biodiversity conservation priorities and practicesin Dhauladhar have been based on expert opinions, but without any spatial analysis. To overcome this, species distribution modeling techniques can demonstrate an ideal approach as it can offer reliable information on various environmental constrained based on moderate number of observed occurences, allowing to spatially extrapolate the habitat niche and also provide a robust way to model regional pattern of species density hotspots and its relationship with changing Land use and Land cover.

Background map demonstrates the pattern of land use and land cover within the sanctuary boundaries and the highlighted areas represents the derived Kernel density of various species.


a) Himalayan Brown Bear
b) Asiatic Black Bear
Dhauladhar WLS
Land Use Land Cover
Band 1 (Palette)
Waterbodies
Conifer Forest
Alpine Thicket
Mixed Conifer Forest
Forest Scrubs
Alpine meadow
Human Settlements
Moraine
Snow Cover
0
2.5
5 km


c) Leopard
d) Leopard Cat
Dhauladhar WLS
Land Use Land Cover
Band 1 (Palette)
Waterbodies
Conifer Forest
Alpine Thicket
Mixed Conifer Forest
Forest Scrubs
Alpine meadow
Human Settlements
Moraine
Snow Cover
0 2.5 5 km


e) Yellow-throated Marten
f) Red Fox
Dhauladhar WLS
Land Use Land Cover
Band 1 (Palette)
Waterbodies
Conifer Forest
Alpine Thicket
Mixed Conifer Forest
Forest Scrubs
Alpine meadow
Human Settlements
Moraine
Snow Cover
0
2.5
5 km


g) Langur
h) All Ungulates
Dhauladhar WLS
Land Use Land Cover
Band 1 (Palette)
Waterbodies
Conifer Forest
Alpine Thicket
Mixed Conifer Forest
Forest Scrubs
Alpine meadow
Human Settlements
Moraine
Snow Cover
0
2.5
5 km

Scat Analysis:

A total of 84 scats were collected during August to November, 2021 in various parts of Dhauladhar Wildlife Sanctuary. Systematic sampling could not be carried out due to terrain ruggedness. Most of the scats were collected on transects, though few scats were also collected on locations which did not fall in transect lines. Out of 84, around 42 scats were found to be of Himalayan Brown Bear. Being the largest and most abundant carnivore in the study area, the scats were easily identified on the basis of appearance, shape and diameter (mean diameter = 2.98 cm, mean length = 5.26 cm and mostly black in colour). Scats were seperately placed in zip lock bags and all relevant details were noted. All the samples were air dried on field and stored until analysis. Similar method was used for remaining scats.

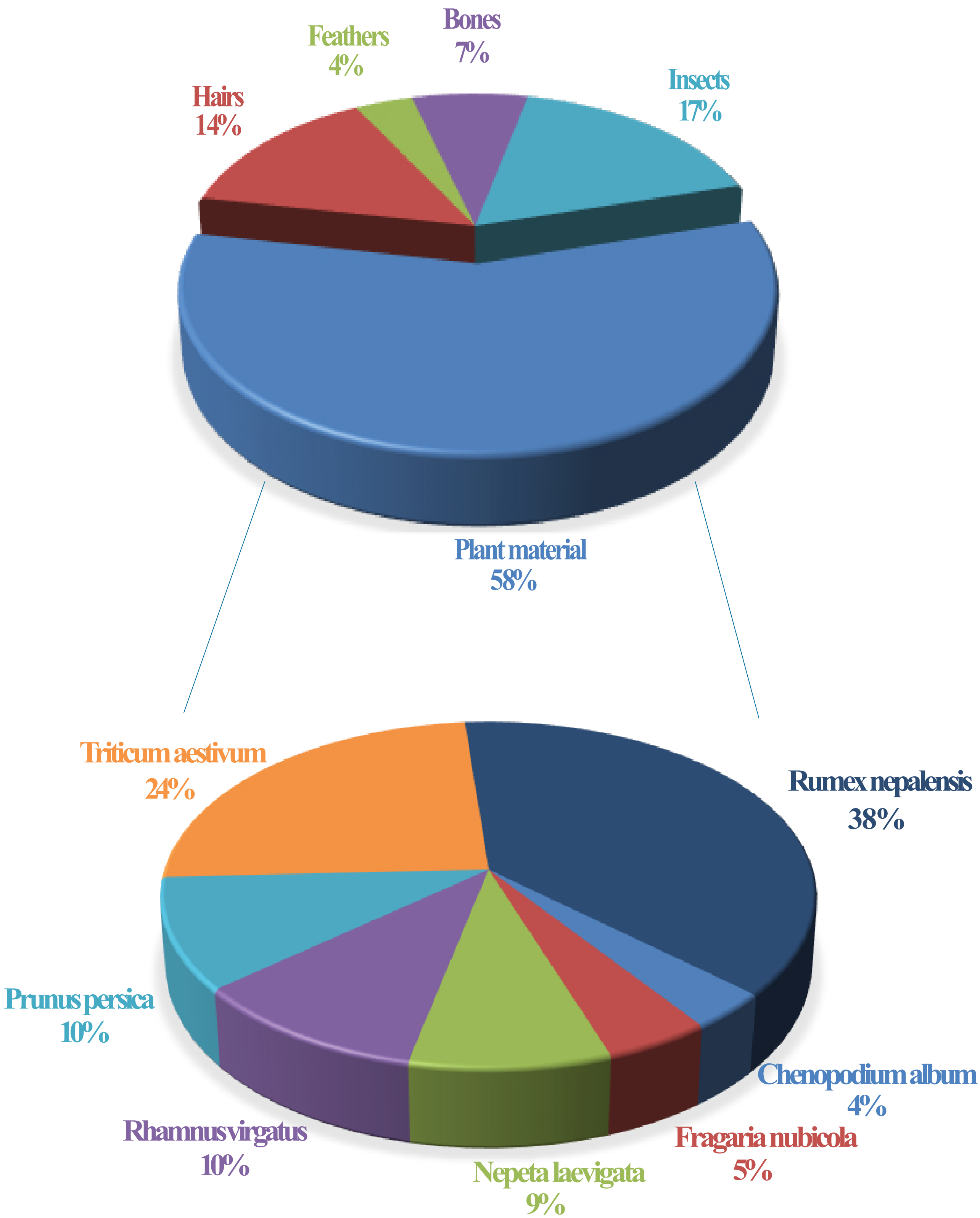
Fecal Analysis:

Scats were weighted seperately and only 10-15% of each scat was used for analysis. Scat samples were kept immersed in water for 20 hrs and were then rinsed thoroughly using sieves to separate vegetative parts, seeds, fruits and other undigested items and then again suspended in water. These samples were again rinsed and washed through 0.7 mm sieve, the remaining parts were oven dried and then analysed manually by separating components like bones, hairs, teeth, fruits, seeds, ants and other insect parts. The plant species were identified using reference slides and expert identification. The dietary composition was estimated in form of percentages based on ocular estimate of volume.

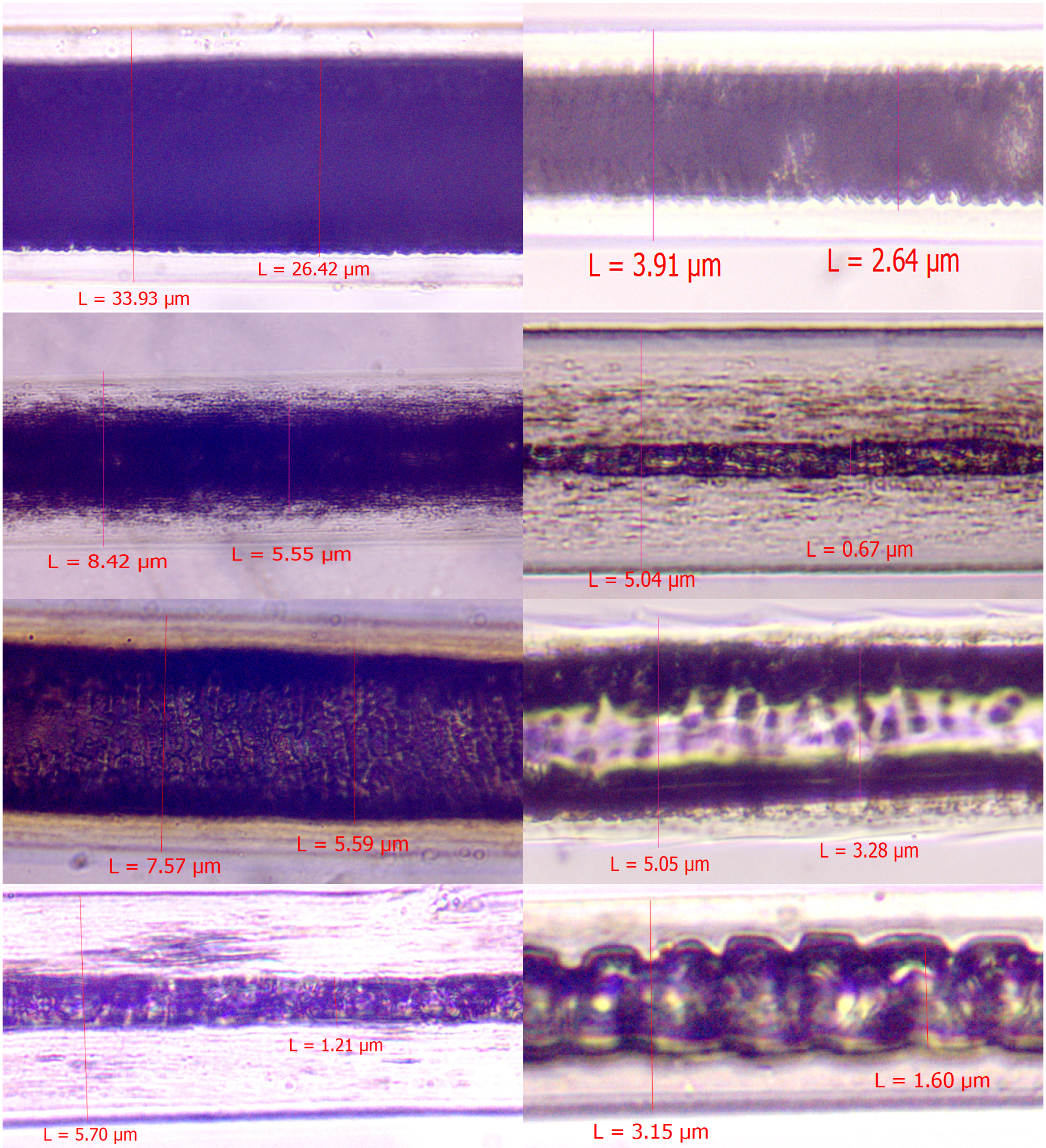
Dietary Composition:

Both plant and animal matter were found in Brown Bear diet during the study duration (n=42). The percentage of plant matter (58%) was higher than that of animal matter (38%). Out of the plant matter observed in scat samples, *Rumex nepalensis* constitutes highest quantity (38%) followed by *Triticum aestivum* (24%). The pie chart presented ahead represents the constitution of Brown Bear diet along with the percentage of various species consumed.

BROWN BEAR SCAT ANALYSIS

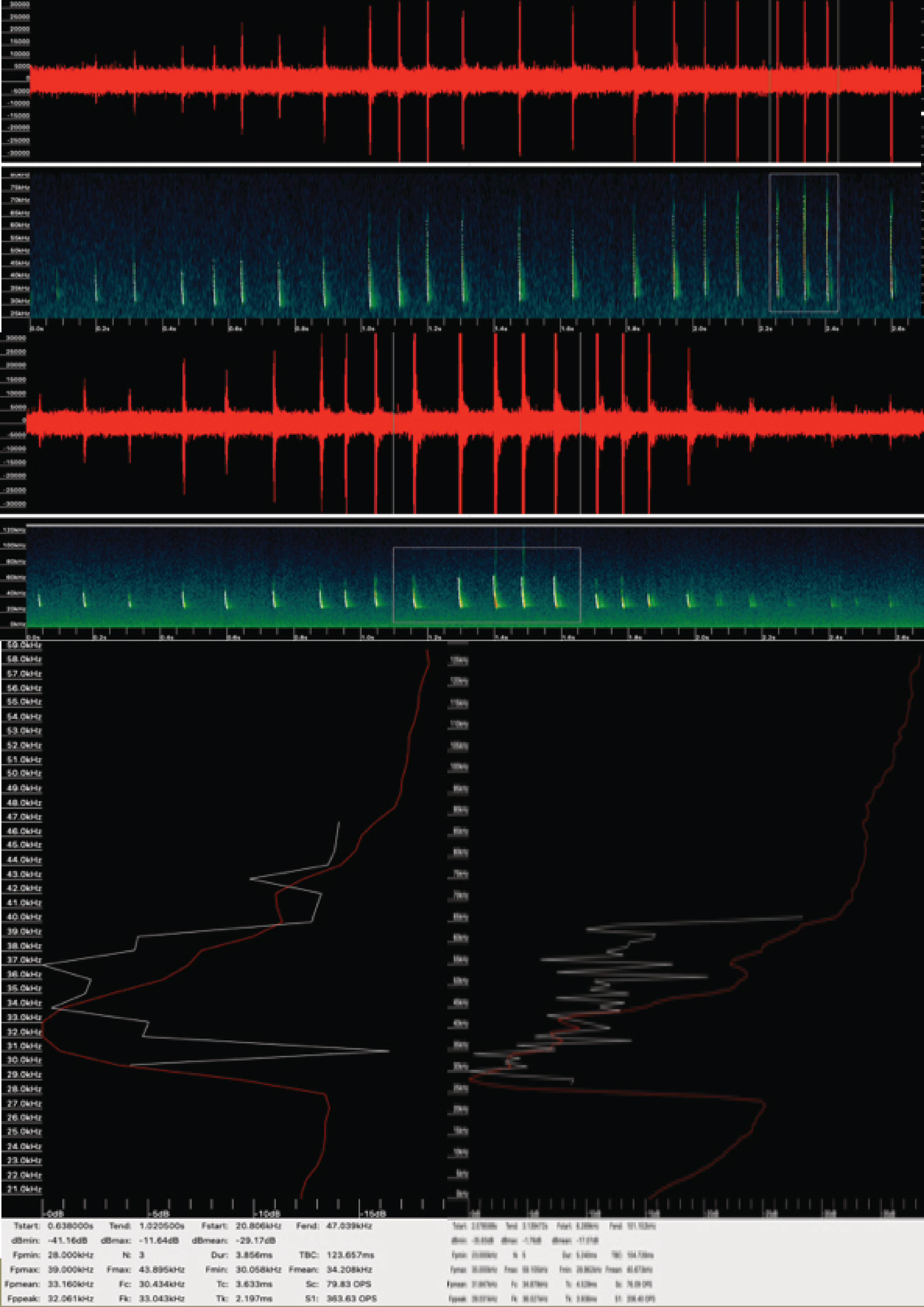


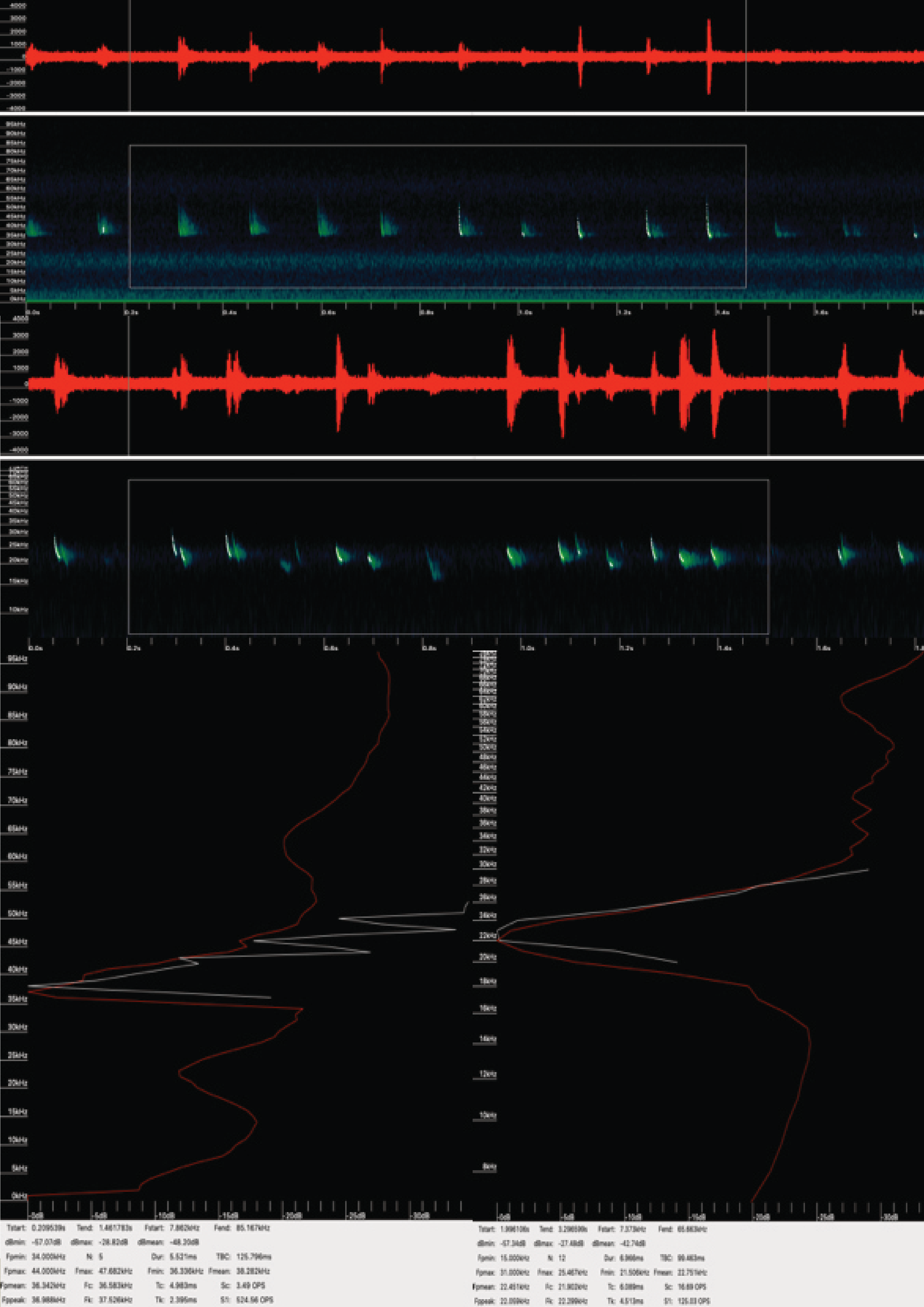
Scat samples of small carnivores like Red Fox, Leopard cat and Yellow-throated Marten were analysed and potential prey species were identified on the basis of hair samples. Remnants of prey species that included bones, hair, beaks, claws and teeth were used identify the animals consumed by these carnivores. Most of the undigested parts including smaller pieces of bones, beaks and teeth were generally fragmented and were considered of little value. The identifiable structure that retained its morphology was the hair. The structural variations of the hair of different mammalian prey species were used for identification by comparing to a reference key prepared by experts and Ph.D scholars at Wildlife Institue of India.



6.7. CHIROPTERA

Ultrasonic calls of bats were recorded using Wildlife Acoustics SMBAT4S and a standard wave audio files were navigated on Kaleidoscope Pro for analysis. Visual and audible feedback and analysis of the recording content was studied at 1/20th of its original speed in detail. The oscillogram (above) displaying the wave form of the audio signal, which is most typically used for observing amplitude at any millisecond was compared with the spectrogram (below) which corelates in the graphs provided. Positive and negative energies of the waveforms along with rectified view of the waveforms were observed in zero crossing view, compressed view and also in real time view carefully. We used a high pass filter trigger to avoid unwanted sounds ranging between 0-7 kHz and later band pass filters were used in the software to avoid low frequency noise. The boxes set up within the analysis guidelines(to compare frequencies of multiple signals) marked in the graphs represents the windows of focus. Zero crossing view was specially used to represent flattest parts of the selected window. A set of white dots over the spectrogram marks it. The extreme left side scale in the spectrograms provided shows frequency from top to bottom and time is displayed from left to right in the bottom. Colour coding was used to represent relative amplitude of the full spectrum audio signal and contrasting was used to remove unwanted background noise. Further, the viewer analysis windows for few significant recordings are provided. It highlights the information about zero crossing and full spectrum of the selection. It also directs us to understand why these number of pulses were selected. For example, the feeding buzz provided in Graph. Auto ID function was compared with results obtained after cluster analysis to group individual species and to understand if a single recording includes calls of two or more different species. Three species of bats(**Hodgson's Bat** *Myotis formosus* (Hodgson, 1835), **Noctule** *Nyctalus noctula* (Schreber, 1774) and **Greater False Vampire** *Megaderma lyra* E. Geoffroy, 1810), were identified from the analysis. The locations of recordings of these species is illustrated on map to understand the distribution within sanctuary boundaries.


Tstart: 0.638000s Tend: 1.020500s Fstart: 20.806kHz Fend: 47.039kHz
dBmin: -41.16dB dBmax: -11.64dB dBmean: -29.17dB
Fpmin: 28.000kHz N: 3 Dur: 3.856ms TBC: 123.657ms
Fpmax: 39.000kHz Fmax: 43.895kHz Fmin: 30.058kHz Fmean: 34.208kHz
Fpmean: 33.160kHz Fc: 30.434kHz Tc: 3.633ms Sc: 79.83 OPS
Fppeak: 32.061kHz Fk: 33.043kHz Tk: 2.197ms S1: 363.63 OPS



Tstart: 0.2095309s Tend: 1.461783s Fstart: 7.862kHz Fend: 85.167kHz
dBmin: -67.07dB dBmax: -28.82dB dBmean: -48.20dB
Fpmin: 34.000kHz N: 5 Dur: 5.521ms TBC: 125.796ms
Fpmax: 44.000kHz Fmax: 47.682kHz Fmin: 36.336kHz Fmean: 38.282kHz
Fpmean: 36.342kHz Fc: 36.583kHz Tc: 4.983ms Sc: 3.49 OPS
Fppeak: 36.988kHz Fk: 37.526kHz Tk: 2.395ms S1: 524.56 OPS
Tstart: 1.998108s Tend: 3.298509s Fstart: 7.373kHz Fend: 65.663kHz
dBmin: -57.34dB dBmax: -27.48dB dBmean: -42.74dB
Fpmin: 15.000kHz N: 12 Dur: 6.966ms TBC: 99.463ms
Fpmax: 31.000kHz Fmax: 25.467kHz Fmin: 21.508kHz Fmean: 22.751kHz
Fpmean: 22.451kHz Fc: 21.902kHz Tc: 6.089ms Sc: 16.69 OPS
Fppeak: 22.059kHz Fk: 22.299kHz Tk: 4.513ms S1: 126.03 OPS

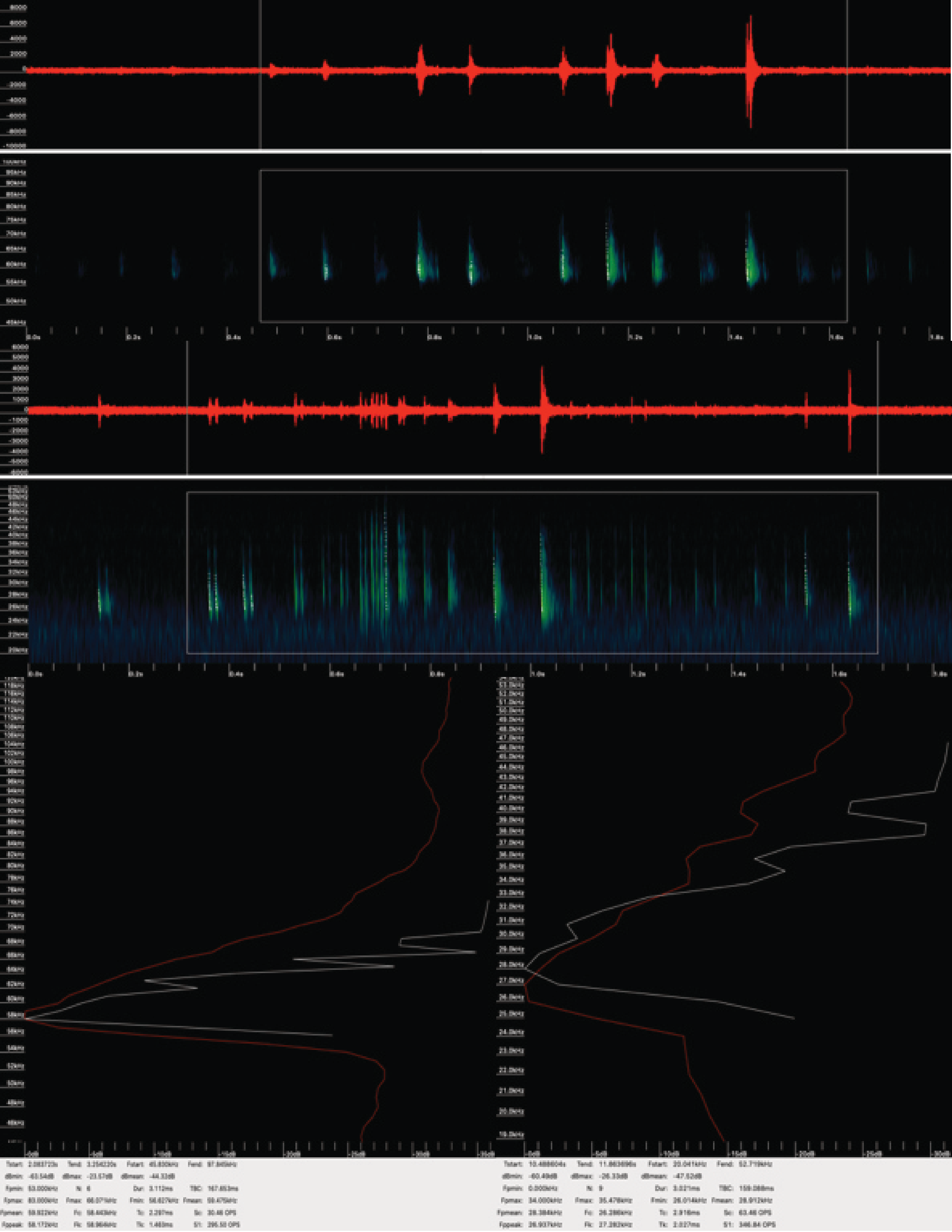


Figure 19: Oscillograms, Sonograms and Call frequency min/max of three species of bats (**Hodgson's Bat** *Myotis formosus* (Hodgson, 1835), **Noctule** *Nyctalus noctula* (Schreber, 1774) and **Greater False Vampire** *Megaderma lyra* E. Geoffroy, 1810) found in Dhauladhar Wildlife Sanctuary, Himachal Pradesh.

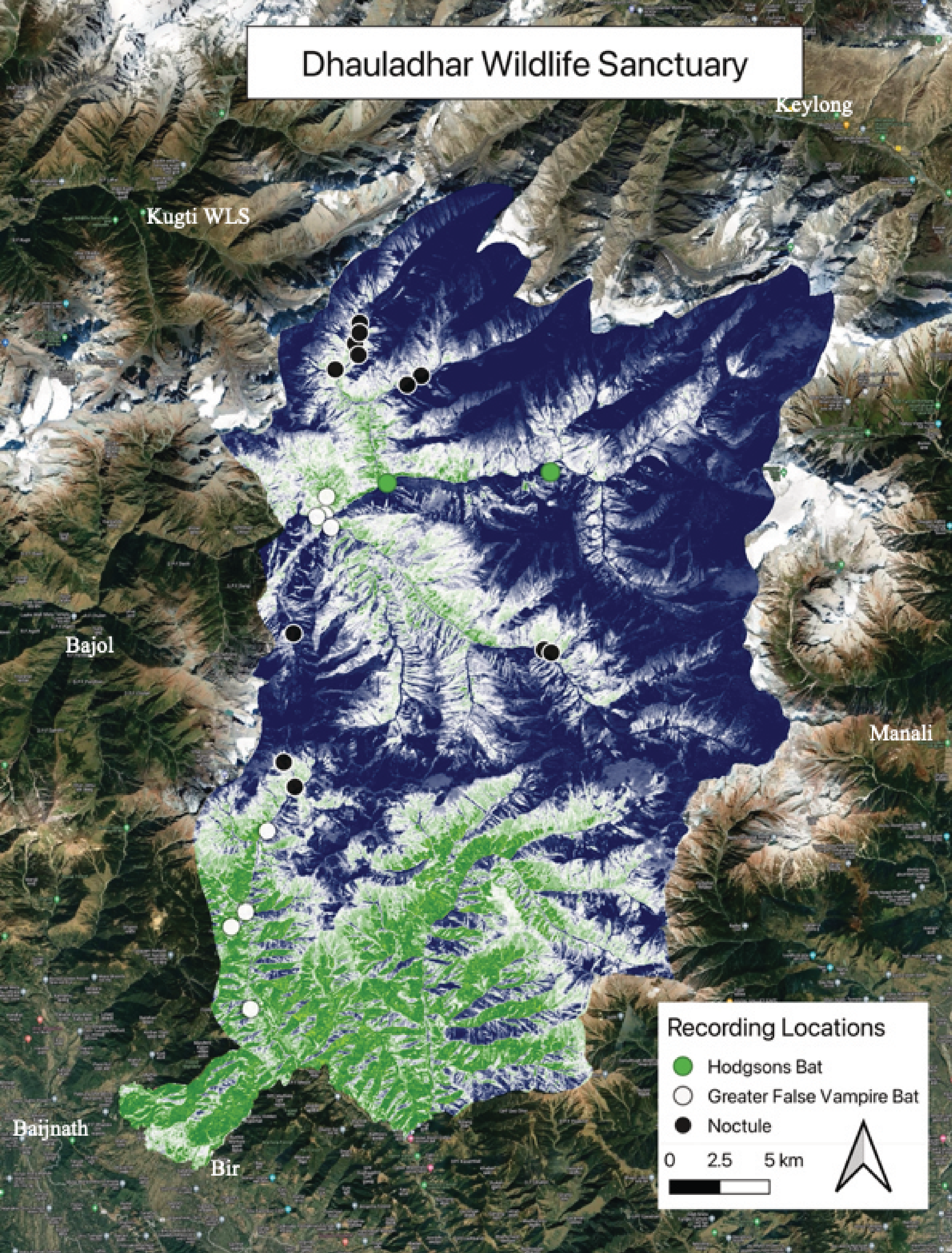


Figure 20: Bat Recording Locations and species of bats recorded in Dhauladhar Wildlife Sanctuary.

7. Recommendations:

- Training workshops should be conducted for pastoralists and provision of simple datasheets for future monitoring of mammals above tree line in Shahnala and Raighar.
- Conservation priority areas for selected mammal species should be monitored on yearly basis based on habitat suitability and distribution maps.
- Volunteers should be paid incentives to build their interest towards wildlife conservation.
- Mammal booklets and datasheets should be provided in each forest office to keep record of selected indicator species.
- More training workshops for local people and forest staff for other sampling methodologies to aid in future monitoring of mammals.

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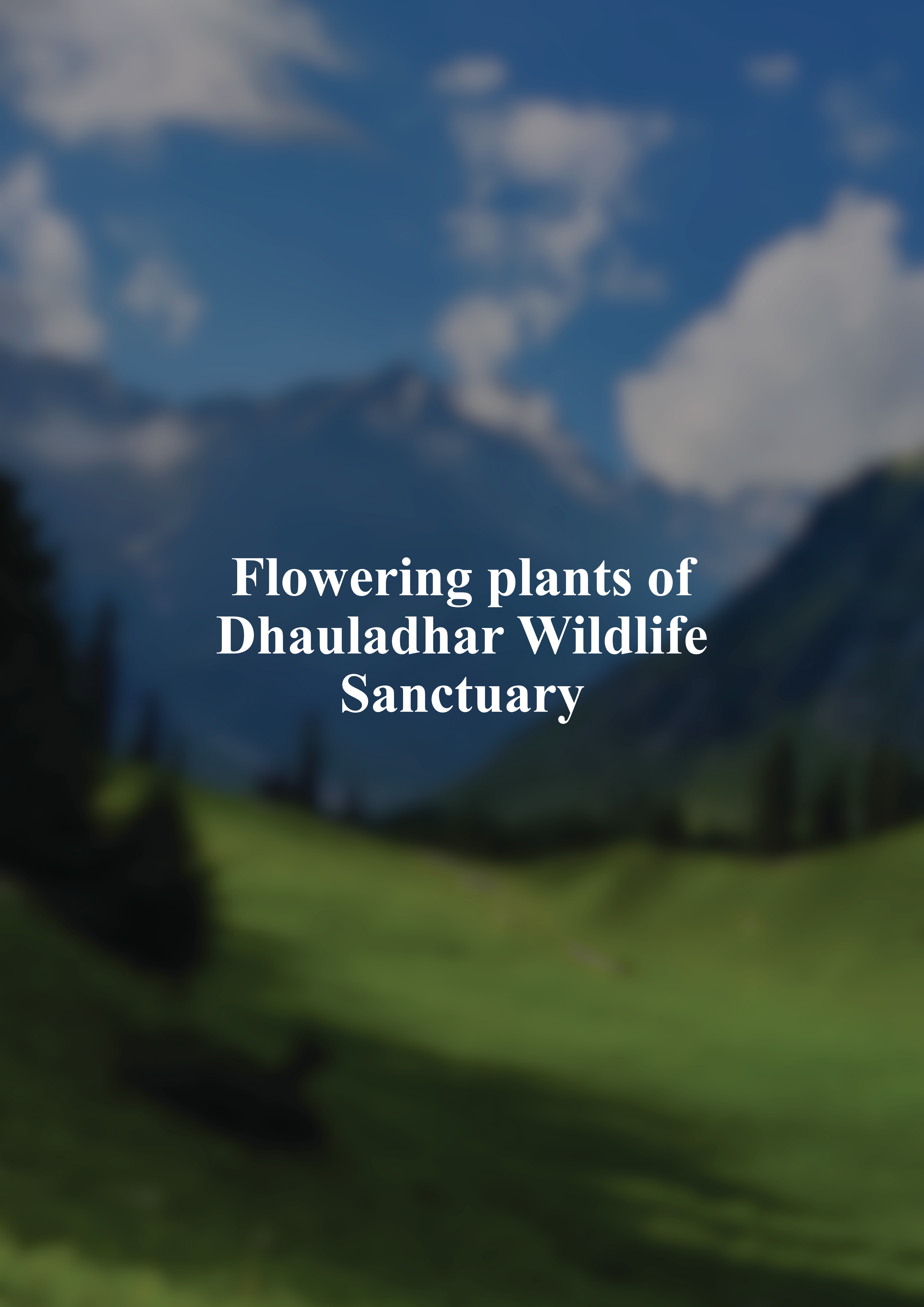
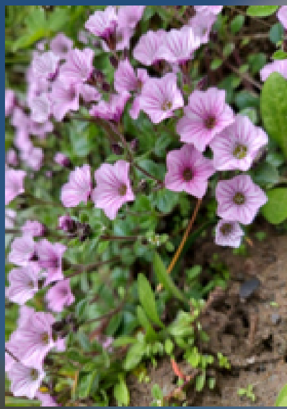
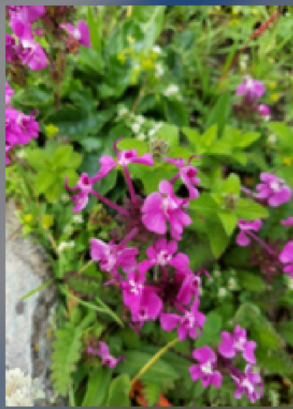


Flowering plants of Dhauladhar Wildlife Sanctuary

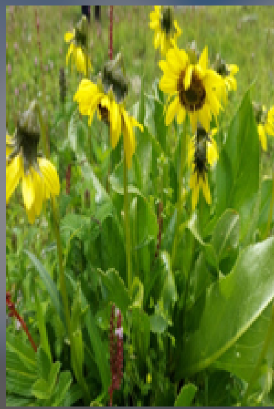
Campanula uniflora



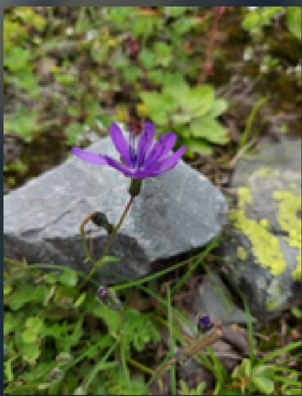
Convolvulus sabatius



Pedicularis pectinata



Cremanthodium sp.



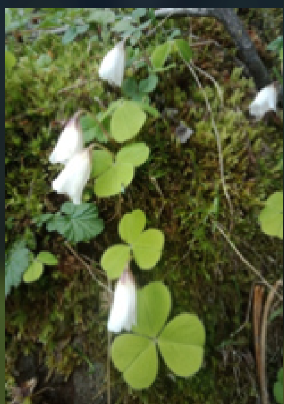
Cremanthodium sp.

Impatiens sp.

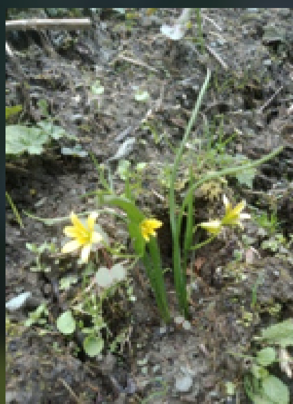
Aster

Aconitum heterophyllum

Catharanthus pussilus

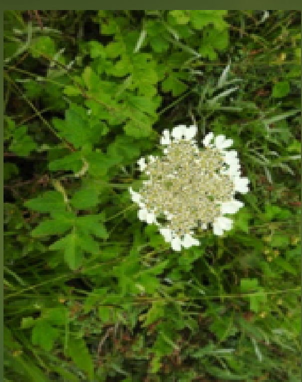


Oxalis acetosella



Tragopogon gra

Trillium govanianum



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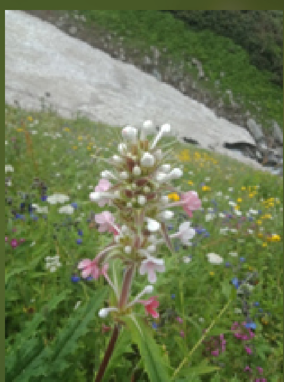

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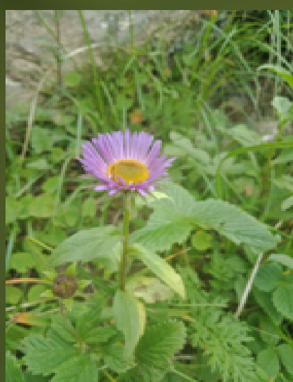
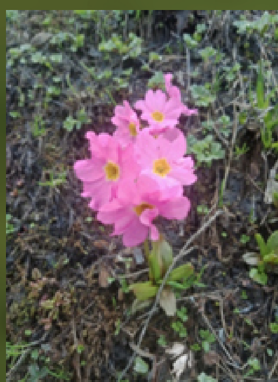
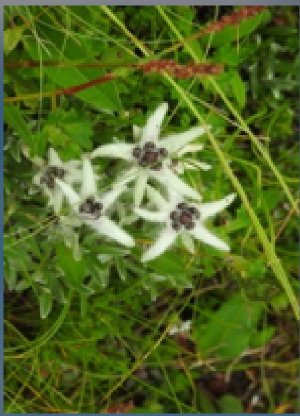


Erigeron speciosus

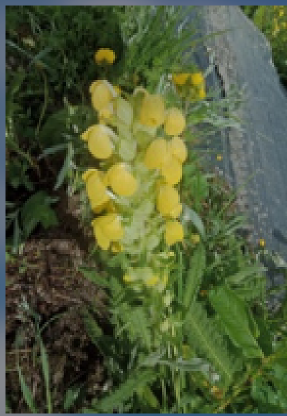


Begonia picta



Leontopodium alpinum

Anaphalis nepalensis



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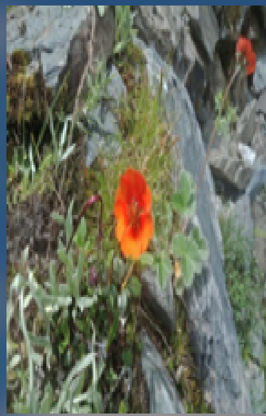
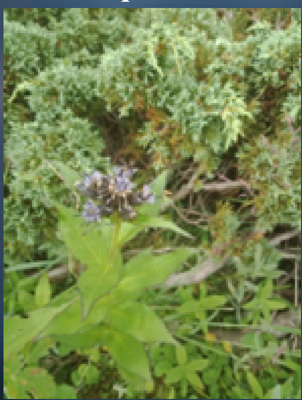
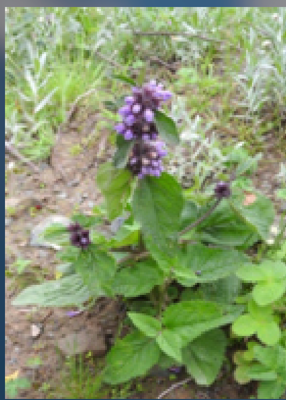


Potentilla agarophylla

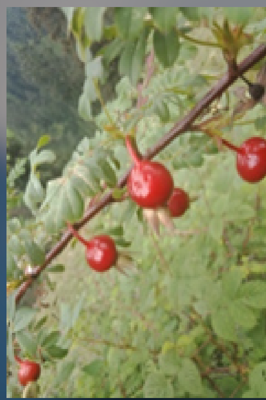


Nepeta glutinosa

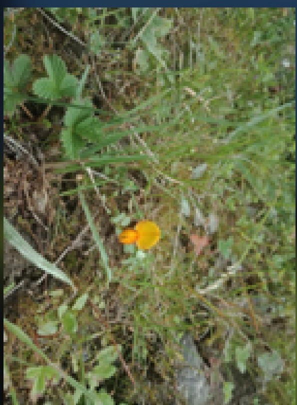
Gaultheria trichophylla



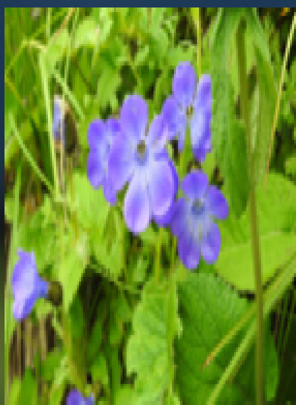
Phlomis bracteosa



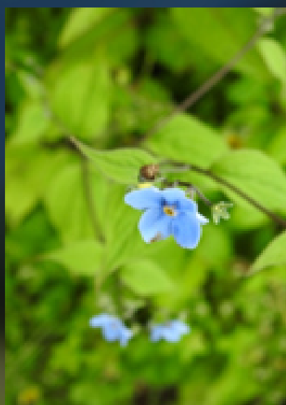
Rosa webbiana



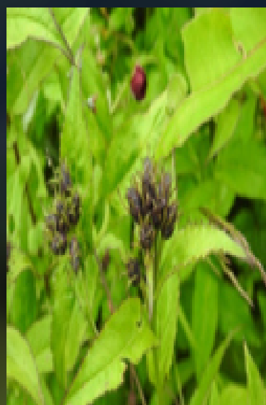
Crotalaria calycina



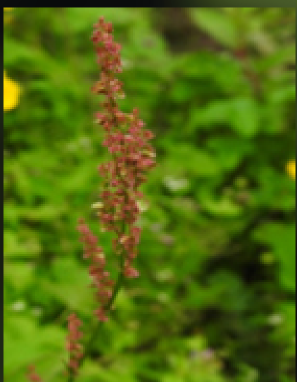
Geranium pratense



Eritrichium patens

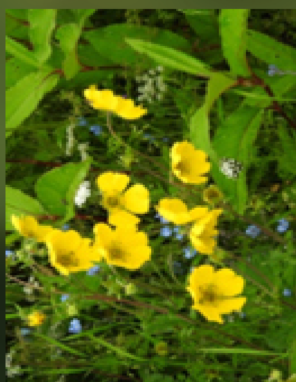


Saussurea costus



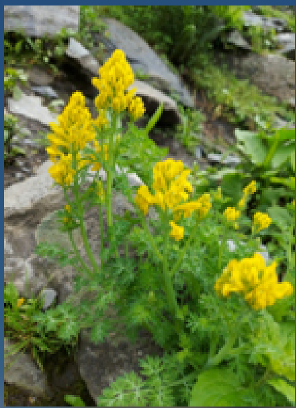
Oxyria digyna

Anaphalis nubigena

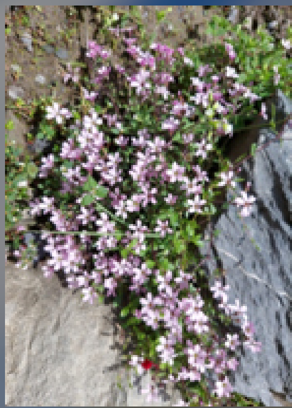


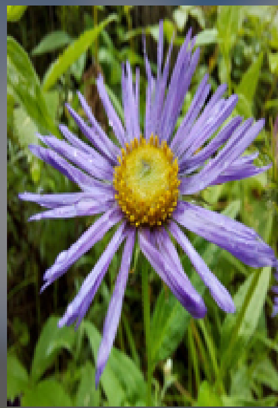
Genum elatum

Pleurospermum candolli

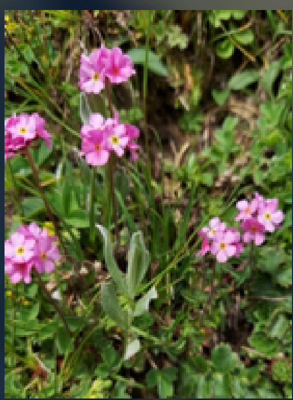

Corydalis govaniana


Meconopsis aculeata

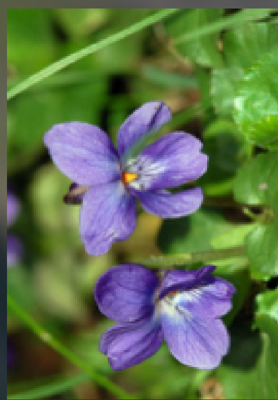

Canscorea diffusa

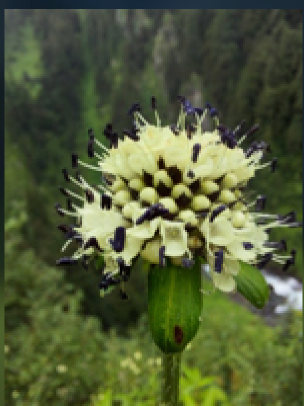

Erigeron multiradiatus


Rhodiola tibetica


Primula macrophylla

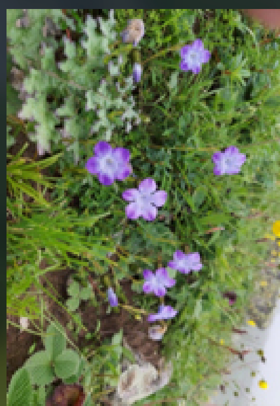

Dudleya virens

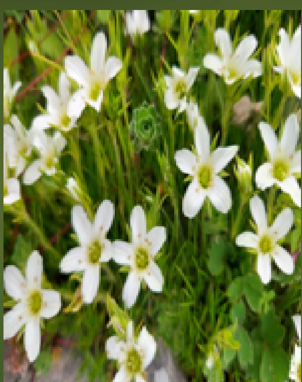

Viola odorata


Dipsacus pilosus


Senecio


Lactuca tatrica


Cyananthus sp.


Saxifraga hypnoides


Pedicularis pectinata


Fragaria vesca

MEDICINAL PLANTS

Over 15,000 species of higher plants are recorded from India so far. Of these, almost 50% are reported to have medicinal value (All India Co-ordinated Research Project on Ethnobiology). The importance of ethnobiological knowledge has received much attention in resource management for suggesting new paths in scientific research and conservation monitoring. But, plant community is affected and ecosystem is differently shaped due to dialectical relationship between ethnobiological knowledge and local practices. According to the reports by World Health Organisation, it is estimated that 80% of the developing world depends on traditional medicines and of these, 85% use plants or extracts as the active ingredient. This means that close to 3 billion people rely on plants for medicine. Such rich plant diversity in Himalaya of over 8000 angiosperms, 44 gymnosperms, 600 pteridophytes, 1737 bryophytes, 1159 lichens etc. is a source of medicine for millions of people in the country and elsewhere in the world. Dhauladhar Wildlife Sanctuary being such a huge area, harbours many medicinal plant species. We made a list of few plants which were used for local medicine and commercial purposes.

***Aconitum heterophyllum**:* Generally called 'Atis' it is an Ayurvedic medicinal plant and is known to possess a number of therapeutic effects. Roots and tuber is used for extraction of medicine. It is used to treat urinary infections, diarrhoea and inflammation. It is also used as an expectorant and for the promotion of hepatoprotective activity(ncbi.nlm.nih.gov).Root extract can be used to cure headache and decoction of tuber is used to cure fever, stomach ache and dyspepsia.

Figure : Aconitum heterophyllum – Plant and roots. Present in Kaliheni area within sanctuary.

***Bergenia ciliata*: 'Shilphori' or 'Pashanbheda'** Leaves of *Berginia ciliata* are widely used as a substitute for tea where, dried leaves are grinded into powder. It is known for versatility as it is used for its diuretic, antidiabetic, antitussive, insecticidal, anti-inflammatory, antipyretic, anti-bradykinin, anti-viral, anti-bacterial, anti-malarial, hepatoprotective, anti-ulcer, anti-cancer, anti-oxidant, anti-obesity and adaptogenic properties. The root is used as a tonic for curing and treatment of fever and pulmonary infections. This root juice is also used to treat cough, cold and haemorrhoids. The root of this plant has a high reputation in indigenous systems of medicine for dissolving stones in the kidneys.

Figure : *Bergenia ciliata*- Found abundantly near Bhedpal

Heracleum candicans: Commonly called **'Himalayan Hogweed'** or ***'Tookar'*** and the tradename of this herb is ***'Patrala'***.

Figure :. Heracleum candicans- Found abundantly in Shahnala

The roots of this herb are good source of xanthotoxins and are used in preparation of sun-tan lotions and treatment of Leukoderma to some extent. It is also well known as a cure for psoriasis. It produces furanocoumarins, which is later converted into xanthotoxins. It is also known to increase the anti-oxidant capacity of liver and maintains hepatocyte during injuries. Due to its diverse chemical constituents, there is an increasing demand in pharmaceutical industries, especially in the international markets.

Figure :. Jurinella macrocephala- Abundant in LumbaPadh area

Jurinella macrocephala: Locally called ***'Dhoop'.*** Dried roots are used are used for the preparation of dhoop and insence sticks. Root powder used with boiled water provides relief from colic pain. A decoction of the root is cordial. It is given in the treatment of puerperal fever. The juice of the roots is used as a cure for fevers among locals. The bruised roots are also applied as a poultice to eruptions and the extract that is left can still be used as an incense. It is majorly extracted for religious purposes mostly to be burnt in Havans. This is the most ideal and traditionally used plant as compared to other species from which incense is extracted because many plants in Himalayas that have anexudate incense is termed dhoop or gugal.

Podophyllum hexandrum: Locally known as ***'Bankakri'***

Figure : Podophylum hexandrum - Abundant all over.

This is also a versatile medicinal herb. Along with its medicinal use, it serves a major food source for Himalayan Brown Bears. Compounds derived from this herb which is known as ' podophyllotoxin; is used in synthesis of anti-cancer drugs like Etoposide, Teniposide and Etophos. This compound is also used for the treatment of lung and testicular cancer as well as certain Leukaemia's. Other uses include medicine for typhoid fever, jaundice, chronic hepatitis, scrofula, rheumatism and bladder problems. It is also used as a purgative and treatment of vaginal warts. It is effective against gonorrhoea and syphilis.

Picorhiza kurroa (above): Locally called '*Kutki*' is used in Ayurvedic medicine for the treatment of digestive problems. Other uses include treatment for asthma, liver damage, wound healing and vitiligo. It is said to be a cure for all types inflammations and cirrhosis. It has hepatoprotective properties and also supports treatment of spleen. Being a perennial herb, it is extracted in large quantity. Local uses includes treatment for chronic diarrhoea, reducing fevers and is known to be effective for scorpion sting. Current research on this species is focused on its anticholestatic, antioxidant and immune-modulating activity.

Figure: *Picorhiza kurroa* – Extracted in huge amount from Jwaharnalah and areas around Shahnala and Raighar.

Figure : Rheum australe – Abundant near all Dera's of Gaddis.

Rheum australe (left)*:*

Rheum australe D. Don (Polygonaceae) has been commonly used in traditional medicine for a wide range of ailments related to the circulatory, digestive, endocrine, respiratory and skeletal systems as well as to infectious diseases.

Rheum australe has been widely used source of medicine for years without any adverse effects. Many studies have provided evidence for various traditional uses. However, there is a need for additional studies of the isolated compounds to validate the traditional uses in human models. The present review on the botany, traditional uses, phytochemistry and toxicity has provided preliminary information for further studies and commercial exploitations of the plant.

Selinum tenuifolium (right)*:*

The plant, like many others belonging to the family Apiaceae, is aromatic - particularly the root. The fruits (of the mericarp type) have sedative and aphrodisiac properties and are also used to treat rheumatism and kidney disease. The roots are used to treat abdominal pain. the powdered root is used as a fumigant in Tantrik rituals intended to cure insanity, nervous breakdown and 'hysteria'. These uses suggest that the extracts of the plant are capable of exerting effects upon the Central Nervous System and Genitourinary system and that this plant may be mildly psychoactive.

Figure : Selinum tenuifolium- found mostly around Plachek area

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MUSHROOMS

Mushrooms constitute a heterogeneous group of macro fungi with tremendous nutritional and medicinal importance. Most of them are edible, medicinal, or both, whereas others are poisonous or even lethal. There are about 15,000 species of mushrooms, of which 7,000 species are considered to be edible to varying degrees, more than 3,000 are regarded as prime edible species, and about 2,000 are considered safe and medicinal with a variety of health attributes; approximately 10% may have poisonous attributes. Mushrooms constitute the most relished commodity among a number of nonconventional foodstuffs primarily because of their unique flavour and texture. On the chronology of cultural evolution, they have been used as food since humans were still a hunter and gatherer society.

Mushrooms, like plants, have great potential for the production of useful bioactive metabolites and thus are a prolific resource of drugs. Mushrooms need antibacterial and anti-fungal compounds to survive in their natural environment. It is, there- fore, not surprising that antimicrobial compounds with more or less strong activities could be isolated from many mushrooms and that they could be of benefit to humans. A wide spectrum of biologically active compounds from mushrooms possesses anti-fungal, antibacterial, antioxidant, insecticidal, nematocidal, and antiviral properties.

Tremella sp.(above) found at the lower elevations within the sanctuary has been widely used in Chinese cuisines and known as a tonic for 'weakness and ageing' Chinese herbal medicines. It is known to contain high dietary fibre and also to significantly lower serum tri-glycerol levels. It has a good polysaccharide stability and as well as an excellent moisturizing and anti-wrinkle effect.

Lycoperdon sp. **(left)*****:*** **The genus Lycoperdon is characterized by having basidiomata with more or less distinct pseudostipe, opening by apical pore and branched, rarely septate, capillitial hyphae. Out of 50 species known from the world over (Kirk et al. 2001), only a few have pedicellate spores.**

Preliminary surveys have revealed rich representation of these genera in the Dhauladhar.

Russula sp. (right): The genus is cosmopolitan and is among the most diverse genera of Agaricomycetes, represented by hundreds of species worldwide. All species are thought to be obligatorily symbiotic and form ectomycorrhizal symbiotic relationships with many species of Gymnosperms and Angiosperms. The members of this fungal genus occur in both the Northern and Southern Hemispheres, in a wide range of climatic regions including boreal, temperate, Mediterranean, subtropical and tropical areas

Phallales sp.(left): Stinkhorns give off a strong, offensive, rotting odour. The odour is typically described as smelling of rotting dung or carrion or a combination of the two. Many stinkhorns have a phallic appearance, which has led to their inclusion in different folklore and cultural superstitions worldwide. In fact, the taxonomic name for this group is the Phallales in reference to their phallic appearance, and one common genus in this group of fungi is the genus Phallus. Stinkhorns are not poisonous. Despite their unpleasant odour, stinkhorns are eaten in a variety of ways ranging from use as salad toppings, in soups, incorporation in sausages and pickled items, and as a short-term food preservative (Laessøe and Spooner 1994).

SPECIES	LOCATION
Acanthophysallum lividocoeruleum (Karst.)Parmasto	*Shahnalah*
Agaricus campestris,	*Raighar*
Amyloathelia crassiuscula Hjortstam & Ryvarden	*Kaliheni*
Athelia pyriformis (Christ.) Jülich	*Shahnalah*
Athelopsis subinconspicua (Litsch.) Jülich	*Sunni Goth*
Botryobasidium laeve (J. Erikss.) Parmasto	*Lumba Padh*
Calvaria flava, Amanita phalliodes, Lysurus borealis	*Kaliheni*
Calyatia sp	*Plachek*
Cantharellus minor	*Lumba Padh*
Clavulicium delectabile (Jacks.) Hjortstam	*Raighar*
Collybia albijorida	*Raighar*
Coniophora cordensis Rattan	*Sunni Goth*
Corticium roseum Pers.	*Kaliheni*
Dendrothele strumosa (Fr.) P.A. Lemke	*Shahnalah*
Entoloma serrulatum	*Shahnalah*
Helvella	*Shahnalah*
Hyphoderma luridum (Bourdot & Galzin)J. Erikss. & Hjortstam	*Sunni Goth*
Leptosporomyces roseus Jülich	*Plachek*
Macrolepiota procera	*Plachek*
Morchella esculenta,	*Lumba Padh*
Odonticium flavicans (Bres.) Nakasone	*Shahnalah*
Phlebiella ardosiaca (Bourdot and Galzin)K.H. Larss.	*Lumba Padh*
Psilocybe subtropicalis	*Kaliheni*

Table 4: Species of mushrooms found in Dhauladhar region during the study

LICHENS

Lichens are popularly known to be the good bio-indicators, as they are very sensitive to the most slight changes occurring around them. These changes or disturbances can be deforestation, pollution, urbanisation or fluctuation in temperature and humidity. Initially, they start showing damage, but eventually some of them die while others tolerate it to some degree; but if these disturbances are too stressful, they are completely wiped out.

We cannot deny that Lichens are fascinating organisms, but what's more fascinating is their ability to disperse and their reproduction. Lichens are dual organisms and their stabilizing structure known as Thallus can only be formed by symbiotic interaction of mycobiont and photobiont. It endures a great challenge as it entirely depends on both symbiotic partners for dispersal and reproduction. But Lichens do have a strategy to cope up with this, i.e. independent reproduction of each symbiotic partner. For long distance dispersal of the mycobiont, the sexual spore production in structures like apothecia and perithecia confirms this fact. However, this strategy also has limitations: what are the chances that these spores find photosynthetic partner, that too, compatible?

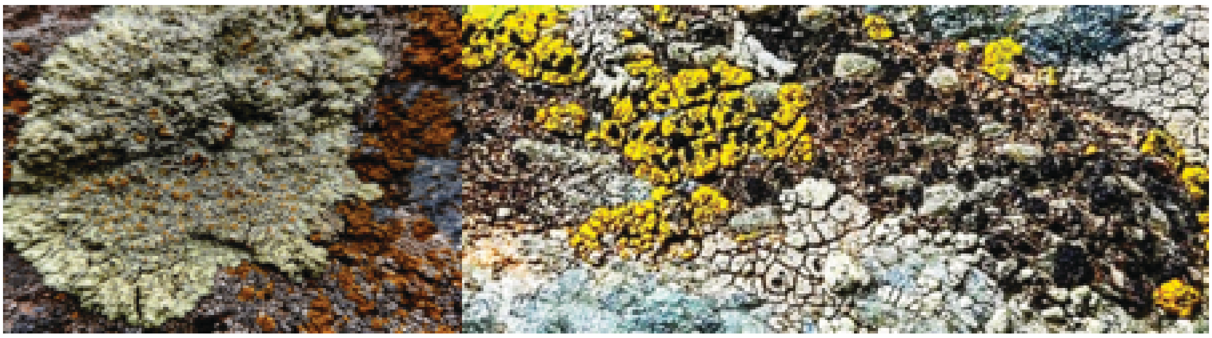


Figure 1: Rhizocarpon geographicum (L.)DC (left) and *Collema polycarpon* Hoffmn. (right) in natural habitat.

To overcome this, few well studied lichens like Soredia and Isidia have evolved their strategies furthermore to disperse both the partners. Though, this type of reproduction hampers the genetic variability and also the distance. These strategies are complicated and sound improbable, but they are so successful that we find them in every terrestrial ecosystems on Earth. For a long period of time, Lichens were thought to be mosses or plants. It was in 19th century that they were proposed as dual organisms and are a product of symbiosis between algae and fungi. But this fact suddenly changed in recent years. Now that the concepts have changed and the studies advanced, these lichens are considered miniature ecosystems, not only made up of mycobionts and photobionts but also a rich complex of protozoans, bacteria and viruses each one of them coexisting to form a stable structure.

The interactions are so complex that they not only occur in various structures and forms, but also exhibit an array of colours. Some even grow fluorescent under UV lights.These colours are mostly due to two factors.

1) Type of photobionts that is associated with fungus.

2) Production of secondary metabolites.

Green lichens are those associating with Green algae; and brown, black blue-greens those associating with cyanobacteria.

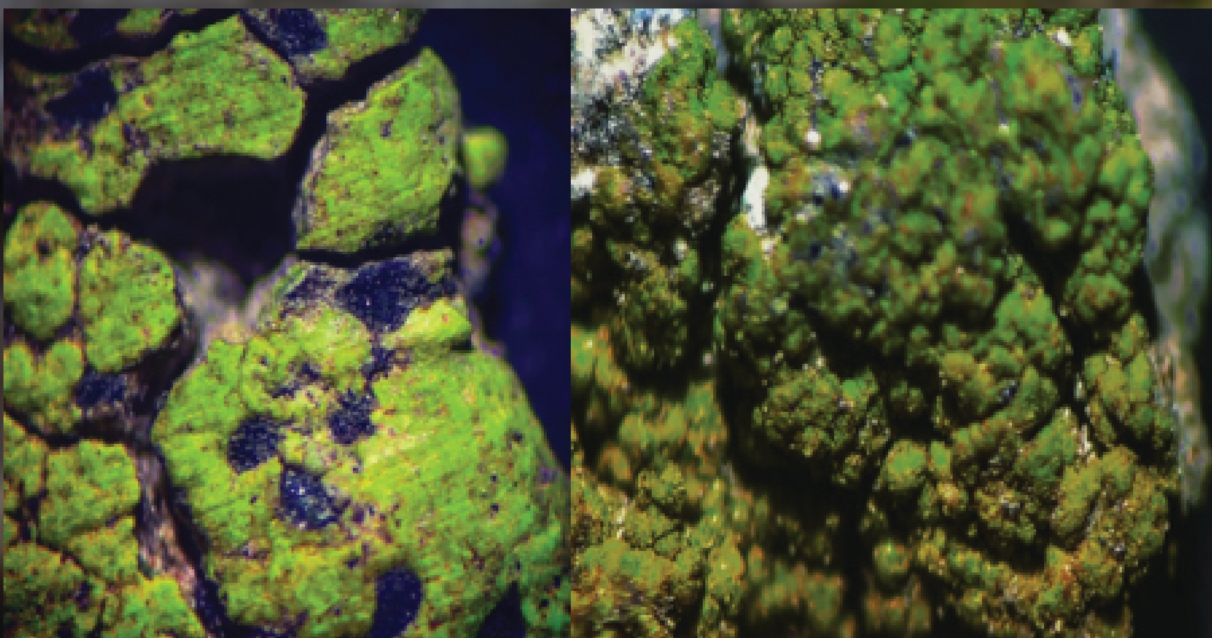


Figure 2: Ramalina sinensis Jatta: Microscopic image detailing green pigments

The success of lichen symbiosis allow these organisms to survive in harsh environmental conditions, even polar regions. They can also tolerate hot and dry areas like deserts due to their ability to survive under low water content levels and then rapidly hydrate themselves through vapour or melting of ice.

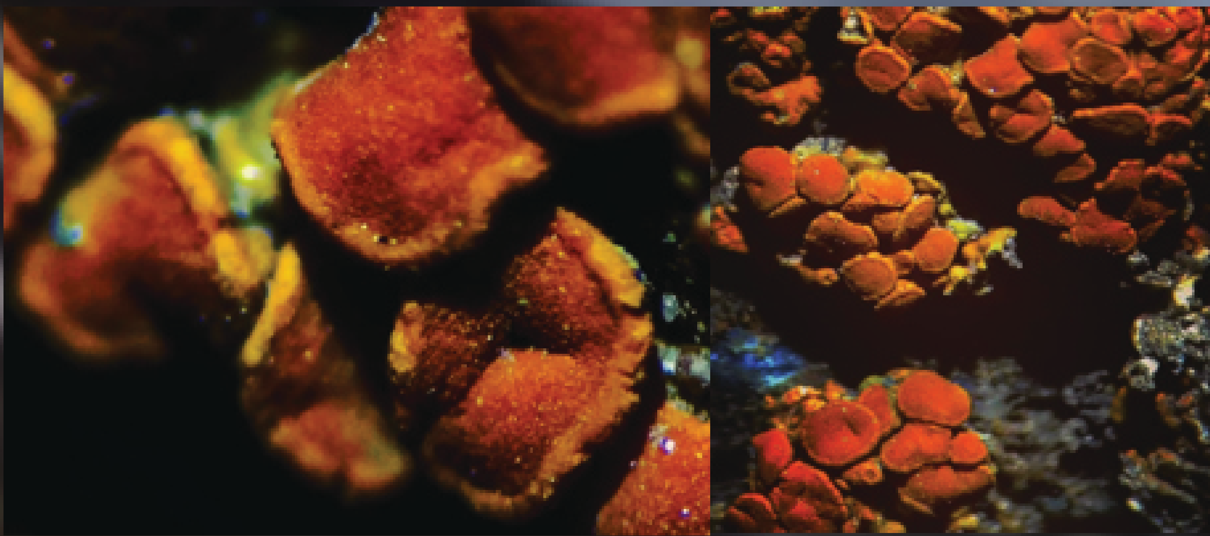


Figure 3: Caloplaca flavorubescens (Huds.) Laundon: Microscopic image detailing orange pigments

In yellow or orange Lichens, the reason behind pigmentation are secondary metabolites, which are nothing but substances that help those lichens for survival in their environment. These pigments sometimes act as inhibitors, sun protectors and even antibiotics. Studies have confirmed adaptive functions of secondary metabolites, with major function being defence. Secondary metabolites defend lichens from invertebrate consumers. Humans also have taken advantage of this. Usnic acids we use in manufacturing antibiotics is one of the most common and abundant lichen metabolites.

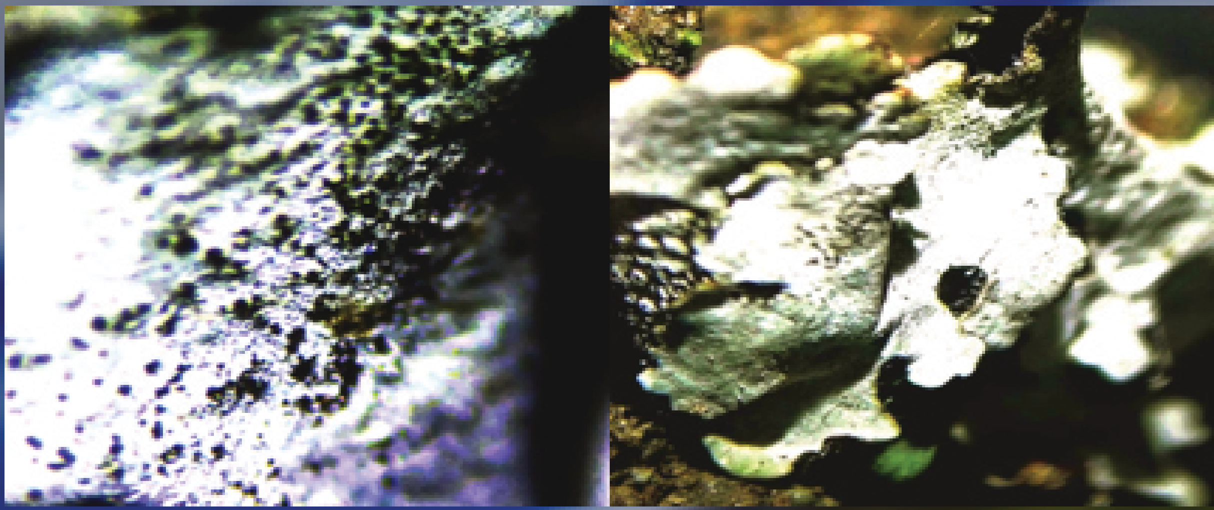


Figure 3: *Hypothrachyna* sp.

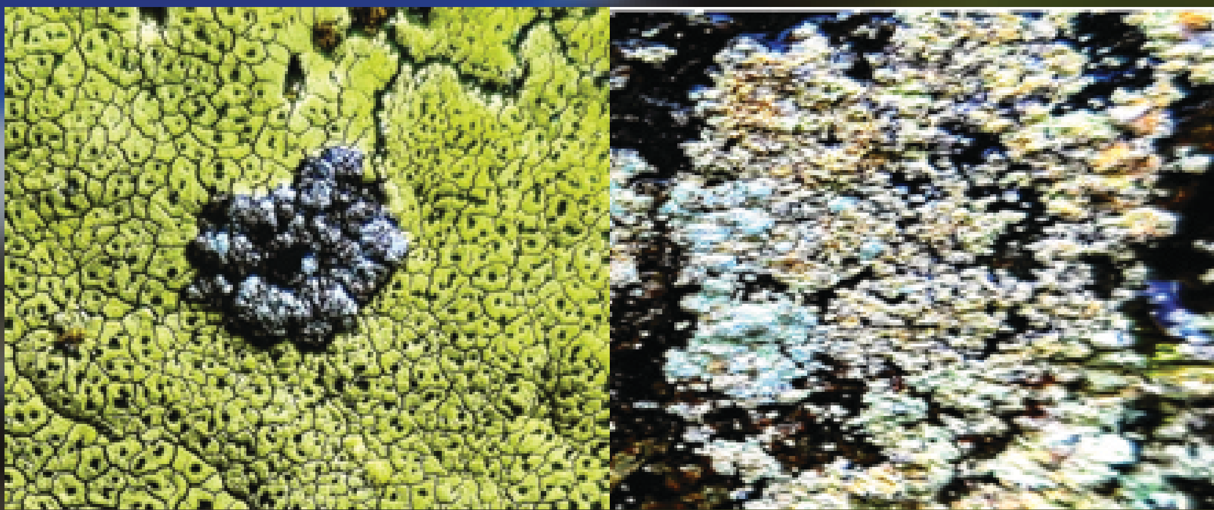


Figure 4: *Heterodermia leucomelos* (L.) Poelt (left)between *Ramalina* colony and *Dermatocarpon miniatum* (L.) Mann. (right)

Sr. No.	Species	Family
1	*Caloplaca flavorubescens* (Huds.) Laundon	Teloschistaceae
2	*Candelaria concolor* (Dicks.) Arnold	Candelariaceae
3	*Chrysothrix chlorina* (Ach.) Laudon	Chrysothricaceae
4	*Cladonia chlorophaea* (Flörke ex Sommerf.) Spreng.	Cladoniaceae
5	*Cladonia coniocraea* (Flörke) Spreng.	Cladoniaceae
6	*Collema polycarpon* Hoffm.	Collemataceae
7	*Dermatocarpon miniatum* (L.) Mann	Verrucariaceae
8	*Heterodermia diodemata* (Taylor) Aswathi	Physciaceae
9	*Heterodermia leucomelos* (L.) Poelt	Physciaceae
10	*Lasapertusa* (Rass.) Llano	Umbilicariaceae
11	*Punctelia rudec*ta (Ach.) Krog	Parmeliaceae
12	*Ramalina sinensis* Jatta	Ramalinaceae
13	*Rhizocarpon geographicum* (L.) DC	Rhizocarpaceaea
14	*Usnea longissima* Ach.	Parmeliaceae

Table 5: List of Lichens found in Dhauladhar Wildlife Sanctuary

BIRDS

Avian fauna is of great significance for human beings, as they play a critical role in controlling the number of inhabiting insects and pests and also help in seed dispersal. They are among the key markers for evaluating the quality of biological system as the avian assemblage structure is highly influenced due to changes in the environment which may be because of natural or anthropogenic pressures.

Himachal Pradesh, located in western Himalayan range has a special significance when we study pheasants and forest birds. It has seven species which are globally threatened. Being a highly biodiverse region, Himachal Pradesh has more than 45% of the bird species that are found in India. Among these bird rich areas, Dhauladhar wildlife sanctuary has a potential to host such diversity. It provides sufficient habitats and chance for resource exploitation. We made a list of birds found during two months of field visit.

Name of species	Scientific name	Family	Concern
Bar-tailed Treecreeper	*Certhia himalayana*	Certhiidae	Least Concerned
Bearded Vulture	*Gypaetus barbatus*	Accipitridae	Near Threatened
Black Bulbul	*Hypsipetes leucocephalus*	Pycnonotidae	Least Concerned
Black Drongo	*Dicrurus macrocercus*	Dicruridae	Least Concerned
Black Redstart	*Phoenicurus ochruros*	Muscicapidae	Least Concerned
Black-and-yellow Grosbeak	*Mycerobas icterioides*	Fringillidae	Least Concerned
Black-chinnedBabbler	*Cyanoderma pyrrhops*	Timaliidae	Least Concerned
Black-crested tit	*Periparus melanolophus*	Paridae	Least Concerned

Black-headed jay	*Garrulus lanceolatus*	Corvidae	Least Concerned
Black-lored Tit	*Machlolophus xanthogenys*	Paridae	Least Concerned
Blue Whistling-thrush	*Myophonus caeruleus*	Muscicapidae	Least Concerned
Blue-capped Redstart	*Phoenicurus coeruleocephala*	Muscicapidae	Least Concerned
Brown Dipper	*Cinclus pallasii*	Cinclidae	Least Concerned
Chestnut Thrush	*Turdus rubrocanus*	Turdidae	Least Concerned
Chestnut-bellied Rock-thrush	*Monticola rufiventris*	Muscicapidae	Least Concerned
Chestnut-crowned Laughingthrush	*Trochalopteron erythrocephalum*	Leiotrichidae	Least Concerned
Chestnut-headed Tesia	*Cettia castaneocoronata*	Cettidae	Least Concerned
Chestnut-tailed Minla	*Actinodura strigula*	Leiotrichidae	Least Concerned
Chukar partridge	*Alectoris chukar*	Phasianidae	Least Concerned
Common buzzard	*Buteo buteo*	Accipitridae	Least Concerned
Common cuckoo	*Cuculus canorus*	Cuculidae	Least Concerned
Common kestrel	*Falco tinnunculus*	Falconidae	Least Concerned
Common Myna	*Acridotheres tristis*	Sturnidae	Least Concerned
Common Raven	*Corvus corax*	Corvidae	Least Concerned
Common Rosefinch	*Carpodacus erythrinus*	Fringillidae	Least Concerned
Common stonechat	*Saxicola torquatus*	Muscicapidae	Least Concerned
Crested kingfisher	*Megaceryle lugubris*	Alcedinidae	Least Concerned

Eurasian Golden Oriole	*Oriolus oriolus*	Oriolidae	Least Concerned
Eurasian Hobby	*Falco Subbuteo*	Falconidae	Least Concerned
Eurasian hoopoe	*Upupa epops*	Upupidae	Least Concerned
Eurasian Sparrowhawk	*Accipiter nisus*	Accipitridae	Least Concerned
Fire-breasted Flowerpecker	*Dicaeum ignipectus*	Dicaeidae	Least Concerned
Fulvous-breasted Woodpecker	*Dendrocopos macei*	Picidae	Least Concerned
Golden Bush-robin	*Tarsiger chrysaeus*	Muscicapidae	Least Concerned
Great Barbet	*Psilopogon virens*	Megalaimidae	Least Concerned
Great Tit	*Parus major*	Paridae	Least Concerned
Green-backed Tit	*Parus monticolus*	Paridae	Least Concerned
Grey Bushchat	*Saxicola ferreus*	Muscicapidae	Least Concerned
Grey-headed Canary-flycatcher	*Culicicapa ceylonensis*	Stenostiridae	Least Concerned
Grey-winged Blackbird	*Turdus boulboul*	Turdidae	Least Concerned
Himalayan Bulbul	*Pycnonotus leucogenys*	Pycnonotidae	Least Concerned
Himalayan Griffon	*Gyps himalayensis*	Accipitridae	Near Threatened
Himalayan monal	*Lophophorus impejanus*	Phasianidae	Least Concerned
Himalayan snowcock	*Tetraogallus himalayensis*	Phasianidae	Least Concerned
House Sparrow	*Passer domesticus*	Passeridae	Least Concerned
Jungle owlet	*Glaucidium radiatum*	Strigidae	Least Concerned
Kalij Pheasant	*Lophura leucomelanos*	Phasianidae	Least Concerned
Koklas Pheasant	*Pucrasia macrolopha*	Phasianidae	Least Concerned

Little Forktail	*Enicurus scouleri*	Muscicapidae	Least Concerned
Long-tailed Minivet	*Pericrocotus ethologus*	Campephagidae	Least Concerned
Orange-flanked Bush-robin	*Tarsiger cyanurus*	Muscicapidae	Least Concerned
Oriental Cuckoo	*Cuculus saturates*	Cuculidae	Least Concerned
Oriental turtle dove	*Streptopelia orientalis*	Columbidae	Least Concerned
Oriental White-eye	*Zosterops palpebrosus*	Zosteropidae	Least Concerned
Pink-browed Rosefinch	*Carpodacus rodochroa*	Fringillidae	Least Concerned
Plain Mountain-finch	*Leucosticte nemoricola*	Fringillidae	Least Concerned
Plain-backed Thrush	*Zoothera mollissima*	Turdidae	Least Concerned
Plumbeous Water-redstart	*Phoenicurus fuliginosus*	Muscicapidae	Least Concerned
Red-billed Blue Magpie	*Urocissa erythroryncha*	Corvidae	Least Concerned
Red-billed Chough	*Pyrrhocorax pyrrhocorax*	Corvidae	Least Concerned
Red-headed Bullfinch	*Pyrrhula erythrocephala*	Fringillidae	Least Concerned
Red-vented Bulbul	*Pycnonotus cafer*	Pycnonotidae	Least Concerned
Rock Bunting	*Emberiza cia*	Emberizidae	Least Concerned
Rose-ringed Parakeet	*Psittacula krameri*	Psittacidae	Least Concerned
Rufous Sibia	*Heterophasia capistrata*	Leiotrichidae	Least Concerned
Rufous-bellied Niltava	*Niltava sundara*	Muscicapidae	Least Concerned
Rufous-gorgeted Flycatcher	*Ficedula strophiata*	Muscicapidae	Least Concerned
Rufous-naped Tit	*Periparus rufonuchalis*	Paridae	Least Concerned

Scaly-breasted Munia	*Lonchura punctulata*	Estrildidae	Least Concerned
Scarlet Minivet	*Pericrocotus flammeus*	Campephagidae	Least Concerned
Slaty-blue Flycatcher	*Ficedula tricolor*	Muscicapidae	Least Concerned
Snow partridge	*Lerwa lerwa*	Phasianidae	Least Concerned
Snow Pigeon	*Columba leuconota*	Columbidae	Least Concerned
Speckled Piculet	*Picumnus innominatus*	Picidae	Least Concerned
Spotted Forktail	*Enicurus maculates*	Muscicapidae	Least Concerned
Streaked Laughingthrush	*Trochalopteron lineatum*	Leiotrichidae	Least Concerned
Ultramarine Flycatcher	*Ficedula superciliaris*	Muscicapidae	Least Concerned
Variegated Laughingthrush	*Trochalopteron variegatum*	Leiotrichidae	Least Concerned
Wallcreeper	*Tichodroma muraria*	Sittidae	Least Concerned
Whiskered Yuhina	*Yuhina flavicollis*	Zosteropidae	Least Concerned
White Wagtail	*Motacilla alba*	Motacillidae	Least Concerned
White-browed Fantail	*Rhipidura aureola*	Rhipiduridae	Least Concerned
White-capped Water-redstart	*Phoenicurus leucocephalus*	Muscicapidae	Least Concerned
White-cheeked Nuthatch	*Sitta leucopsis*	Sittidae	Least Concerned
White-collared Blackbird	*Turdus albocinctus*	Turdidae	Least Concerned
White-tailed Nuthatch	*Sitta himalayensis*	Sittidae	Least Concerned
White-throated Fantail	*Rhipidura albicollis*	Rhipiduridae	Least Concerned
white-throated kingfisher	*Halcyon smyrnensis*	Alcedinidae	Least Concerned

Winter Wren	Troglodytes hiemalis	Troglodytidae	Least Concerned
Yellow-bellied fantail	Chelidorhynx hypoxanthus	Stenostiridae	Least Concerned
Yellow-billed blue magpie	Urocissa flavirostris	Corvidae	Least Concerned
Yellow-billed Chough	Pyrrhocorax graculus	Corvidae	Least Concerned
Yellow-breasted Greenfinch	Chloris spinoides	Fringillidae	Least Concerned
Yellow-browed Tit	Sylviparus modestus	Paridae	Least Concerned

Table 6: List of Birds observed within the sanctuary during the study

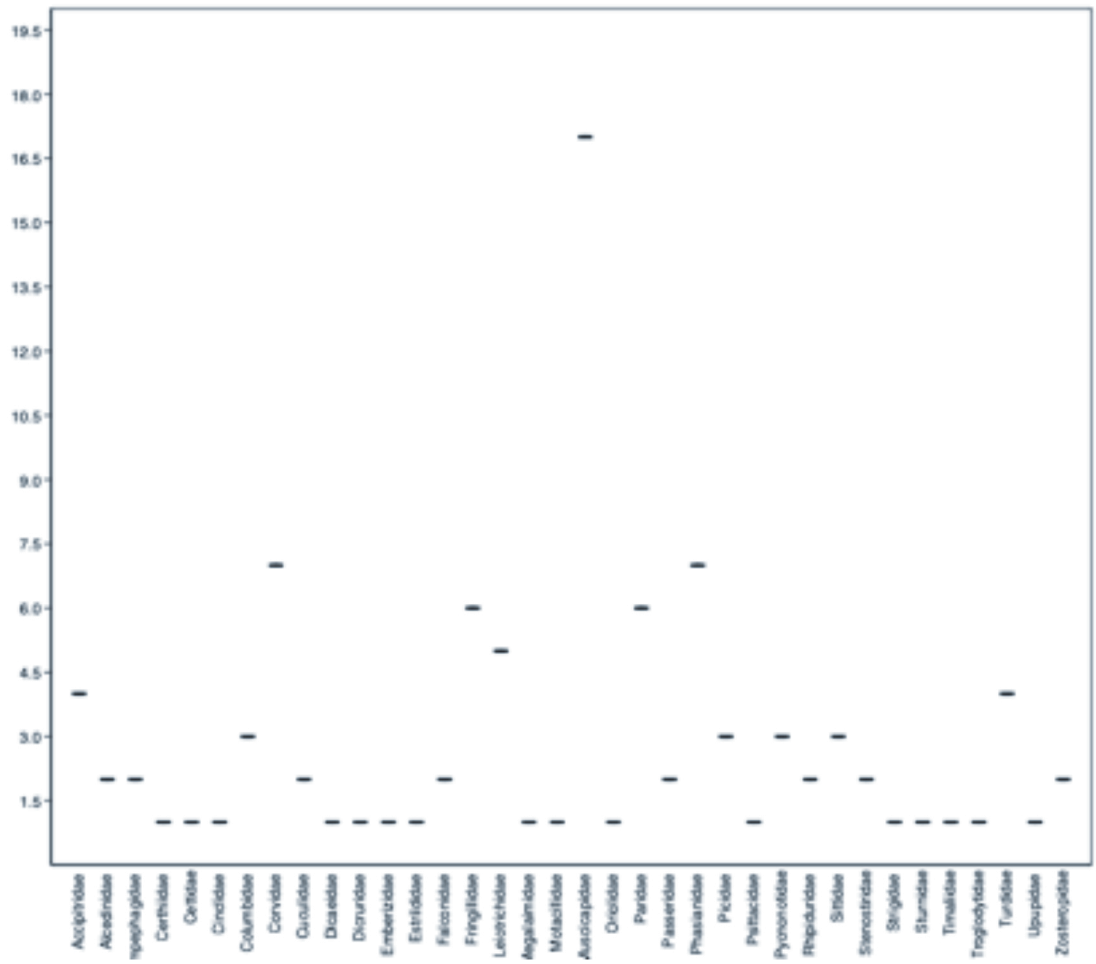


Fig 29: Box plot representing the dominance of Family Muscicapidae over 35 other families within the sanctuary area.

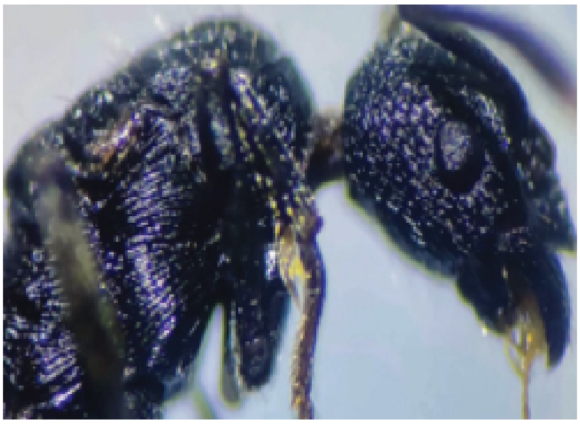
ANTS

As one of the 17 mega-diverse countries of the world and with four biodiversity hotspots represented in its borders, India is home to a diversity of life forms. However, much work remains to document and catalogue the species of India and their geographic distributions, especially for diverse invertebrate groups. In the present study, we also tried to document the lesser fauna within the study area. A total of 32 species were found during the period of 2 months. The present listing of ants from this area will provide a holistic view about diversity and will also help to identify major under sampled areas where future sampling and taxonomic efforts should be directed.

Lasius sp.: This genus is hitherto known to comprise 111 extant species and 3 subspecies. In the Himalayas, 17 species have so far been reported, including 13 species from the Indian Himalaya. Likewise other Himalayan ants, this species also shows restricted distribution, which suggests a rather high degree of endemism (45%) of this group in the Himalayas.

Temnothorax sp.: Temnothorax is a widely spread genus with 335 described species (BOLTON 2012) and a high number unexplored taxa. The genus is very poorly investigated for India, as no significant contributions except for a few isolated descriptions have been published. Menozzi (1939) listed 8 Temnothorax taxa for the Indian Himalaya region, including 2 new species/subspecies.

Myrmica sp.: The ant genus Myrmica comprises 148 valid species in the Old world which are widely distributed in the Palaearctic and South-East Asian tropical and subtropical regions. The Myrmica fauna of the Central Asian mountains, which comprise the Hindu Kush, Karakorum, and south-western slope of the Himalayas (Afghanistan, Pakistan, India, Nepal and Bhutan), contains 36 species representing 7 species groups; 34 species (94.44%) are endemic to this region.



Species	Site	Elevation
Aphaenogaster cristata	Lumba Padh	3733
Crematogaster sagei	Shahnala	3502
Lasius elevatus	Shahnala	3430
Lasius lawarai	Shahnala	3217
Leptogenys transitionis	Thamsar Dal	4208
Myrmica adrijae	Kaliheni	3115
Myrmica inezae	Sunni Goth	3399
Myrmica nefaria	Shahnala	3469
Myrmica wittmeri	Sunni Goth	3345
Myrmica wittmeri	Thamsar Dal	4210
Pheidole indica	Lumba Padh	3667
Pheidole latinoda	Bada Bhangal	2500
Polyrhachis illaudata	Shahnala	3542
Ponera taylori	Kapoor Dera	3786
Stenamma wilsoni	Kaildhar	3769
Temnothorax himachalensis	Jwahrinala	2916
Temnothorax rothneyi	Sunni Goth	3356

Table 7: List of Ant species and the elevation which they are found in Dhauladhar Wildlife Sanctuary

List of Figures

Dr. Salvador Lyngdoh
Department of Animal Ecology and Conservation Biology
Wildlife Institute of India, Chandrabani
Dehradun, India 248001
Tel: 00 91 135 2646281
Fax: 00 91 135 2640117
E-mail: salvador@wii.gov.in

भारतीय वन्यजीव संस्थान
Wildlife Institute of India